Memorandum

To: Vicki Sandiford, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency

From: Leland Deck, Lauraine Chestnut, and Colleen Donovan, Stratus Consulting Inc.

Date: 11/18/2008

Subject: Summary of Urban Visibility Workshop

On October 6 through 8, 2008, the U.S. Environmental Protection Agency's (EPA's) Office of Air Quality Planning and Standards (OAQPS) held an expert workshop on urban visibility preferences and valuation. The workshop was held in Lakewood, Colorado, at the offices of the Air Resources Division of the National Park Service (NPS).

The purpose of the workshop was to identify and discuss methods and materials that could be used in "next step" projects to develop additional information about people's preferences for reducing existing impairment of urban visibility, and about the value of improving urban visibility. The additional information obtained from such projects would be used to inform EPA considerations about the role of achieving acceptable levels of urban visibility in setting a secondary particulate matter (PM) National Ambient Air Quality Standard (NAAQS). Similar to the limited existing research on urban visibility preferences, the potential new projects would likely involve focus groups and survey methods to elicit information from individuals about their preferences and values. The workshop explored a set of eight specific issues (introduced in a white paper distributed prior to the workshop) about topics that could be considered in designing additional projects to better understand urban visibility preferences and valuation. The issue white paper is included as Appendix K. Prior to the workshop, the participants were also provided a background paper reviewing previous urban visibility valuation and preference studies (included as Appendix L).

Prior to the workshop, OAQPS and Stratus Consulting identified a set of individuals with expertise in technical fields related to urban and rural visibility, preference elicitation, and valuing aesthetic environmental goods. The invited individuals came from a broad array of relevant technical and policy backgrounds, including visual air quality (VAQ) science, sociology, psychology, survey research methods, economics, and EPA's process of setting NAAQS. The 23 people who attended the workshop (including one via teleconference line) came from EPA, the National Oceanic and Atmospheric Administration (NOAA), NPS, academia, regional and state air pollution planning agencies, and consulting firms. The list of attendees is included as Appendix A.

The remainder of this memorandum summarizes the discussions in each of the workshop sessions on the eight issues introduced in the white paper.

Workshop Organization

The workshop was organized into eight separate sessions, plus an initial session (moderated by Vicki Sandiford of OAQPS) and a summary session (moderated by Marc Pitchford of NOAA) at the end of the workshop. The agenda for the workshop is included as Appendix B. The initial session discussed the role of urban visibility in setting a secondary NAAQS for PM. The PowerPoint slides used in this presentation are included in Appendix C.

The next eight sessions focused on each of the eight issues discussed in the white paper distributed prior to the workshop. A moderator led the discussion in each session. Some moderators used PowerPoint or Word to make a presentation as part of the session. These presentations are included as Appendices D through I.

At the end of each session Marc Pitchford used a flipchart to identify the summary points of each session, with the aim of identifying any consensus items and any unresolved questions. Each session’s summary points are presented below in the section on each session. At the conclusion of the workshop, Marc moderated a final session that reviewed each of the key summary points from each previous session.

Due to the integrated nature of the subject, the discussions in each session of the workshop were not necessarily confined strictly to the topic of the session. Instead of strictly following the chronological order of the discussions during the workshop, the remainder of this memorandum summarizing each session generally organizes all of the discussion pertaining to an issue under that issue’s section (regardless of when the discussion actually occurred). Because two pairs of the original eight issues were found to be closely integrated, this workshop summary combines the discussion of those pairs into a single review. The issues that are combined are regional differences and scene selection, and two topics focusing on economic valuation: joint goods and payment vehicles.

Session on Framing the Questions about Preferences

Leland Deck was the moderator of this session. His PowerPoint slides are included in Appendix D. The presentation reviewed the methods and findings of four previous preference studies (examining urban visibility in Denver; Phoenix; two locations near Vancouver, British Columbia; and Washington, DC), and introduced some of the challenges on how to present preference questions in a focus group or survey study.

Discussion Topics

One major topic of discussion in this session was the meaning of the terms “adverse” and “acceptable” when describing visibility conditions. Because of the importance of the interpretation of adverse and acceptable, the workshop discussion returned to this topic in many of the later sessions. Because the Clean Air Act calls for secondary standards to protect the public welfare from any known or anticipated adverse effects, identifying “adverse” urban visibility conditions is likely to be a key element in assessments undertaken to inform the secondary NAAQS review process. The main goal of previous visibility preference studies, however, was identifying the visibility level felt to be “acceptable.” Each of the four previous preference studies asked people to evaluate a series of photographic depictions of VAQ and judge whether they were acceptable or unacceptable, for the purpose of identifying identify a threshold level of visibility impairment they consider unacceptable. The workshop participants felt it was critical that any future project on urban visibility preferences develop a clear understanding about how survey respondents are interpreting the term acceptable, and develop a successful approach to help the respondents reach a common understanding of how the term should be understood.

The discussion pointed out that in the context of urban visibility, the term adverse does not refer to the minimal level of visibility impairment that people can notice, but rather a level of impairment people personally feel is “too much” in some fashion which begins to negatively affect a person’s enjoyment and sense of wellbeing. Alternative terms may more clearly communicate the concept instead of (or in complement to) the term adverse, such as acceptable or preferable. Several workshop participants suggested that the articulation of adverse, and the selection of words to communicate this idea, is a topic that should be explored in a preliminary focus group project. Open-ended discussions with participants would help determine the words that best describe this idea for the general public. Introductory material presented in any subsequent focus groups or surveys should use these words to explain the concept of adverse visibility impairment to respondents.

A related topic of discussion was about how much, and what kind, of background and introductory material should be presented to focus group and survey respondents. One element of this discussion was about introducing survey respondents to the concept of the differences between natural visibility impairment (fog, rain, etc.) and pollution-related impairment, and the role of humidity. In the eastern United States, people may not be aware that much of visibility impairment is VAQ degradation related to pollution (perhaps thinking it is the result of humidity alone). The concern expressed was that if respondents believe the impairment is natural, this would influence how they answer questions about how they are affected by different levels of VAQ degradation. Workshop participants generally felt that people in the western United States are aware that pollution is involved with impairing visibility.

Another topic discussed was whether introductory information presented to survey respondents should mention specific sources of pollution that may cause VAQ degradation. Some workshop participants felt very strongly that specific types of sources should not be mentioned when discussing visibility impairment.

The discussion identified that background information and “warm up” exercises in a survey where people get accustomed to reviewing and rating photographs can help educate people prior to asking the acceptability or adverse questions, and may provide a somewhat standardized framework of understanding among the participants.

This session introduced the issue of separating out preferences for visibility from concern over health risks arising from observed pollution-related VAQ degradation. This topic arose in many of the subsequent sessions as well; it is a central issue confronting urban visibility preference and valuation assessments. The overall goal is to obtain information on the visibility component alone, separating visibility from preferences about the actual or perceived health risks of air pollutants. However, people are not accustomed to making this distinction; they generally form an overall impression about their preferences for improvements in VAQ. It can be very hard to get people to separate health from visibility. Even after asking people to make the separation, it is important to explore whether they have successfully done so. This is a critical issue because the primary NAAQS are set to protect health. A secondary NAAQS, which protects human welfare and wellbeing, is aimed at non-health issues. In the context of a secondary NAAQS, successfully making the distinction between health and visibility becomes very important and very challenging.

Summary Consensus Points

- We do not want to commingle natural and anthropogenic impairment to VAQ. Respondents need to be told they are viewing the anthropogenic effects.

- We should not tell people about specific pollution sources that cause VAQ degradation, especially since it can be very location-specific.

- Further study is needed to determine the best terms to use (e.g., acceptable vs. unacceptable; preferable vs. objectionable) to identify at what point noticeable impairment in VAQ is judged to be “adverse” by the respondent.

- We need to provide a minimum amount of background information and context for people to be able to respond meaningfully to preference or valuation questions.

- We need to understand people’s assumptions about the causes, remedies, and effects of VAQ degradation by exploring their understanding and assumptions in focus groups. This should be further explored in debriefing questions during the group interview stage to improve the understanding of respondent’s answers in a final survey.

Session on Temporal Distribution of Visibility Conditions

Dan Ely was the moderator of this session. His PowerPoint slides are included in Appendix E.

Discussion Topics

A basic policy relevant question is what are people's preferences for changes in the distribution of visibility conditions, not just their preferences concerning visibility conditions on a single day. The first discussion topic was whether the annual distribution was the best temporal distribution to present and ask respondents about, or if seasonal or even monthly distributions would be required in some regions. It is likely that in some areas of the country people may be more concerned about visibility in certain months than in others, and that VAQ impairment may differ substantially by time of year as well. However, workshop participants noted that the concept of potentially setting a national visibility standard, and the desire to conduct consistent preference and valuation studies across the country, suggest that it will be difficult to use results from studies conducted with a location-specific, seasonal-based approach in some locations and an annual basis in others.

Another topic discussed was whether 24-hour average VAQ was a desirable way to measure or describe relevant visibility impairment. During any given day people see a series of instantaneous visibility conditions, and visibility conditions can change rapidly. Some changes can occur minute-by-minute, with even a broader variation occurring across a day as both pollution levels and weather patterns change. The general workgroup consensus was that depicting visibility conditions averaged over a shorter timeframe, such as a four-hour, mid-day period, was preferable to using daylight or 24-hour averages.

Weather-related visibility conditions also are a factor in presenting the distribution of visibility conditions. Workshop participants felt we need to be explicit in mentioning that natural weather conditions (such as rain, snow, and fog) impair visibility some of the time, but we are interested in their preferences for visibility conditions at the times when weather is not the main reason for impaired visibility. A study should present information describing the distribution of visibility conditions during periods not primarily affected by adverse weather.

A fourth topic discussed in this session was how important it is to provide accurate information on existing (baseline) visibility conditions in the city being studied. One approach is to tell respondents how existing conditions relate to the photographs that are being presented, and ask questions directly about the acceptability of current conditions. An alternative approach is to present photographs spanning the full range of existing and potential conditions, but not directly inform the respondents about the current conditions (e.g., annual mean, 80th percentile day, or visibility conditions related to the level of the primary PM NAAQS). Opinions differed about which approach would be best in conducting a preference study (where some felt avoiding any reference to the existing conditions might be preferable), and which would be best in a valuation study (where a change from existing conditions plays a major role).

Summary Consensus Points

- We should ask about the frequency of occurrence of impaired visibility to determine acceptability.
- We should indicate clearly how many hours of the day are represented by the conditions we present.
- We should not highlight seasonality issues, but concentrate on changes in the distribution of annual visibility conditions.
- Only consider visibility impairment that occurs during daytime hours (e.g., do not include nighttime visibility).
- We should tell people that visibility impairing weather conditions are excluded from the distributions we present, and that visibility conditions change throughout the day.
- An open question was determining how important it is to tell respondents about the current visibility conditions and distributions.

Sessions on Regional Differences in Visibility Preferences and Scene Selections

Bruce Polkowsky was the moderator of the session on regional differences in preferences. His Word slides are included in Appendix F. Rich Damberg was the moderator of the session on scene selections; his PowerPoint slides are included in Appendix G. Mr. Damberg introduced his topic by showing a series of different urban scenes from around the country, ranging from iconic cityscape scenes to residential streets. Some photographs showed the impact of different visibility conditions on the scene, and others showed the differences in scenes and visibility issues in different regions of the country. He included the photographs used in the four preference studies.

Discussion Topics

One topic discussed was the importance of presenting photographs of scenes that are sensitive to visibility conditions. Long-sight distances, with both nearby and distant objects, can provide respondents information about the range of impacts of visibility impairment on different objects. Scenes without distant objects will make smaller differences in impairment levels difficult to see. In some cities long-sight distances may not be common. While in western cities mountains and other terrain features provide sight distances of perhaps hundreds of kilometers, flatter eastern and coastal cities often do not have such long-sight distance scenes (except perhaps from manmade objects such as tall buildings or observation towers). Clouds can provide targets with long-sight distances even in the East. People in the East may not be aware that cumulus clouds in an otherwise clear sky are often present, and could be seen at a distance, if they were not obscured by impaired VAQ. Including clouds in photographs presented to respondents could help alleviate the restricted sight distance issues, although people may have to be informed that such clouds would be a much more frequent feature of a city scene if not for poor VAQ. The issue of whether to tell people “you could be seeing more than you are now” applies to all distant objects, not just clouds. Not introducing such additional information may bias valuation questions, but introducing such new information may change the context of the questions by altering the understanding of the status quo conditions.

Workshop participants noted that people experience visibility where they live as a series of instantaneous visibility conditions involving a range of different scenes. They see some scenes on a nearly daily basis, others are seen perhaps once a week (e.g., different scenes on weekends), while others are actually seen occasionally during the year. Natural landmarks (e.g., mountains) and manmade features (e.g., prominent buildings or bridges) can make up a portion of the well recognized city scenes for a particular city, even if some residents do not see (or notice) that scene on a daily basis. More ordinary scenes, such as street and local park locations, make up more frequent opportunities for observing urban visibility conditions. There are wide ranges of patterns of which scenes different people living in a metropolitan area see during the course of a year.

An important question discussed was whether it is necessary to present photographs of scenes from a respondent’s own metropolitan area. The general consensus of the workgroup was that a readily identified iconic scene from a respondent’s home city, such as a broad vista of a city with mountains in the background or a scene including a famous local manmade structure, would be immediately recognized. Using such iconic photographs from one city would not be acceptable in surveys conducted in another city. An early visibility valuation study used an easily identified skyline photograph from one city in surveys conducted in other cities, and was heavily criticized for it. The workgroup conclusion was that an immediately recognizable local broad vista or iconic photograph should only be used in focus groups or surveys conducted in that city.

Scenes such as photographs of local parks, however, were felt to be much more generic than iconic photos. The participants discussed that residents of one city are not likely to notice that a local park scene photograph was actually taken in another city. If successful, this would not compromise the believability of the study materials. This could offer appreciable cost-savings in a project by avoiding the need to prepare local park photographs in each city included in a study, and would have the additional advantage of eliminating possible variations in preference responses associated with having different base photographs for each of the urban areas.

An important topic discussed in this session was how many scenes need to be used in a study to show the impact of different visibility conditions across a range of scenes. Using more scenes can help respondents better understand that visibility does not impact all scenes equally, and demonstrate that many common scenes are less sensitive to visibility than less frequently observed scenes including longer sight distances. Presenting multiple scenes, however, creates logistical difficulties, and can lead to information overload.

The general consensus of the group was that while more scenes were desirable, practical presentation logistics limit the number of scenes to two. In a print setting (hard copy photographs), three scenes could potentially be used but the size of the photographs must become smaller to avoid unwieldy photograph presentations.

Summary Consensus Points

- As long as we have objects that disappear or become less distinct under poor VAQ conditions, people will be able to express preferences for different VAQ levels. All images must have some sensitivity to changes in VAQ (e.g., range of sight distances) to be useful for eliciting preferences.

- Two scenes, an iconic or broad vista of a city and a generic local park scene, may be sufficient.

- May be able to use the same generic local park scene in all studies, regardless of region.

- Focus groups and survey need to allow respondents the option of saying they do not care about visibility impairment separate from health concerns.

- Group interviews during the survey development process should include a debriefing session in order to better understand sources of preference differences (e.g., what people are thinking, what assumptions they were making when answering questions).

- Need to test some of these questions or assumptions in a focus group setting.

  - Scene selection: Can a single generic local park scene be used in multiple cities? Is an iconic scene from each surveyed city also necessary?
  - To what degree does context of the questions affect the stated preferences?

    - Does information/knowledge regarding the sources of pollution affect local VAQ affect preferences?
    - Does information or knowledge regarding the costs of controls of sources affect preferences?
    - Does information, knowledge, or assumptions about associations between VAQ and human health effects affect preferences?

- Regional differences: Are there regional differences in preferences?
  - Does preference for blue sky/cloud conditions vary between the East and West)?
  - Do people notice or react to different components of visibility impairment (e.g., loss of scenic detail and color or changes in sky color) differently by region?

Session on Number and Composition of Focus Group and Survey Respondents

Robert Mitchell was the moderator of this session.

Discussion Topics

The discussion began by clarifying terminology used to differentiate different components of a study, and the following distinctions were offered.

Focus groups (referred to as investigative focus groups in the issue paper) are used to initially develop a survey design, and find out what people are thinking and understanding about the topics they are being asked about. Different focus groups are needed to explore separate questions in the survey design. These are very interactive sessions, with a greater focus on understanding what people are thinking than on the answers they provide. Focus groups can use participants from either convenience groups (e.g., students, civic clubs, church groups) or individuals selected from the general population (known as a random recruitment process). In a random recruitment process, the developers of the focus group identify a profile of the mandatory attributes of individuals they wish to have participate (e.g., have lived in the metropolitan area for at least 5 years, have adequate vision, and understand English), as well as a profile of the distribution of the mix of individuals they wish to have participate (e.g., a minimum of 40% male, and 20% with less than a college education).

Group interviews are used to test a survey instrument, and can serve as a pilot study for a full field survey. Background material may be shown to the group without a group discussion. Individual responses to survey questions are then collected with relatively little feedback or discussion. The moderator may answer questions to clarify what is meant by a question, or the directions on how to complete the survey. After the survey instrument questions are answered, an interactive session can be held to help improve the survey instrument.

Individual interviews are the final survey component to determine respondents' preferences and valuation responses. Individual interviews can be held in group sessions for efficiency (such as to show slides to a large group of people simultaneously), but the responses are collected from each individual. In person interviews, or surveys completed at home, can also be used as an individual interview.

A survey project must be designed to be able to consider both the reliability and validity of the responses. Reliability has to do with understanding the consistency of people's responses. This includes examining both the consistency for an individual's responses (e.g., do they give the same VAQ rating to the same photograph?) and within groups. As opinions and preferences vary by individuals, do different groups of individuals and different methods of asking the questions result in reasonably consistent results? Validity deals with the issue of whether we are measuring the correct concept we are interested in. In some contexts it may be easier to design a survey that measures a related concept, but not the one we are most interested in. An example in urban visibility is it could be easier to design a study to examine preferences for reducing VAQ impairment that combine health and visibility effects in a single concept. This would not be a valid survey of preferences for the visibility component alone.

The discussion concluded that we would likely need focus groups in two to four locations, selected to provide considerable regional variability. Perhaps four sessions (two sessions on two days) would be appropriate in each location to cover the range of topics raised in the workshop as needing investigation in the process of developing a survey instrument. The actual content of each focus group would evolve as results from earlier focus groups help refine the content of subsequent groups.

Participants noted that the Office of Management and Budget (OMB) review under the Paperwork Reduction Act will be a necessary component of any substantive project. An Information Collection Request (ICR) is required for any focus group project with more than nine total participants. Asking different questions in different focus group sessions does not avoid the ICR requirements. We would need to go through this process separately for focus groups and for the final survey. The ICR approval process works best if EPA staff have early and continual communication with OMB through the EPA OMB liaison. Using ICR application materials developed for the ongoing NPS study of visibility in National Parks and Class I areas may speed the ICR approval process. The NPS study has received approval for the focus group phase; approval for the survey phase is still under review. We need to make a schedule to see if conducting focus groups and/or the main survey is feasible given EPA's timeline.

Summary Consensus Points

- Focus groups may use either convenience groups or random recruitment.
    - Random recruitment is needed for group interview and survey phases.
- Screen participants for adequate vision, including adequate color vision.
- Early involvement with OMB can greatly increase the speed of the ICR approval process.

Session on Presenting Visibility Conditions

John Molenar was the moderator of this session; his PowerPoint presentation slides are included in Appendix H.

Discussion Topics

The range of presentation options includes new generation digital image projectors, high dynamic range (HDR) monitors, light emitting diode (LED) monitors, and reflection prints (hard copy photographs). Emerging technologies (such as HDR) are very expensive, and perhaps not practical for field studies at this time. High-quality digital image projection is a substantially better technology than reflection prints for accurately reproducing visibility conditions. Home computer monitors are too variable for use in accurately presenting visibility conditions.

The use of projection equipment requires respondents (in focus groups or surveys) to be in a suitable room; reflection prints create the possibility of mailing materials to respondents in a survey phase of the project. Completing the survey in a respondent's home using reflection prints creates unknown viewing conditions. Using projection equipment can allow better control of these variables. The lighting conditions used in viewing printed photographs can have a very substantial impact on what people are able to see in a photograph, and how they respond to the images they do see.

The size of the image presented is important to accurately represent the real world situation. When held at a normal viewing distance, an 8" by 10" hard copy photograph taken with a non-telephoto lens is a reasonably accurate depiction of a normal, real world viewing situation. A projection setting, with proper arrangement of seating distance to the screen, allows a more accurate depiction of the real world (e.g., onsite field of view, or FOV). It is difficult to maintain these accurate rendition conditions in a large group (e.g., 50 persons) viewing situation because of how the effective image size changes with the distance between each observer and the projection screen.

One issue that participants felt has been underemphasized in previous urban visibility studies is transparency, which refers to how well an object can be seen through a three-dimensional haze. Most studies have found that people focus on whether they can see a distant object at all, but react differently when they become aware that they are viewing an object through a tangible haze and pay less attention to how well objects appear when there is some haze between the observer and the object. It is difficult to present transparency accurately in a two-dimensional format (such as a slide projection or a printed photograph); however, realistic three-dimensional presentation may not be possible in an urban visibility study.

Differing visibility conditions can be presented using images prepared using WinHaze, a computer software application developed for the NPS by Air Resource Specialists. Starting with a suitable base photograph taken when atmospheric loadings (and hence visibility impairment) is as low as typically occurs in a year, the WinHaze program can simulate visibility conditions under alternative loadings of different chemical aerosols. This technology allows the creation of images of a constant scene showing the full range of relevant VAQ levels. WinHaze images have been used in previous preference and valuation studies. Air Resource Specialists have a large collection of photographs suitable for the original "pristine" air quality conditions needed in WinHaze, including some urban visibility scenes, and have conducted the extensive analysis on them that is necessary to prepare images accurately depicting alternative visibility levels. Preparing a WinHaze rendition of a new scene requires both an original base photograph taken when visibility conditions are excellent, as well as information about the sight distance between the camera and each point in the picture. WinHaze can prepare both digital images for projection as well as images for making hard copy reflection prints.

There was consensus among the workshop participants that projecting WinHaze generated slides in a controlled situation was preferable to using a printed presentation. There are, however, considerable cost differences and survey recruitment issues. This is not as relevant in focus group projects (e.g., where respondents would be coming to a single location anyway), but could be a major concern in a full survey implementation. Recruiting a representative sample, with an adequate response rate, of any population to come to a location to participate in a survey using slides will be far more difficult than getting a representative sample using an in-home survey method and mailing hard copy images to the respondents.

John Molenar presented a pair of slides (Appendix H) in this session showing the dramatic difference that composition of the aerosol makes in visibility conditions. At the same level of PM concentrations and extinction level for the same scene, the color differences between visibility conditions with aerosols dominated by local urban anthropogenic sources and the conditions when the aerosol was dominated by rural (primarily natural) sources were dramatic. Tom Moore also provided two photographs from Phoenix showing visibility when $PM_{2.5}$ concentrations were 75 $\mu g/m^3$ and 93 $\mu g/m^3$ (the NAAQS is 35 $\mu g/m^3$); these slides are included in Appendix J.

One innovative idea that was discussed was using high-quality, calibrated computer monitors in a controlled setting (i.e., not on home computers). A set of six or eight computers and monitors could allow a large number of survey participants to participate in a 15-minute survey collection. Perhaps this could occur after introducing each group to the subject via projected slides (e.g., running groups of people through a two-step process in rapid sequence). The workgroup discussed adapting the WinHaze software to allow the participants to use a mouse or keyboard with a slider to rapidly identify the level of visibility they find adverse (rather than viewing multiple pictures and rating each one individually).

One idea mentioned was using a personal slide viewer to present the visibility conditions in an at-home survey.

Summary Consensus Points

- Projection slides are preferred, but require that participants come to a location.
- Print images may be mailed for in-home surveys, but are not as good as projected images.
- There is no simple relationship between PM loadings and visibility conditions, but holding scene content and other variables constant, there is a relationship between judgments of VAQ and light extinction due to pollutants.
- Use of in-home computers would create substantially varying viewing conditions and inconsistent responses.
- Investigate idea of allowing respondents to “dial in” a level to quickly find an acceptable level.

Sessions on Economic Valuation: Joint Benefits and Payment Vehicle

Laurie Chestnut was the moderator for the session on joint benefits (also known as mental accounts), and Robert Mitchell was the moderator for the session on payment vehicle (asking the valuation question). Because both of these topics deal with eliciting economic valuation (willingness to pay, or WTP) information and the discussions intertwined the two subjects, the summary of both sessions are presented together. Laurie Chestnut’s PowerPoint slides are included in Appendix I.

Discussion Topics

Throughout the workshop, the issue of clearly defining the good in question (i.e., acceptable visibility conditions) came up. Separating health from visibility was extensively discussed and needs further consideration. One suggestion was that a way to clearly state the essential preference question is “At what level is enjoyment of daily activities reduced?”

A question discussed is how to measure strength of preferences, rather than looking for a single “bright line” between acceptable and unacceptable conditions. A WTP approach lends itself to exploring the strength of preferences in a straightforward manner, but it may be possible to design good strength of preference questions that use metrics other than dollars to investigate this as well.

One of the initial questions was whether to include WTP questions as part of a study also investigating preferences and adverse levels, or is it necessary (or desirable) to conduct separate studies? WTP responses can help analysts understand the strength of preferences, furthering understanding about what level is adverse. WTP estimates would also be very helpful to OAQPS staff who prepare the risk and benefits assessments for the secondary standards, because the visibility improvements (benefits) could also then be presented in economic terms. Including WTP questions will likely require some additional focus group effort to develop a good WTP framework, but will probably not add much to the length or complexity of an eventual survey instrument.

It is important to use a plausible scenario to ask valuation questions in a realistic and understandable context in which visibility improvements will occur. Reflecting the earlier conversations about avoiding mentioning specific sources of visibility impairment (e.g., power plants, transportation), the context must strike a balance between being overly general and too specific. The context has to be clear enough to be understood and accepted by the participants in order to standardize people's assumptions about the situation.

The specific context of the WTP questions will be paying something for going from condition A to condition B, or to prevent going from condition A to B. The form of payment must be plausible and understandable. Possible examples include taxes, special fees, increases in general prices or in prices of specific items, etc. The payment vehicle should be logically tied to improving visibility, and be collectable from everyone. A complication to selecting a specific context for payment is the possibility of "scenario rejection" where a respondent's strong preexisting opinions about a particular issue mentioned in framing the questions (such as an increase in residential electricity prices) could lead to the individual inaccurately stating they have no interest in improving visibility.

Workshop participants noted there is a difference between asking respondents to select a single level of VAQ impairment they consider unacceptable and asking them about their WTP for a specific change from one VAQ condition to another. It is difficult to ask WTP questions about a series of gradual changes in VAQ; it is easier to ask about a more abrupt change. The study design team must select the before and after VAQ levels about which to ask the WTP questions. Showing multiple VAQ levels simultaneously (on the projection screen or on printed paper) will help people focus on the different choice levels rather than using their memory about the changes in VAQ from previous photographs. Focus group results can be useful for selecting the change in VAQ levels to be investigated, and the range of relevant policy choices can also factor into the decision.

A conjoint analysis approach can be used for either preference or valuation questions. Conjoint analysis does not directly ask a WTP question, but instead forces respondents to make a choice between two or more bundles of different conditions. A conjoint approach may be useful in forcing respondents to separate the health effects from visibility effects, for example, by offering choices between bundles of conditions that differ in visibility conditions, health risks, and overall price levels. The ongoing NPS study of National Park visibility is using a conjoint analysis form of question.

Summary Consensus Points

- Presenting a plausible scenario of both VAQ improvements and payment methods is critical, but scenario rejection needs to be evaluated in any final instrument.
- Valuation questions are a low-cost add-on to preference studies.
- WTP studies can help capture strength of preferences, not just a yes/no level of preference.
- WTP studies need to define a set of specific VAQ changes to estimate values.

Compilation of Recommended Topics for Investigating in Focus Groups

In the closing session of the workshop, the workgroup participants expressed a general consensus that a high-quality survey project on a complex topic such as preferences and the valuation of urban visibility will need to be developed by initially conducting a series of focus groups to gain insight into a set of issues and questions. The following list of ideas for investigating in focus groups is not intended to be a list of mandatory topics that must be explored or an exhaustive list of important topics to explore in a focus group setting.

- Investigate alternative wording to present the concept of selection of words to communicate the concept of adverse or unacceptable.
- Explore the type, depth, and wording of introductory materials presented to explain visibility and VAQ impairment to the participants.
- Investigate whether respondents are aware of the role of pollution in VAQ impairment, especially to learn whether people living in the eastern United States know pollution is involved.
- Explore people's assumptions about the causes, remedies, and effects of VAQ degradation by exploring their understanding and assumptions in focus group debriefs.
- Investigate alternative ways of getting respondents to separate their preferences for avoiding health risks arising from noticing VAQ conditions from their preferences for visibility conditions alone.

- Explore the impact of telling respondents how existing conditions relate to the photographs that are being presented, or to present photographs spanning the full range of existing and potential possible conditions but not directly inform the respondents about the current conditions.

- Investigate whether including cumulus clouds in a blue sky will provide a useful long-sight distance to observe the effects of increasing VAQ impairment, especially in the eastern United States.

- Investigate whether a single set of photographs of a generic park scene could be acceptable for use in surveys in cities throughout the United States.

- Conduct initial focus groups in cities in different regions of the country to gain an understanding about whether visibility preferences substantially differ across the country.

- Investigate whether people are able to use a high-quality computer monitor equipped with "dial in" visibility impairment software to identify their acceptable level of visibility.

- Investigate alternative wording of WTP questions, including variations in both context and payment vehicle (including whether to specifically mention costs of control).

- Investigate the level of change in VAQ best suited to asking WTP questions.

- Explore what combinations of alternative bundles of conditions are best suited for use in a conjoint analysis approach to valuation.

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Marc Pitchford	NOAA	Marc.Pitchford@noaa.gov
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Bruce Polkowsky	NPS	bruce_polkowsky@nps.gov
Bob Rowe	Stratus Consulting	browe@stratusconsulting.com
Steve Sakiyama	British Columbia Ministry of Environment	Steve.Sakiyama@gov.bc.ca
Vicki Sandiford	EPA/OAQPS	Sandiford.vicki@epa.gov

B. Agenda, EPA Workshop on Urban Visibility Preferences and Valuation, October 6-8, 2008

Monday, October 6		**Discussion leader**
1:00 PM	Welcome and introduction	Marc Pitchford
1:45 PM	Role of urban visibility in secondary PM NAAQS	Vicki Sandiford
2:30 PM	*Break*	
2:45 PM	Framing the questions about preferences (#3 in Issue Paper)	Leland Deck
4:00 PM	Session wrap-up, summary	
4:15 PM	Temporal distribution of urban visibility conditions (#2 in Issue Paper)	Dan Ely
5:15 PM	Session wrap-up, summary	
5:30 PM	END OF DAY	
Tuesday, October 7		
8:00 AM	Review of yesterday, finish #2 if necessary	
8:15 AM	Differences in regional preferences (#5 in Issue Paper)	Bruce Polkowsky
9:30 AM	Session wrap-up, summary	
9:45 AM	*Break*	
10:00 AM	Scene selection (#1 in Issue Paper)	Rich Damberg
11:45 AM	Session wrap-up, summary	
12:00 PM	*Lunch – bring in*	
1:00 PM	Number and composition of focus group and survey respondents (#7 in Issue Paper)	Robert Mitchell
2:30 PM	Session wrap-up, summary	
2:45 PM	*Break*	
3:00 PM	Method of presenting visibility conditions (#4 in Issue Paper)	John Molenar
5:15 PM	Session wrap-up, summary	
5:30 PM	END	
7:00 PM	Informal dinner (TBA)	
Wednesday, October 8		
8:00 AM	Review of yesterday, finish #4 if necessary	
8:15 AM	Joint Benefit or “Mental Accounts” (#6 in Issue Paper)	Laurie Chestnut
9:30 AM	Session wrap-up, summary	
9:45 AM	*Break*	
10:00 AM	Payment vehicle (#8 in Issue Paper)	Robert Mitchell
11:45 AM	Session wrap-up, summary	
12:00 PM	Workshop review and summary; next steps	Marc Pitchford
1:30 PM	END OF WORKSHOP	

C. Vicki Sandiford PowerPoint Slides on Role of Visibility in Secondary NAAQS

Role of Urban Visibility in Particulate Matter National Ambient Air Quality Standards (PM NAAQS) Reviews

Vicki Sandiford
Ambient Standards Group
Health and Environmental Impacts Division
Office of Air Quality Planning and Standards
U.S. EPA, RTP, NC
October 6, 2008

Overview

- Clean Air Act (CAA): NAAQS program
- Current NAAQS review process
- Current PM NAAQS review schedule
- 1997 & 2006 PM NAAQS reviews
- Genesis of 2008 PM Visibility Workshop
- Ongoing Litigation

Clean Air Act NAAQS Program

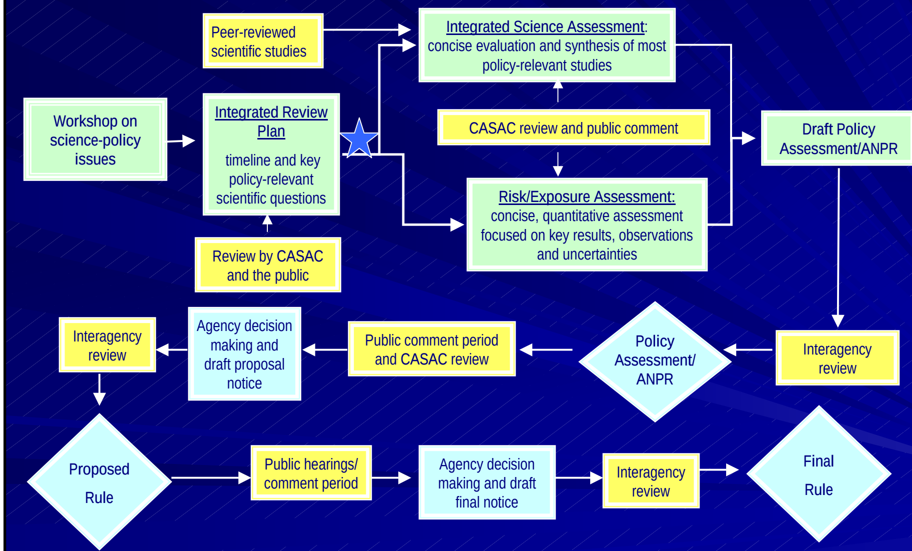
Sections 108/109 direct the Administrator to:

- Publish and if necessary revise a list of ambient air pollutants that threaten public health or welfare
- Issue air quality "criteria" for each pollutant reflecting latest science useful in indicating kind and extent of health/welfare effects
- Periodically review science/standards (5 year intervals) and, if appropriate, revise primary (health) and secondary (welfare) standards
- Establish independent scientific review committee (Clean Air Scientific Advisory Committee - CASAC) to:
  - Review air quality criteria
  - Recommend to the Administrator any new standards and revision of existing criteria and standards as may be appropriate

Clean Air Act NAAQS Program:

- Section 302 (h) public welfare definition:
  - All language referring to effects on welfare includes, but is not limited to, effects on soils,…weather, **visibility**, and climate, …hazards to transportation, as well as effects on economic values and on personal comfort and well-being, whether caused by transformation, conversion, or combination with other air pollutants."

*Current NAAQS Review Process



Current PM NAAQS Review Schedule

(Some dates subject to change)

- PM Secondary Kickoff Workshop – Jul ’07
- Final Integrated Review Plan – Mar ’08
- PM Visibility Workshop – Oct. ‘08
- 1st Draft Integrated Science Assessment – Dec ’08
- Draft Scope and Methods Plan – Feb ’09
- 1st Draft REA – Aug ‘09
- Final ISA – December ‘09
- Final REA – July ’10
- ANPR – August ‘10
- Proposed Rule – January ‘11
- Final Rule – October ‘11

Planning (OAQPS and NCEA)

- Joint sponsorship of "kickoff" workshops
  - Receive early input from experts, including CASAC members
  - Broadly discuss and identify key policy-relevant issues around which we would structure the review and the most meaningful new science available to inform those issues
- Preparation of one ***integrated*** review plan (IRP) to guide the entire review
  - Specifies schedule, process, and key policy-relevant science issues defining this review
  - Includes very general outline of planned assessments
- CASAC consultation/public review of draft IRP

Integrated Science Assessment (ISA) (NCEA)

- ISA Document provides:
  - a concise and peer-reviewed (CASAC/public) evaluation and synthesis of the most policy-relevant science
  - a clear characterization of the strengths and uncertainties of the available scientific evidence
  - additional supporting scientific evidence in accompanying detailed "annexes"
  - the scientific foundation that informs the design and development of the Risk/Exposure Assessment (REA) and the Policy Assessment/ANPR

Risk/Exposure Assessment (REA) (OAQPS)

- REA initiated through preparation of Draft Scope and Methods Planning document
- Draft Scope and Methods Document:
  - considers need for risk and/or an exposure assessment
  - if needed, considers what scope and methods/approaches would provide information most useful for decision-makers
  - developed in parallel with preparation of second draft ISA
- CASAC consultation/public review of draft Scope and Methods Plan
- CASAC/public review of 1st/2nd Draft REAs
- Final REA and ISA inform Policy Assessment

Policy Assessment (PA) (Agency)

- Policy assessment initiated by preparation of draft Advance Notice of Proposed Rulemaking (ANPR)
- Draft ANPR:
  - Presents wide range of policy options being considered by the Agency for standard setting
  - Discusses the underlying interpretation of the scientific evidence and risk/exposure information drawn from the ISA and REA that might support each option
- Inter-Agency review of draft ANPR
- Publish final ANPR
- *CASAC and public review of ANPR

Proposed and Final Rules

- Notice of Proposed Rulemaking (NPR)
  - Published in Federal Register Notice (FR)
  - Public comment period, including public hearings, following publication of NPR
- Final Rulemaking Notice (FRN) in FR
- Response-to-Comments document (RTC)
  - prepared/finalized in parallel with FRN
- NAAQS rulemaking may be accompanied by or combined with rulemaking changes to monitoring and/or implementation regulations

Recent History of NAAQS Visibility Protection

- 1997 PM NAAQS Review:
  - Most data available in non-urban, rural or Class I areas
  - Regional differences in relationship between PM fine and rural visibility impairment limited consideration of separate secondary NAAQS
  - Focus on protection of rural visibility impairment led to secondary standard set in context of upcoming Regional Haze Rule
  - Final decision – make secondary equal to primary
- Post 1997 Developments
  - Increase in urban $PM_{2.5}$ data availability
  - Increase in number of State and local standards and programs to protect VAQ beyond the degree provided by current NAAQS
  - Availability of simulated images and actual photographs to help inform judgments about the acceptability of varying levels of VAQ in urban areas across U.S.

Recent History of NAAQS Visibility Protection (cont.)

- Staff Paper (2005) assessments included:
  - air quality analyses for both urban and rural areas
  - evaluation of standards and programs developed in some areas to address urban visibility
  - evaluation of photographic evidence
  - Pilot Study- Results of small study conducted by EPA in Washington, D.C. consistent with earlier perception studies
- Staff Paper recommendation:
  - A PM2.5 secondary standard with an averaging time from 4 -8 hrs. daylight set within the range of 20-30 mg/m3 should be considered

Recent History of NAAQS Visibility Protection (cont.)

- CASAC Comments and Contributions:
  - Poirot comments key to EPA moving forward with urban risk assessment in 2006 review
  - Clear support for sub-daily standard
  - Continued comment and feedback throughout review

Recent History of NAAQS Visibility Protection (cont.)

- 2006 Proposal:
  - Appropriate to revise 24-hr. $PM_{2.5}$ standard to provide protection from visibility impairment principally in urban areas
  - Indicator – $PM_{2.5}$
  - Averaging times – retain 24 hr. Took comment on a range of averaging times from 4 to 8 daylight hours.
  - Level – Equal to revised primary (35 mg/m3). Took comment on 20-30 mg/m3 of PM2.5 corresponding to a range of median visual ranges between 25-35 km
  - Form –A concentration-based percentile form consistent with the primary of the 92 to 98th percentile, representative of the mean of the distribution of the 20 percent most impaired days

Recent History of NAAQS Visibility Protection (cont.)

- 2006 Final Rule:
  - Need to revise existing secondary to provide additional protection for urban visibility impairment
  - Public perception and attitude surveys provided useful but quite limited information on the range of levels appropriate for a national standard, given the subjective nature of the welfare effect
  - Percent of areas covered by primary similar to secondary
  - Set secondary equal to revised primary

Genesis of Oct. PM Visibility Workshop

- CASAC advice (June 6, 2005 letter)
  - "…developing a more specific (and more protective) level in future standards would require updated and refined public visibility valuation studies. Agency staff are strongly encouraged to support such studies prior to the next round of NAAQS review…."

NAAQS TTN Webpage Set-Up

- **Contact:** Name, email address, and phone number (HEID Overall Coordinator)
- **Documents from Current Review**
  - Planning Documents
  - Integrated Science Assessments
  - Risk and Exposure Assessments
  - Policy Assessments
  - Other Technical Documents
  - CASAC Documents
  - Federal Register Notices
  - Response to Comments Document
  - Regulatory Impact Analysis
  - Litigation
- Documents from Review Completed in xxxx
- Air Quality Index
- Plain Language Information About Pollutant
- Summary of Current NAAQS Table

D. Leland Deck PowerPoint Slides on Framing the Question

What Are The Questions ?

Key questions we want to explore in a project on preferences for urban visibility

Leland Deck
October 6, 2008

What did Phoenix study ask ?

- Report form (not journal article) provides detailed script of material presented to participants
- Warm up ranking questions
  - Familiarize participants with photo, observing differences in VAQ
- Ranking (0-7) of VAQ
  - 25 slides (5 repeats), random order
- Reviewed slides again, rated “acceptable or not”

Details of how questions are phrased matter

- “seeking public input in acceptable visibility quality”
- Base your answers on 3 factors
  - For city area, not a pristine area
  - Unacceptable means unreasonable or objectionable, not merely some haze detected
  - Base answers only on visibility
    - Do not consider health
    - Do not consider cost

STRATUS CONSULTING # 3

More on acceptability questions

- Answer what is acceptable to you
- Time dimension
  - Right now
  - Not if lasting several hours or all day

STRATUS CONSULTING # 4

Third exercise: # of days acceptable

- Used 7 slides (not all 25)
- Asked how many days would this visibility be acceptable
  – Range of answers 0 to 365 days

STRATUS CONSULTING

5

Denver variations

- Asked everything in context of a visibility STANDARD
  – E.g., ‘would this be an acceptable standard’
- Defined acceptable for a standard
  – VAQ is unreasonable, objectionable and unacceptable
- Cost never mentioned, ignore health was

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6

Washington variations

- Background provided
  - VAQ is caused by pollution from various sources, near and distant
- Walk through initial slides
  - Notice colors shift, crispness, distant objects
- “visibility only”, but health or cost NOT mentioned in script
- Acceptable is personal, varies; no definition given

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7

Washington and time

- Provided background on time
  - Sometimes this condition lasts for a few hours
  - Sometimes lasts for a number of days
- For small set of slides (5)
  - Consider this is worst in day
  - How long would this be unacceptable
    - Hours or days are possible responses
- Valuation question implied asking about annual mean

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8

Questions for discussion

- What context to mention?
  - Standard setting or "just your opinion"?
- Ask Yes/No Acceptable question, or 3 way
  - Acceptable
  - Unacceptable
  - Objectionable
- Is numerical ranking exercise useful, done right?
- Something Else? Not yet mentioned ???

Questions for discussion

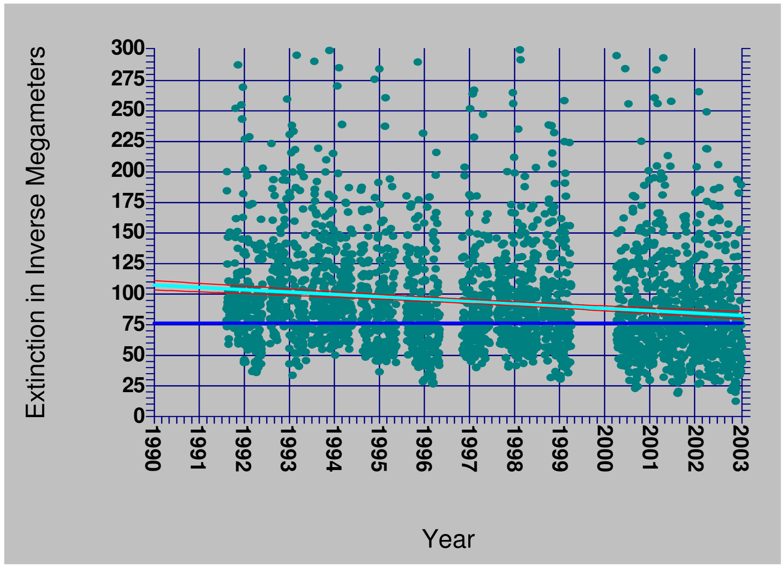
- Provide background on visibility science, photos?
- How important is issue of "visibility only" ?
  - Health and costs?
- What aspects of temporality do we care about ?

E. Dan Ely PowerPoint Slides on Temporal Distribution


Issue 2
Temporal Distribution of Visibility Conditions
Dan Ely
Colorado Dept of Public Health & Environment
Air Pollution Control Division
10/6/08
02/28/2008 09:00


The Temporal Realms of Concern
1. Annual Distribution
– Assume there is an annual distribution of visibility conditions in an urban area that can be described/presented
• What are people's preferences concerning changes in different parts of the distribution?
– More interested in changes in the worse days?
– More interested in increasing the number of good days?
– Thru what mechanism do we determine what is the policy relevant shift?
11/07/2007 09:00

Trend in Daily Max Extinction - Denver



The standard level is represented by the dark blue line.

Temporal Realms of Concern

2. **Seasonal-ish Distributions**
   – **Some potential control strategies combined with natural met conditions will likely influence some seasons more than others**
     • **This will vary by location in the country**
   – **Do people have a preference?**
     • **Seasonal? Winter/Summer? Other periods?**

Temporal Realms of Concern

3. **Natural Visibility Impairment**
   - **Any presentation of a distribution of visibility conditions must deal with natural impairment (?)**
     - e.g., % of time fog, rain, snow, volcanic ash, wildfire smoke, fallout from meteor strike, etc.
   - **How convey natural viz information?**
     - e.g., include RH% on each slide
     - People are often confused by the natural impairment issue
       - "How much of what I'm seeing is natural? Should I consider it somehow? Discount it? Why don't I skip this slide…"
   - **Exclude any slide with obvious snow storm, rain etc and/or above X% RH?**

05/01/2008 10:30

Temporal Issues

4. **Partial day visibility impairment**
   - **Anthropogenic visibility impairment varies throughout daylight hours**
     - Are some times more important than others?
     - Do people's preferences differ for early morning, mid-afternoon, late-in-the-day visibility?
   - **How treat/address heterogeneous visibility conditions in calculating/presenting visibility conditions?**
   - **How many hours of "unacceptable" visibility does it take to count as an exceedance?**

Temporal Issues

5. **Nighttime visibility**
   - **Impairment of surface features at night is potentially of interest**
   - **Do people consider nighttime visibility in their preferences of overall urban visibility?**
   - **Should nighttime viz be excluded from this round of focus group projects?**

F. Bruce Polkowsky Presentation on Regional Distribution

Do people's preferences for urban visibility vary substantially in different regions of the country?

Sight Path

Personal Experiences within the urban area (daily, weekly, seasonally)
Landmarks (natural, man made)

Pollution impacts (episodic, frequent, magnitude)

Education about what is lost
Eastern pollution levels
Attributes of a "clear sky" (clouds, blue color)
Summer Humidity exacerbates but does not cause visibility

Impact on Survey Instrument:
What is the "appropriate" level of education on current visibility conditions?
Is it beneficial to have the survey indicate "best science" on natural visibility

G. Rich Damberg Presentation on Scene Selection

PM NAAQS Review
Urban Visibility Workshop

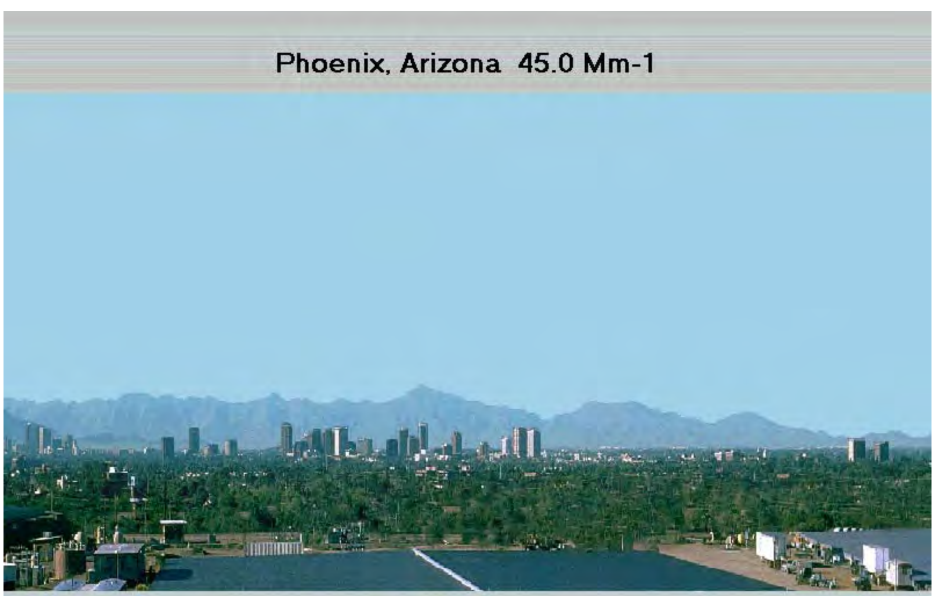
Scene Selection Issues

Rich Damberg
EPA Office of Air Quality Planning and Standards

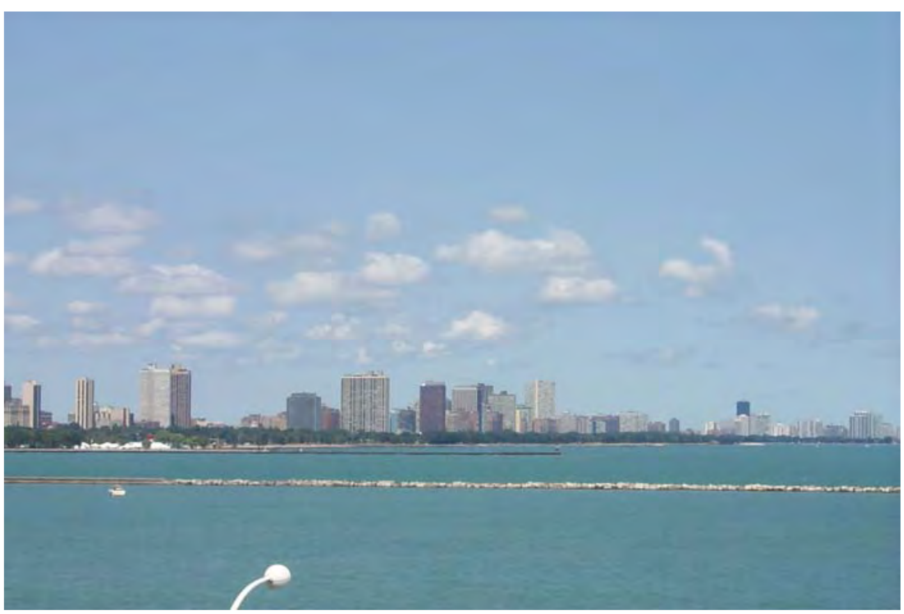
October 7, 2008

Scene Selection Issues

- What type of scene should be used in a focus group or survey study?
  - Scenes specific to each urban area (e.g. St. Louis Arch), or generic urban area scenes?
  - The iconic postcard scene or skyline scene?
  - Scenes that are less dramatic but experienced more frequently (e.g. on ride to work; or walking / driving around town)?
  - Scenes that are associated with positive outdoor experiences (e.g. urban park)?
  - Use multiple scenes per urban area, or a single scene?
  - Should people or cars be present in the scene?
- Select scenes where change in haze appearance is sensitive to PM changes
  - Traditionally, scenes with distant features have been used in western studies.
  - However, this is more challenging for Eastern urban areas, where expansive vistas are not as common. In some cases, sky color and/or cloud appearance may be the most sensitive scenic elements.

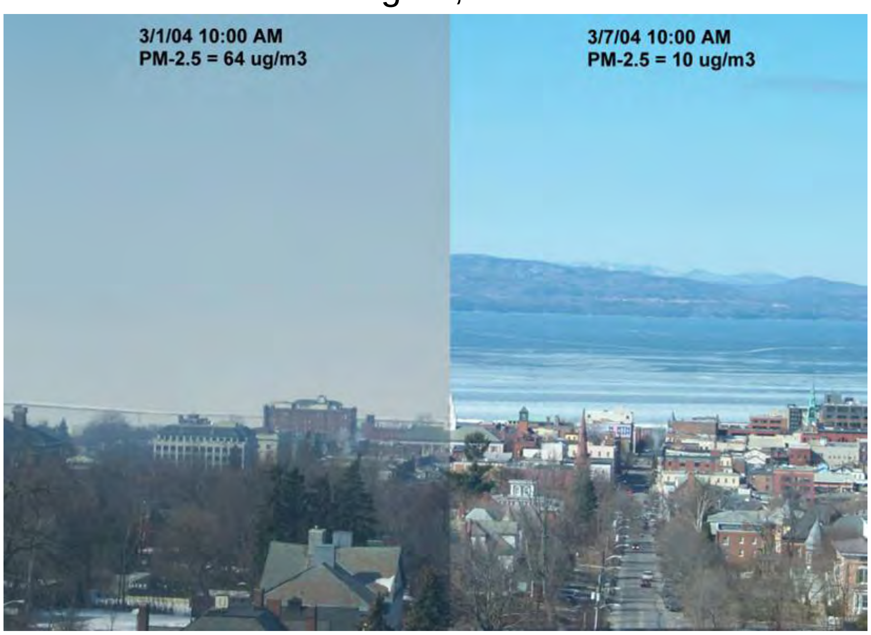

Phoenix, Arizona 45.0 Mm-1

5 ug/m3



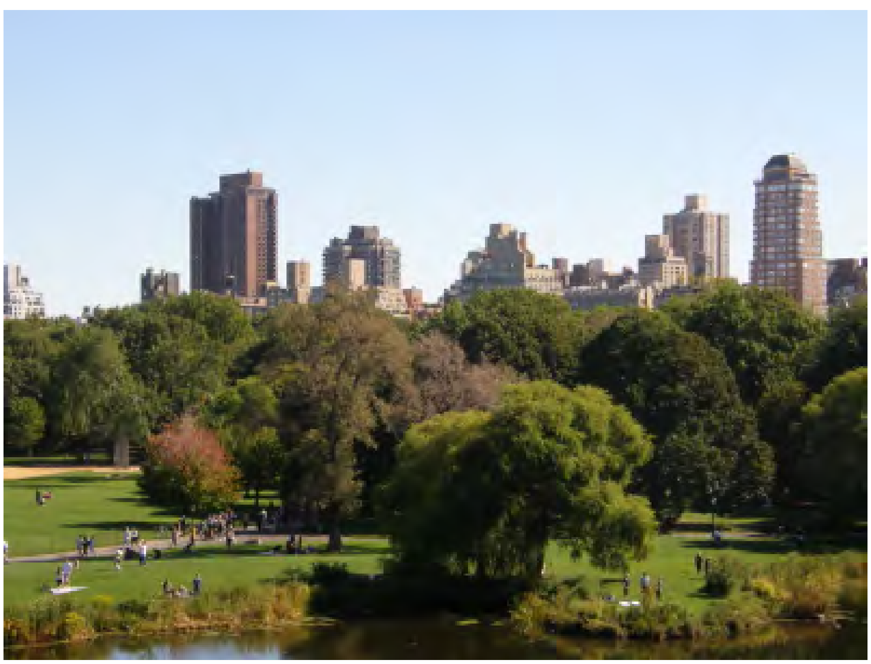
35 ug/m3

Burlington, Vermont




© Tim Knight

Brookfield, WI




BUS

Cranbrook, British Columbia
Commercial strip


SCHOOL

H. John Molenar Presentation on Presenting Visibility Conditions

Use of Visuals in Visibility Surveys

(and some other comments)

John V. Molenar
Air Resource Specialists, Inc.
Ft. Collins, Co.
jmolenar@air-resource.com
10/07/2008

Onsite Observations

- Would mimic the actual visual air quality experience.

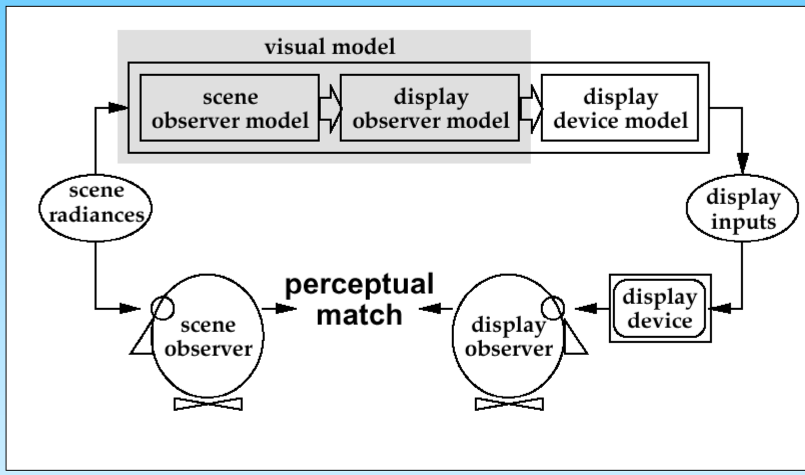
However:

- Uncontrollable visual air quality and/or scenic beauty levels.
- Unless observers are brought to location, limited to respondents who are onsite.

Possibilities Instead of Onsite Observations

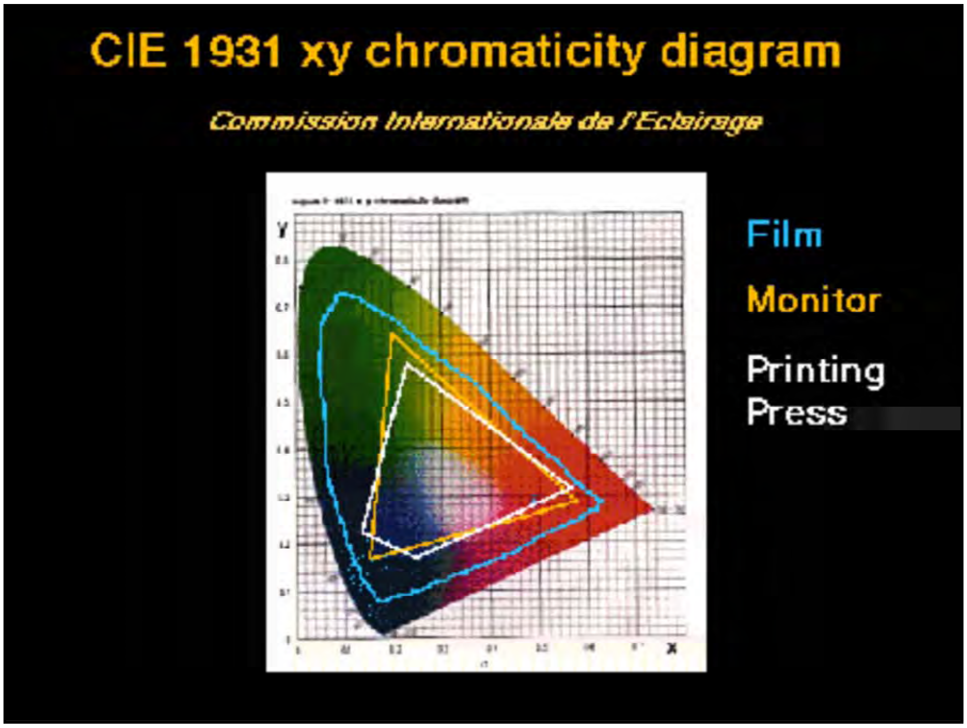
- **Projected 35 mm Slide**
- **Digital Image Projector**
- **Computer Monitor**
- **Reflection Print**
- **Virtual Reality**

Seeing is a psychophysical phenomenon not easily modeled or reproduced by any process that is strictly physical in origin.



Requirements For Match

- Spectral Sensitivities
- Color Gamuts
- Dynamic Range



Color Reproduction

Spectral: **Equality of spectral reflectances or spectral power distributions.**

Colorimetric: **Equality of chromaticities and relative luminances.**

Exact: **Equality of chromaticities and relative and absolute luminances.**

Color Reproduction

Equivalent: **Chromaticities and relative luminances are set such as to ensure equality of appearance.**

Corresponding: **Chromaticities and relative luminances are set such as to ensure equality of appearance when the the original and reproduction luminances are the same.**

Dynamic Range

• Human visual system:	100,000 : 1
• HDR Monitor	50,000 : 1
• LED or Plasma Monitor:	3000 : 1
• Projected slides:	500 : 1
• CRT Monitor:	200 : 1
• Reflection Prints:	
Highest Quality	50 : 1
Newspaper	15 : 1

Transparency Effects

A subjective phenomenon when the observer has the impression that he is looking at a scenic feature through a distinct semi-transparent surface.

Advantages of Projected 35 mm Slides or High Quality Digital Projector

- Best Color Saturation and dynamic range
- Proven (35mm slides) to be valid representations of actual scenes for judgments of perceived scenic beauty, landscape preferences and visual air quality
- Can easily design survey to include preview images, control scenes and multiple visual air quality scenarios

Slide Viewing Distance To Match Onsite Field of View (FOV)

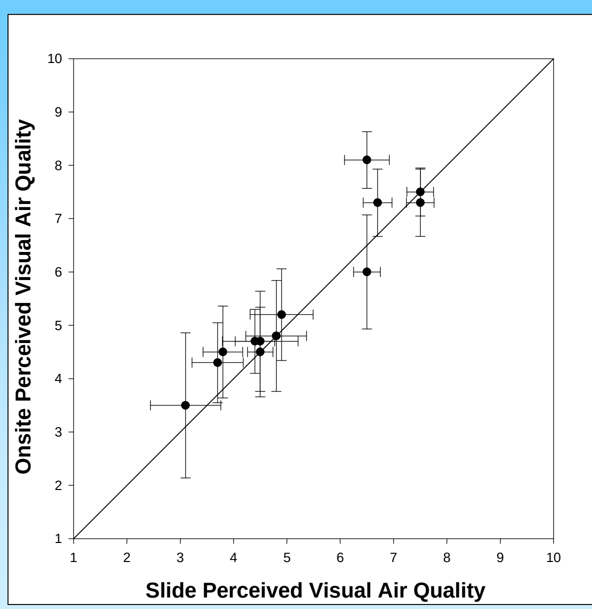
Focal Length of Camera Lens (mm)	Field of View degrees	Viewer distance from screen in feet for Width of Projected Image in Inches					
		36"	48"	60"	72"	84"	96"
28	75	2.3	3.1	3.9	4.7	5.5	6.3
50	47	4.1	5.5	6.9	8.3	9.7	11.0
70	34	5.9	7.9	9.8	11.8	13.7	15.7
105	23	8.8	11.8	14.7	17.7	20.6	23.6
135	18	11.4	15.2	18.9	22.7	26.5	30.3
300	8	25.7	34.3	42.9	51.5	60.1	68.6
500	5	41.2	55.0	68.7	82.5	96.2	109.9

Lengths Photographic Companies Have Gone To !!!

- "The experiment was conducted in a dark environment. The monitor was put on a desk resulting in eye-level viewing for the subjects. The viewing distance was maintained at about 16 inches by fixing the position of the subject's chair … ***(no head-bar was used)*** …"

"Comparison of Color Difference Perception on Soft-Display Versus Hardcopy", King F. Choi, Eastman Kodak Company, Rochester, New York

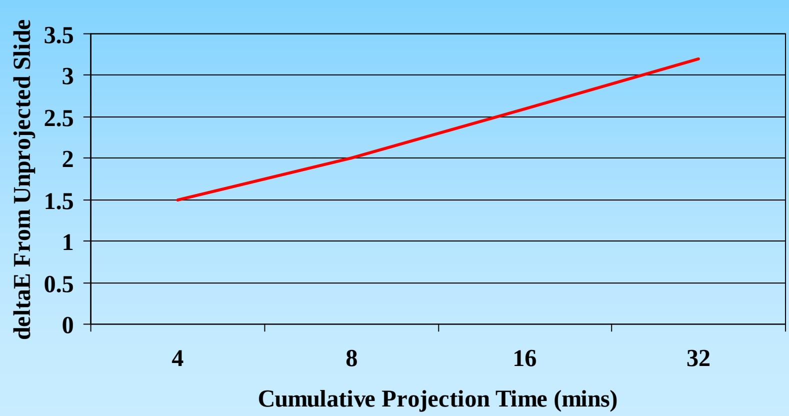
Slides vs. Onsite Judgments



Projected 35 mm Slides Disadvantages

- **Must be viewed in darkened room**
- **Respondents must be brought to central facility**
- **Slides degrade rapidly with projection time**

Degradation of 35 mm slides



Reflection Prints: Advantages

- Easily transportable so can be brought to respondents
- Do not degrade as fast as 35 mm slides
- Have been used in most previous CV studies of visibility benefits

Reflection Prints: Disadvantages

- Limited dynamic range means small changes in visual air quality cannot be presented
- Must use small focal length lens and large print size to mimic onsite field of view
- Difficult to efficiently present multiple visual air quality levels with prints

Reflection Prints: Sizing

The visual angle subtended by objects on a print is determined by the focal length of the lens and the dimensions of the image plane of the camera system used to take the image; that is if the print is created without additional sizing and cropping.

For 35mm slides taken in the IMPROVE monitoring program the image plane is 24 x 36 mm. Two lenses were typically used, a 135mm or a 50mm focal length lens. The horizontal field of view (FOV) in degrees is approximately 40^{O} for the 50mm lens and 15^{O} for 135mm lens. Objects imaged onto the focal plane by the 135mm lens will be approximately 2.7 times larger than when imaged by the 50mm lens.

Reflection Prints: Sizing

Thus, if prints are viewed at the same distance, those made from images taken with a 50mm lens will have to be 2.7 times larger than the prints from the 135mm image for objects to have the same visual dimensions.

If the prints are the same size, the print from a 135mm lens will have to be 2.7 times farther away as the print from a 50mm lens for objects to be the same size.

If one views prints at a distance such that the FOV of the print as viewed by the eye matches the FOV of onsite image as captured by the lens onto the image plane, objects will subtend the same visual angle (appear to be the same size on the print as in the actual scene).

Reflection Prints: Sizing

The basic equation to calculate this distance is

Distance = [Width / 2] / TAN(FOV/2)

Where:

Distance = distance from eye that print must be held

Width = horizontal dimension of print

(in same units as distance)

FOV = Horizontal FOV of camera in degrees

TAN = tangent of angle

Reflection Prints: Sizing

Print Dimensions (inches)		Distance in inches from eye of print to match FOV of 35 mm slide taken with lens	
Height	Width	135mm lens	50 mm lens
4.0	6.0	27.4	9.9
5.3	8.0	36.5	13.2
6.7	10.0	45.6	16.5
8.0	12.0	54.8	19.8
10.7	16.0	73.0	26.4
13.3	20.0	91.3	33.0

Describing Visual Air Quality Is A Complex Issue Depending On:

- characteristics of observer
- optical characteristics of target
- illumination of scene
- optical characteristics of atmosphere

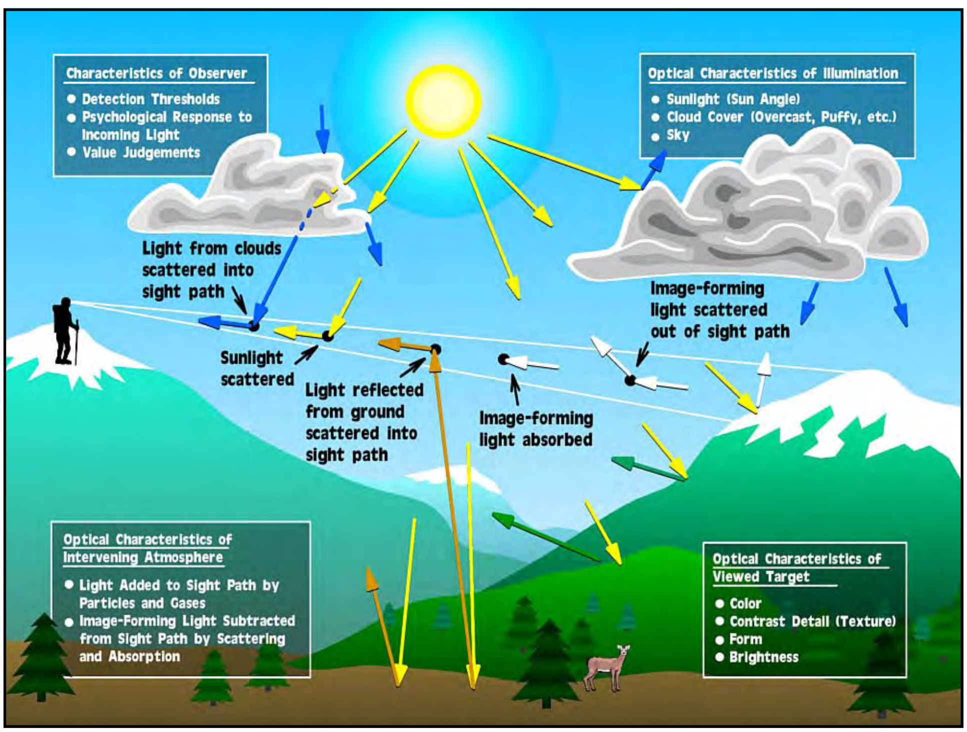
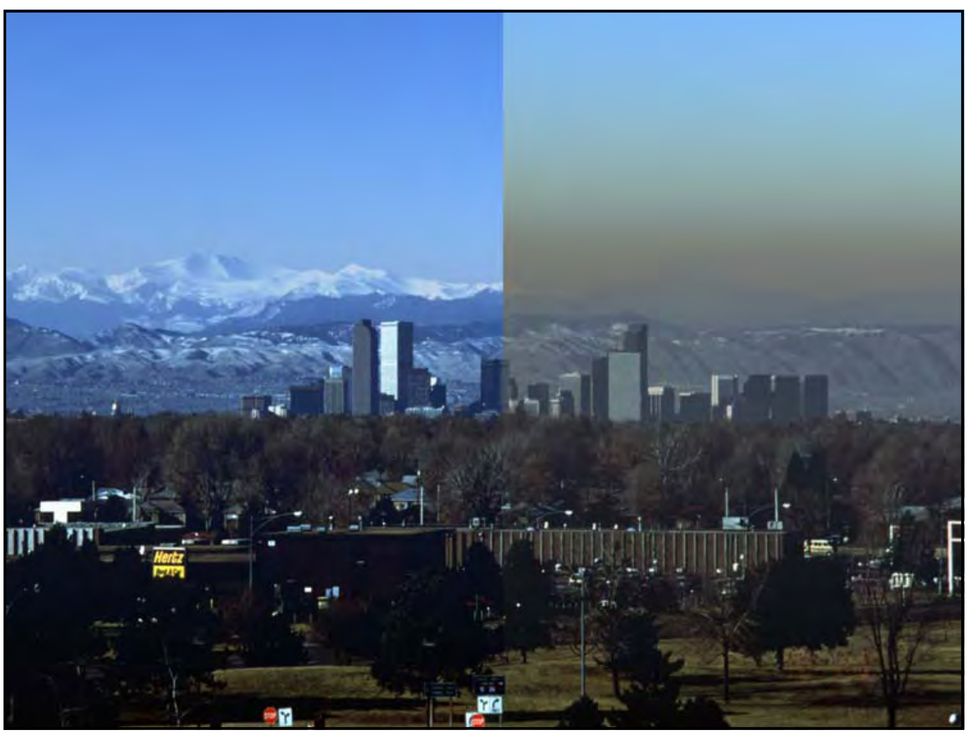
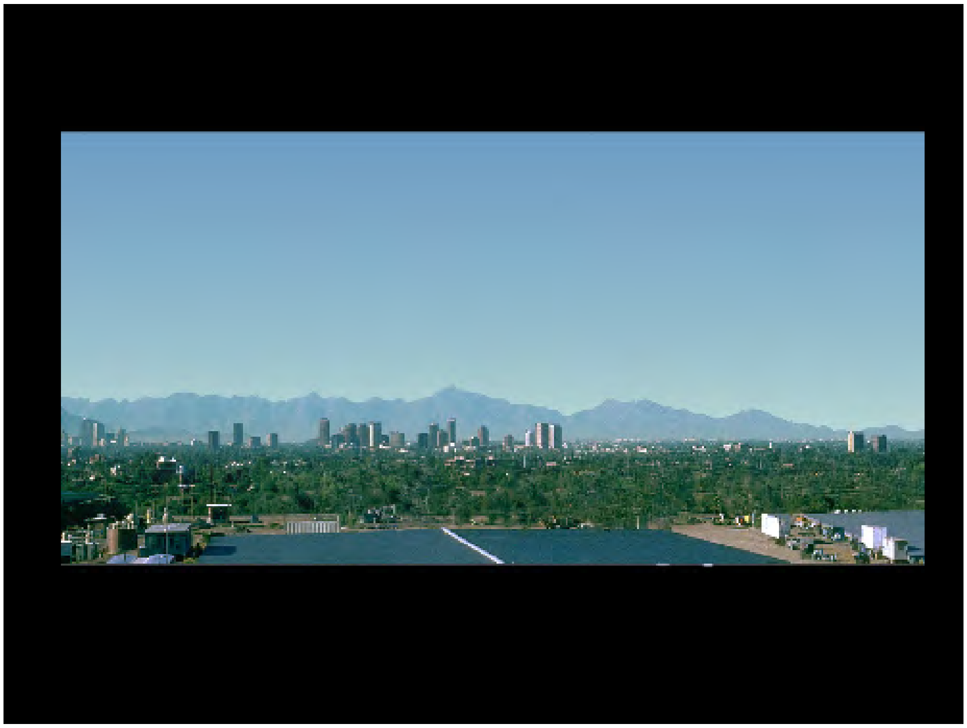


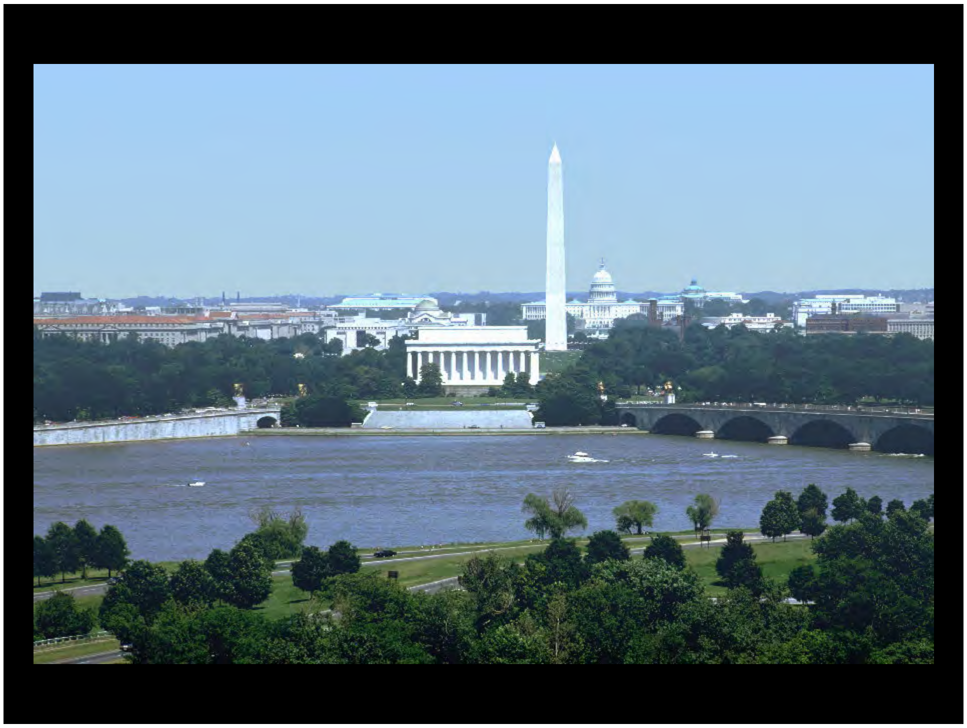
Fig. 3.18 Four photographs showing the effect of a progressively shifting sun angle on the appearance of a vista as seen from Island in the Sky, Canyonlands National Park. In each photograph, the air quality is the same. In (a) (6:00 a.m.) the sun angle-observer-vista geometry results in a large amount of scattered air light (forward scattering) added to the sight path, but minimal amount of imaging light reflected from the vista. (d) (12 noon) shows just the opposite case. Scattered light is minimized and reflected imaging light is at a maximum.

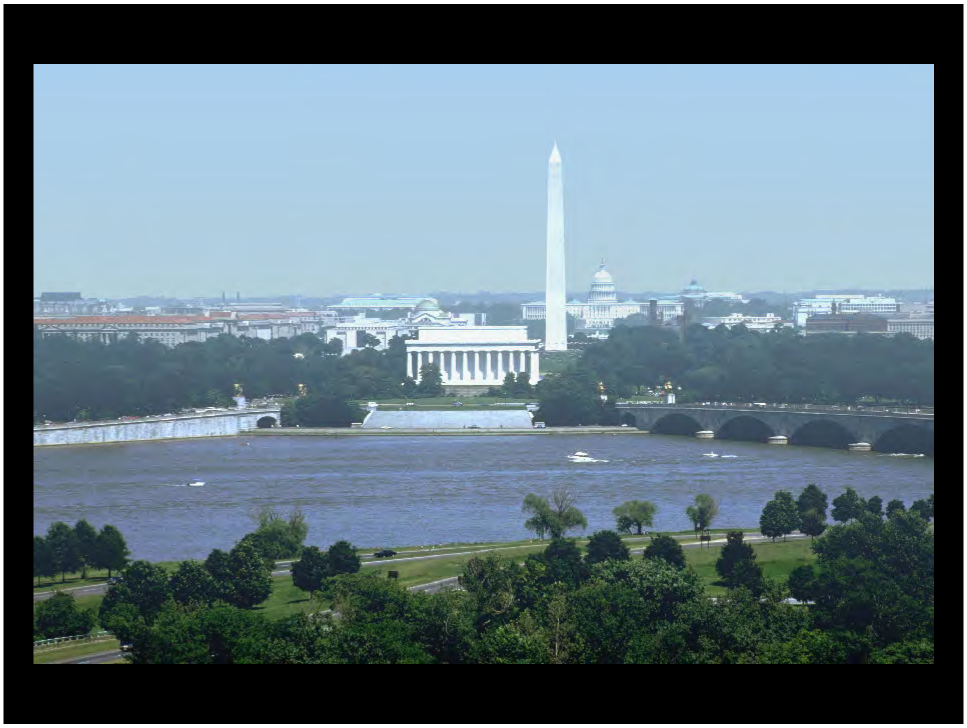

Hertz

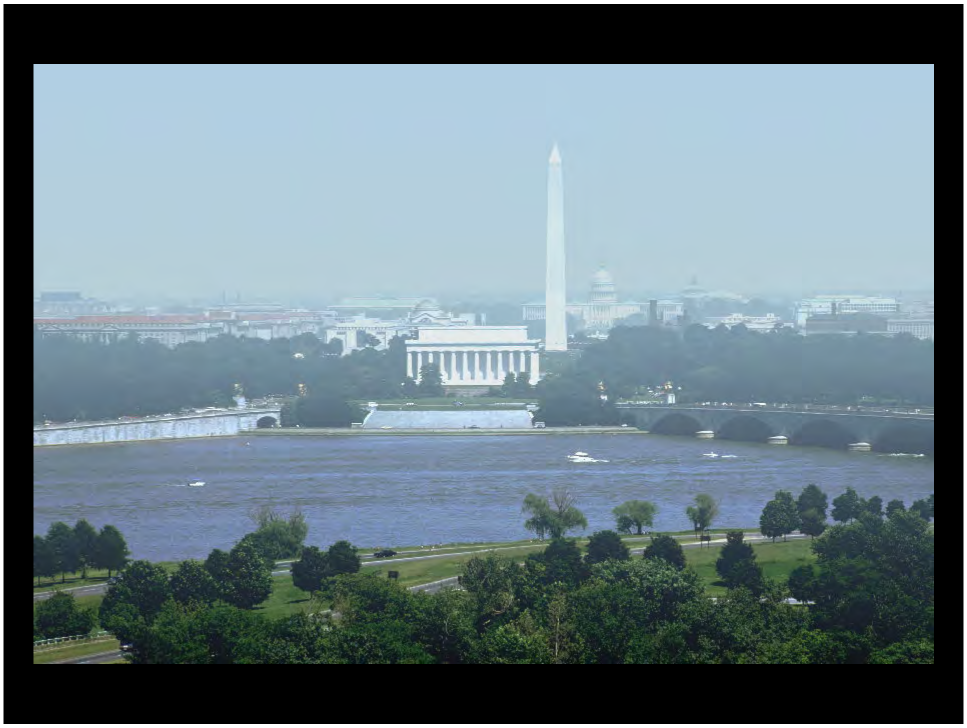

Hertz

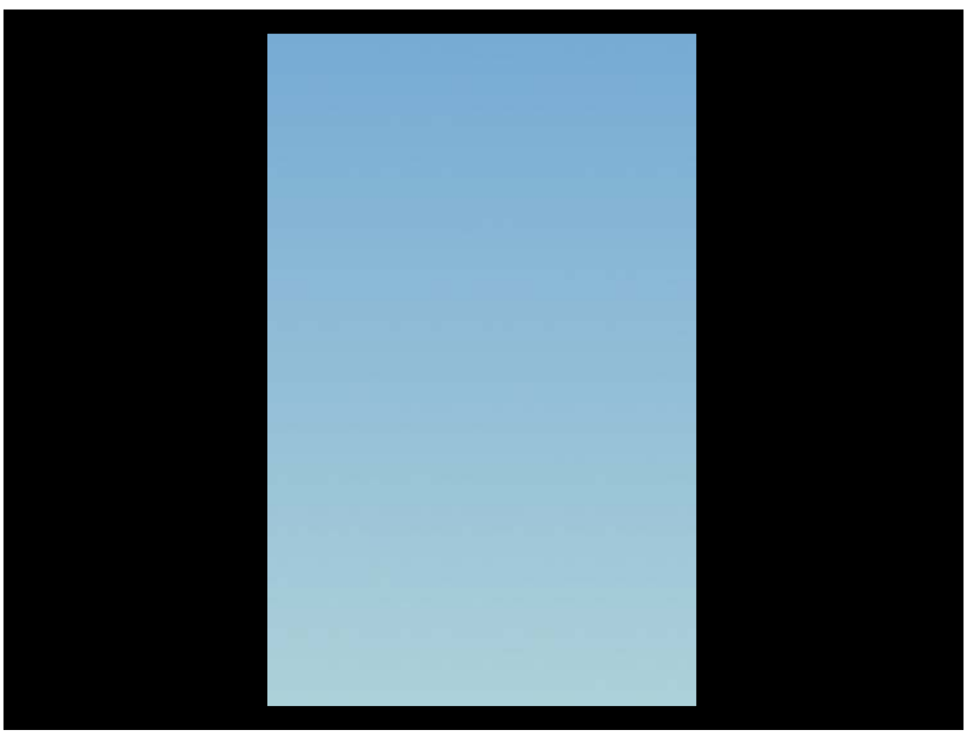
Urban Images

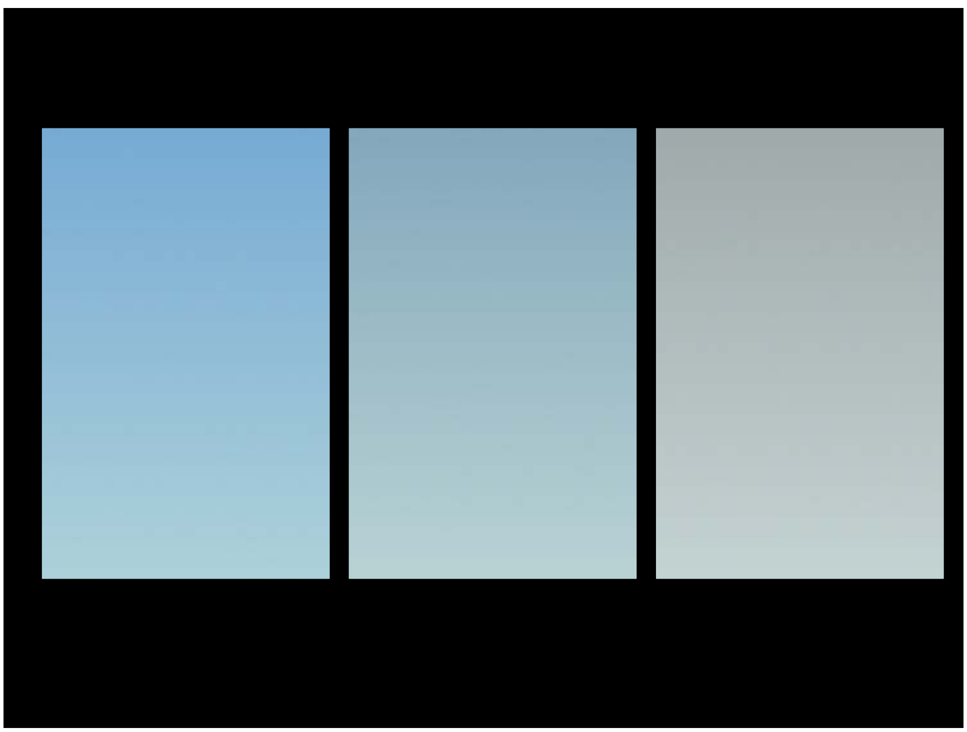


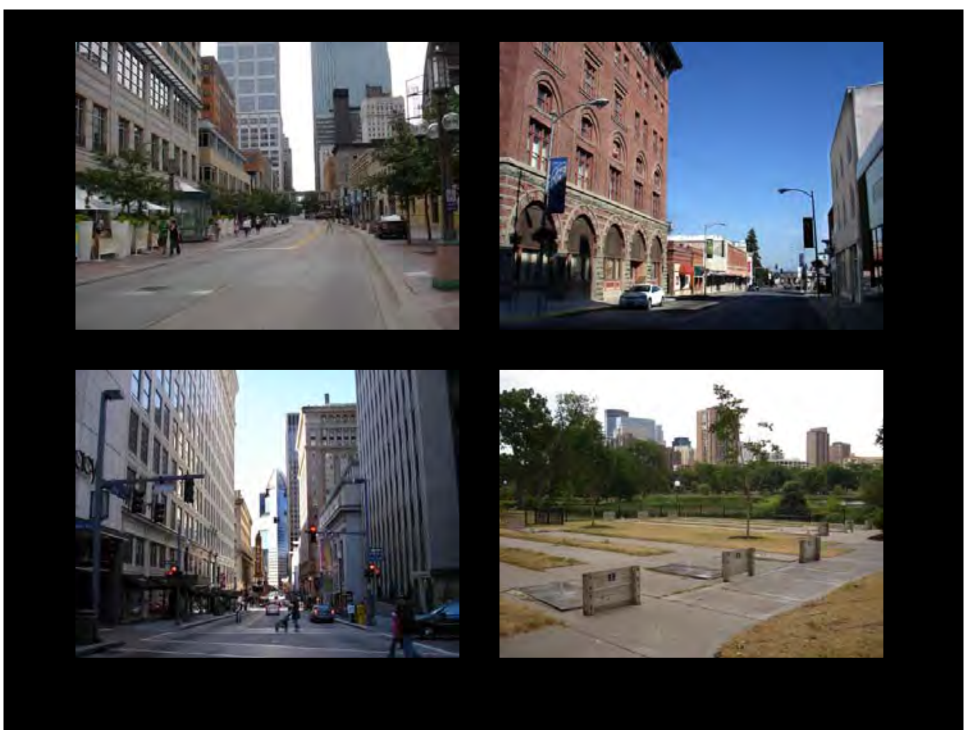


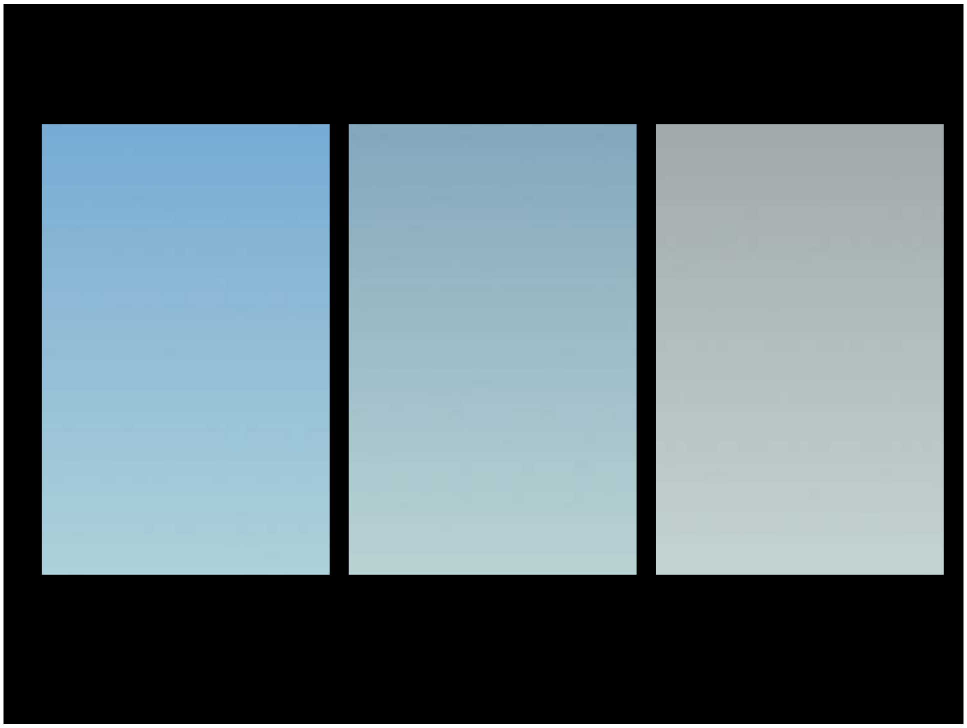


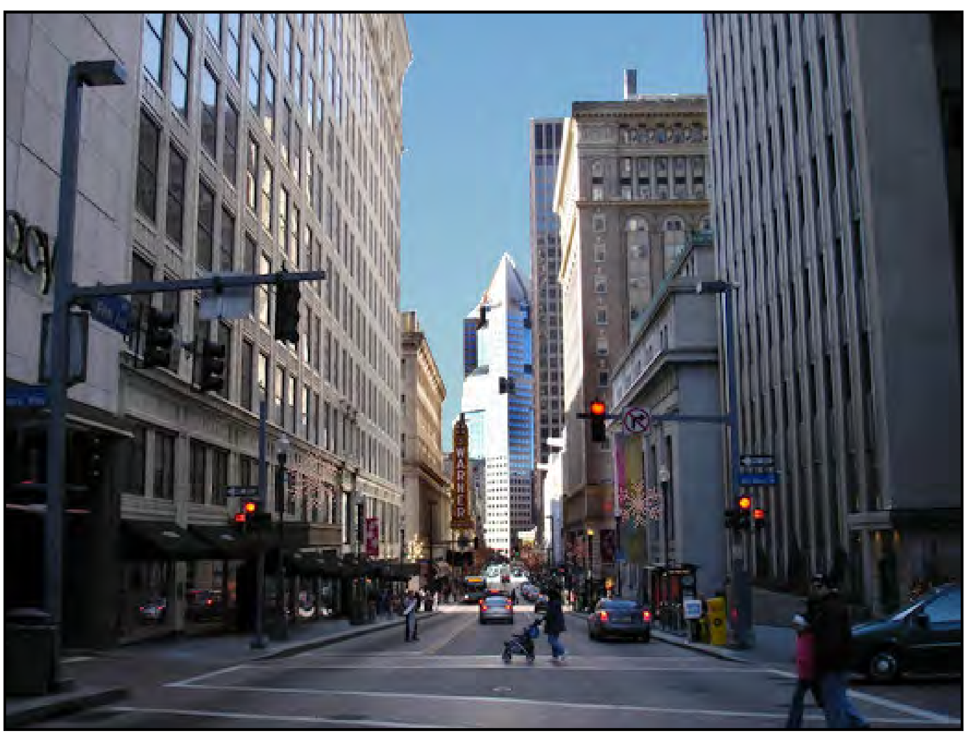











WARNER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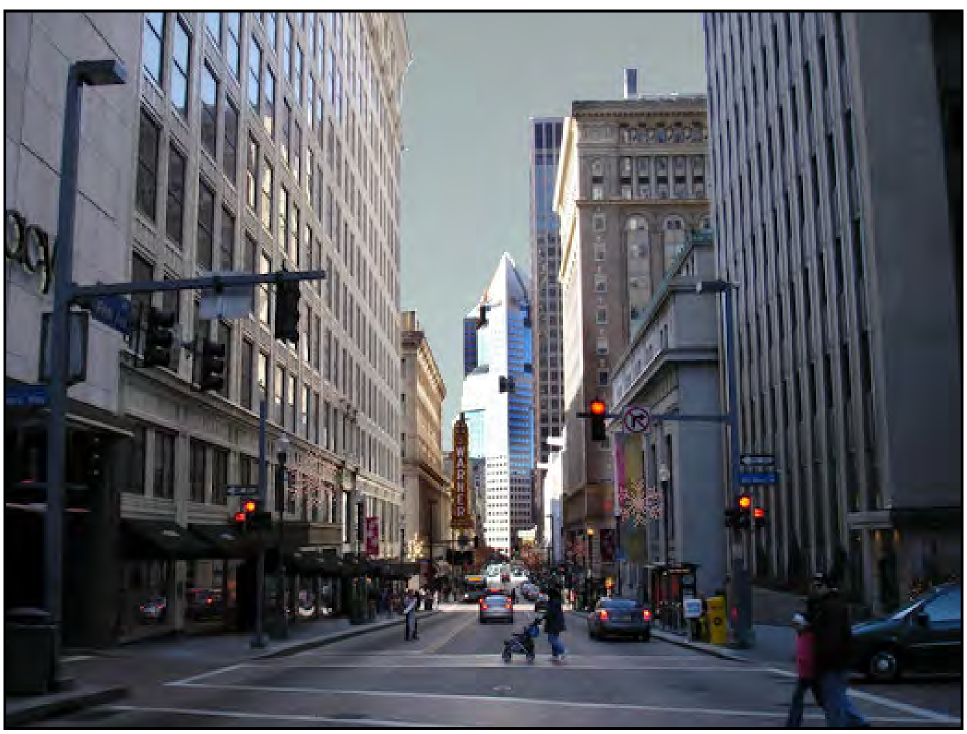

WARNER

Regional Haze Rule metric is based on a geographically non-uniform weighted partially speciated PM_{10}

$$
\begin{aligned}
b_{ext} \approx\ & 2.2 \times f_S(RH) \times [\text{Small Sulfate}] + 4.8 \times f_L(RH) \times [\text{Large Sulfate}] \\
& + 2.4 \times f_S(RH) \times [\text{Small Nitrate}] + 5.1 \times f_L(RH) \times [\text{Large Nitrate}] \\
& + 2.8 \times [\text{Small Organic Mass}] + 6.1 \times [\text{Large Organic Mass}] \\
& + 10 \times [\textit{Elemental Carbon}] \\
& + 1 \times [\textit{Fine Soil}] \\
& + 1.7 \times f_{SS}(RH) \times [\text{Sea Salt}] \\
& + 0.6 \times [\textit{Coarse Mass}] \\
& + \text{Rayleigh Scattering (Site Specific)} \\
& + 0.33 \times [NO_2 (ppb)]
\end{aligned}
$$

So what happens when the metric is collapsed to a single measurement of Fine Mass ???

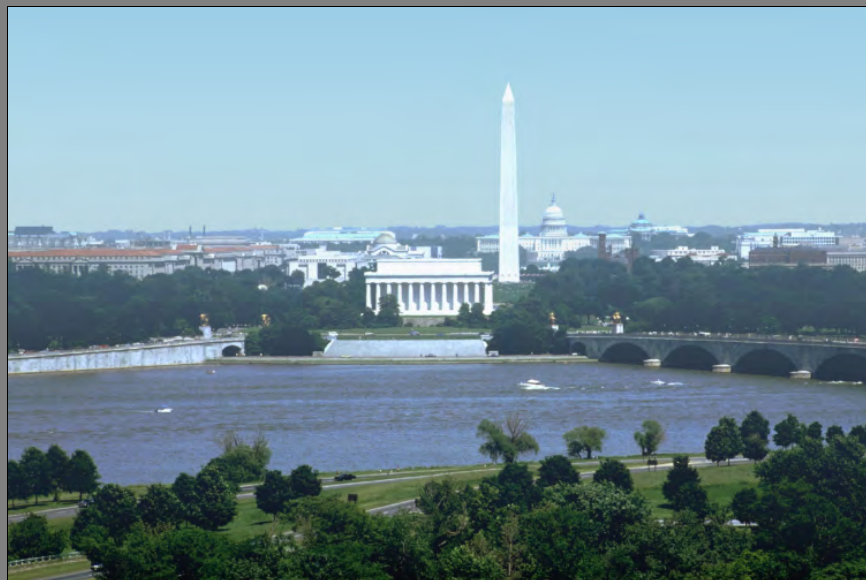
Effects of Various Aerosol Types

	Sulfate Aerosol	Soil Aerosol	Organic Aerosol
Sulfate	6.25	1.0	1.0
Nitrate	1.25	0.5	0.5
Organic	3.15	0.5	8.0
LAC	1.25	0.0	2.0
Soil	0.60	10.0	1.0
Fine Mass	**12.5**	**12.5**	**12.5**
Coarse Mass	3.75	3.75	3.75
50% rh	**65.0 Mm^{-1}**	**27.5 Mm^{-1}**	56.5 Mm^{-1}
80% rh	87.5 Mm^{-1}	33.6 Mm^{-1}	61.2 Mm^{-1}
95% rh	**142.0 Mm^{-1}**	**45.0 Mm^{-1}**	**73.5 Mm^{-1}**

Soil Aerosol at 50% rh: b_{ext} = 27.5 Mm^{-1} dv = 10

Soil Aerosol at 95% rh: b_{ext} = 45.0 Mm^{-1} dv = 15

Sulfate Aerosol at 50% rh: b_{ext} = 65.0 Mm^{-1} dv = 19



Organic Aerosol at 95% rh: b_{ext} = 73.5 Mm^{-1} dv = 20

Sulfate Aerosol at 95% rh: b_{ext} = 142.0 Mm^{-1} dv = 27

I. Laurie Chestnut Presentation on the Joint Benefits

Joint Benefits / Mental Accounts

- Defining the good: what you are trying to measure?
- What level of visibility impairment begins to cause an adverse welfare effect? At what level is enjoyment of daily activities reduced?
- Basic issue: Are people considering more than you want them to when answering the preference questions? Are answers biased?
- Focus groups to figure out what words/context are best to describe measure for general public?

Strength of preference measure

- Binary: zero/one Is this good or bad?
- Scale: 3 to 7 levels How good or bad?
- Willingness to pay: tradeoffs between personal cost and air quality improvement
  - requires a specified "mechanism" by which change is implemented
- Need to allow people to say they are not affected by visibility conditions

Examples of associations people may make that can bias preference responses

- That haze is natural humidity, therefore it is acceptable because it is natural.
- That smog must be bad to breathe, so it is unacceptable.
- If something is unacceptable, then something should be done to change it and that will cost money, so I'll say some level of pollution is acceptable.
- The oil companies make so much money, I shouldn't have to pay for cleaner fuel.

Results from previous urban visibility valuation studies

- Need a payment mechanism--adds complications
- Telling people to think only about visibility was not sufficient to eliminate health concern bias.
- Approaches to disentangle
  - varying combinations of visibility and health risk (conjoint)
  - ask total value with follow-up to partition
- Visibility about 20-40% of total value for air pollution change

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Questions to assess/explore nondollar preference measurement

- Open-ended questions about how it affects you when seeing different visual air quality in day-to-day activities.
- Reactions to different preference wording: acceptable, bothersome, enjoyable.
- Can I convince you to focus on only visibility?
- How much do you need to know about natural variations versus anthropogenic pollution?
- How much are they thinking about policy or control measures when giving preferences?
- Frequency versus level—need to ask these jointly?

Debrief questions for consistency/validity evaluation

- Repeat some images to check consistency of ratings.
- Multiple choice of what influenced responses
- Agreement/disagreement with various statements
- Would you change your answer if….?

Feasibility of adding economic valuation

- Low marginal cost for additional useful information
- Several bits of information needed to set the dollar valuation context:
  - Payment mechanism
  - Alternative reduction levels
- Probably have to look at total value of change in air quality to disentangle health concerns
- Need to be careful about fatigue factor of lengthening questionnaire, but can explore in focus groups

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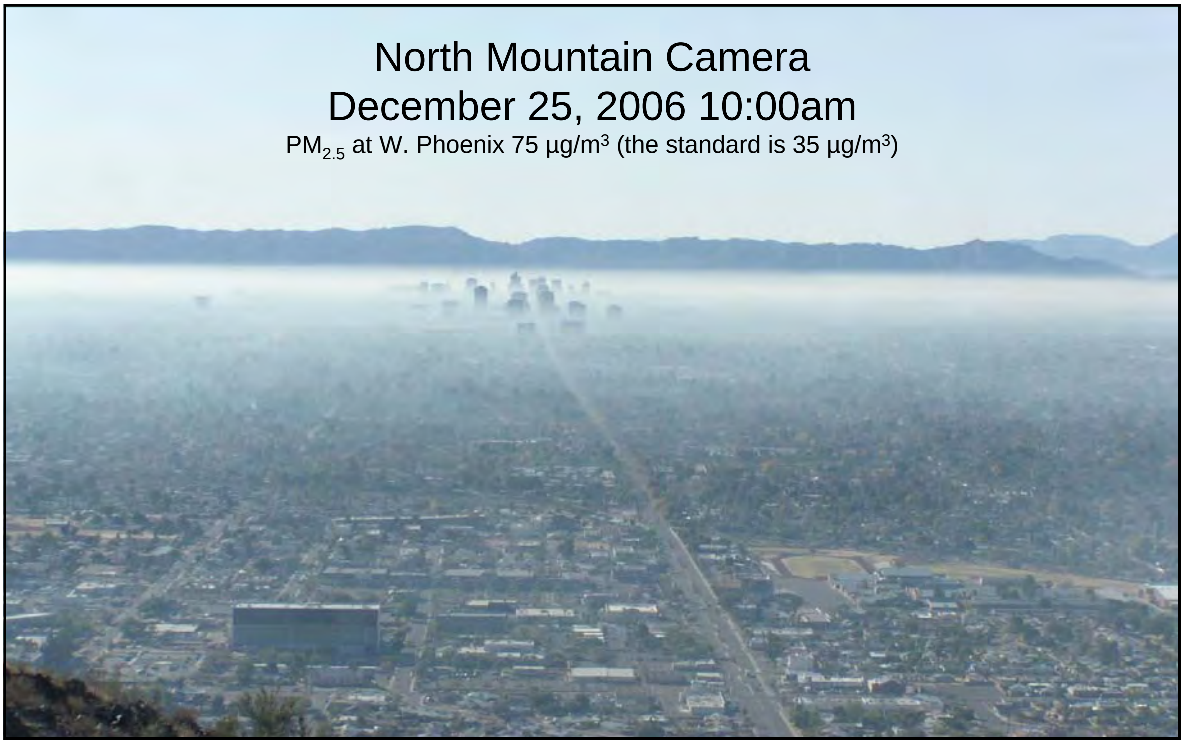
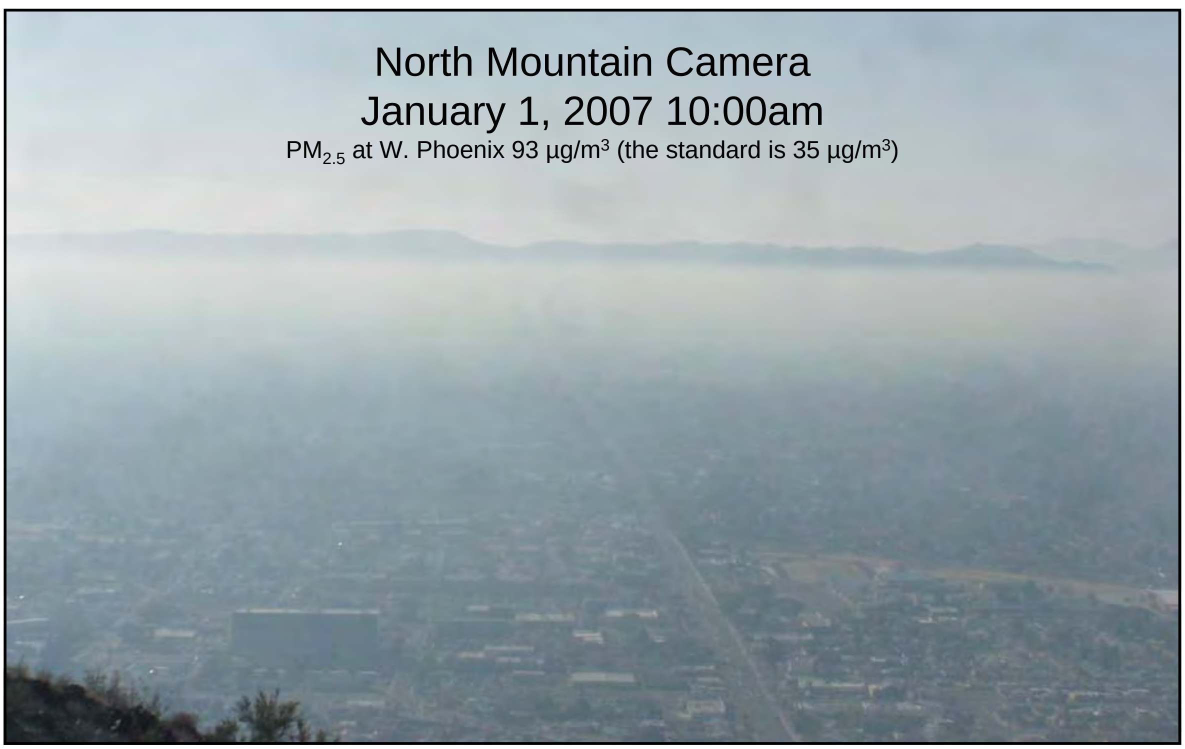
J. Tom Moore PowerPoint Slides on Phoenix Visibility Conditions


North Mountain Camera
December 25, 2006 10:00am
$PM_{2.5}$ at W. Phoenix 75 µg/m^3 (the standard is 35 µg/m^3)


North Mountain Camera
January 1, 2007 10:00am
$PM_{2.5}$ at W. Phoenix 93 µg/m^3 (the standard is 35 µg/m^3)

K. Urban Visibility Issues

Background Issues Relevant to Investigating Urban Visibility Preference and Valuation

EPA wishes to develop additional information that could be used to inform a decision as to whether a secondary standard for PM might be justified based on achieving an acceptable level of visibility in urban areas. There is some information from a few existing focus group and survey studies on urban visibility (Denver and Phoenix) that found encouragingly similar levels of acceptable visibility impairment. An additional smaller EPA focus group project provided information about urban visibility preferences in Washington, DC. Critical questions remain whether these findings are robust, and whether these initial findings are valid in all regions of the country.

Additional data collection and investigations concerning what individuals find to be acceptable urban visibility levels in other regions of the country will help to better understand individuals' preferences about urban visibility. Measuring preferences for urban visibility in terms of economic value is also an important component in understanding visibility preferences and supporting EPA programs affecting visibility. Thus, EPA is sponsoring an expert workshop designed to explore or evaluate potential focus groups and survey projects that could produce useful information for consideration in the review of an appropriate secondary PM standard (e.g., information to support consideration of a secondary standard indicator, averaging time, level and form). The potential projects could lead to a better characterization of the economic value of public welfare visibility benefits across a range of alternative secondary PM standard options that potentially achieve acceptable urban visibility.

Potential urban visibility projects could involve multiple project elements, which could have different objectives and use different methods. There are at least three different types of project components that could be a part of the overall project, and other substantially different types of project elements could also be important components of the project. While different terminology is sometimes used to describe each type of components, in this paper the terms used for the three identified types of potential components are:

- *Investigative focus groups*, which are used to explore questions such as the issues discussed later in this paper. Alternative materials depicting urban visibility, and alternative approaches to eliciting individuals preferences and valuations are used in different focus groups to gain an understanding of the effective structure, format and content for conducting a focus group on urban visibility.

- *Applied focus groups*, which use one established set of materials and questions in each of a series of focus groups. These focus groups would not only allow for larger numbers of participants to be involved, but could also be conducted in different locations to investigate differences between responses of people who live in different areas. The Denver and Phoenix urban visibility studies conducted applied focus groups, conducting 17 and 27 focus group sessions, respectively.

- *Survey Methods*, which strive to reach a statistically representative sample of the population. This can include a nationwide survey (infeasible for a focus group approach), or a significantly larger number of participants within a single metropolitan area than is possible using focus groups. Valuation research projects have tended to use survey methods (although there are alternatives recently developed). An ongoing National Park Service study of visibility valuation in National Parks (as well as previous studies of National Park visibility), and EPA's 1990 and 1991 studies of urban visibility valuation in Denver, Atlanta and Chicago, used survey methods.

The specific goals of EPA's upcoming urban visibility expert workshop are:

- Reach consensus (if possible) on what are the key questions for a set of "next step" urban visibility projects to expand the current state of knowledge about urban visibility. Identify any of the key methods questions which cannot be adequately resolved *a priori* and incorporated into an applied focus group project, but which will require investigation as an integral part of investigative focus group activities.

- Design a project (or a sequential set of projects) using investigative and/or applied focus groups that will expand the existing knowledge base about individuals preferences for urban visibility, with particular emphasis on what level of urban visibility impairment is considered "acceptable".

- Develop a portion of the investigative and applied focus group activities that can best support development of a follow-on survey project focusing on valuation (willingness to pay) for improving urban visibility.

This issues paper introduces eight key issues that are relevant for further investigations in urban visibility preferences and valuation. The identified issues can be used to help organize the topics that will be discussed in the urban visibility workshop. While all of these issues are relevant for designing and conducting a full scale urban visibility project including a survey-based component, each issue identified here would not necessarily become an explicit topic of discussion during the workshop. There are likely to be additional issues raised by the workshop participants that will need to be considered in developing a focus group or survey project.

The issues included here are directly relevant for projects investigating urban visibility preferences, as well as those additional issues relevant for valuation purposes. Though the issues relevant for a preference-related investigation are also directly relevant (and in fact required) for any valuation project, the opposite is not necessarily the case; some of the valuation-related issues are not relevant or essential for a study limited to preferences.

This document briefly describes each of the eight key issues, and in a few cases introduces associated contextual issues that may be relevant. It is not intended as an extended discussion of any one issue.

In this background paper the term "urban visibility" refers to visibility conditions across an entire metropolitan area. This includes downtowns, central city residential areas, suburban areas, local parks and recreational areas, etc. The primary distinction is that "urban visibility" is not meant to include;

- visibility in Class I areas (including both "destination" iconic National Parks and Wilderness Areas as well as Class I areas and similar locations likely to be of interest primarily to regional residents),

- visibility in such land uses as agriculture and forests, small towns, remote lakes and rivers, beaches, etc., or

- night sky visibility (i.e., viewing of stars, planets, and similar features). It is an open question whether viewing of ground level features at night, such as observing the expanse of a city at night from popular elevated locations, seeing "the city lights" such as in Los Vegas and on Broadway, nighttime sporting events, etc. should be included as part of the description of urban visibility

Issue # 1: Scene Selection

Key Question: What urban scenes, and how many scenes, should be used in a focus group or survey study?

Background Discussion:

There are a wide variety of settings (or scenes) where a person may observe visibility in an urban area. One specific question is in what type of urban scenes are visibility conditions important to people? A practical related question for designing a project is what scenes, and how many scenes, are needed to give the participants an adequate understanding of visibility conditions in their metropolitan area.

There is a very broad range of possible scenes in a metropolitan area where visibility may be important. The range of scenes may include:

- *Iconic "picture postcard" scenes* of a famous city scene that includes a long sight distance, such as a photo including downtown Manhattan, the Seattle Space Needle with Mt. Rainier in the background, or the St. Louis Arch with the Mississippi River. Virtually every city will have some scene that local residents describe as a classic place to "enjoy the view" of the city.

- *Highway photos*, such as from an interstate-type expressway through the heart of a city. These scenes, while not necessarily beautiful settings in and of themselves, may make up a substantial portion of a routine "viewing opportunity" of urban visibility conditions for many people on a daily basis. Highway settings provide some of the longest sight distances within an urban setting that people routinely experience.

- *Downtown city streets;* the "urban canyons" type of photo with long sight distances (down the middle of the street), short sight distances of nearby buildings, and with increasing amounts of sky appearing in the middle and far distances. These are a very urbanized setting, including city street traffic, pedestrians, commercial buildings, etc.

- *Urban park scenes*; the green grass, big trees, open areas with sport fields is an iconic American scene which connotes outdoor recreation and leisure to many. Unlike some of the other urban scenes, parks have a familiar look to them throughout the country. Also when people are in parks they have an opportunity to spend more time viewing the sky, clouds and other available long-distant views than possible in most other urban scenes.

- *Suburban major commercial streets*, while similar to downtown "urban canyons" with traffic and commercial activity, typically have with lower buildings and often much wider streets and more open sky. Like the major highway scene, this type of scene can make up an important portion of daily "viewing opportunities" for local residents.

- *Residential streets*, which may have rather limited sight distances. In the eastern portion of the country where deciduous trees line residential streets there may be relatively little sky exposure due to the tree canopy and limited sight distances. Many western residential streets have very different attributes, with longer vistas and more sky exposure. Apartments and similar high density housing are residential settings that can be substantially different than detached, single family housing, creating a different type of visibility situations.

In selecting among scene types, it is important to make sure at least some scenes include elements that are sensitive to changes in visibility impairment. Traditionally that included distant terrain features. Large man-made structures such as city skylines and bridges viewed from a distance are also sensitive to air quality changes. For scenes that don't include such distant visible features (i.e., they either don't exist or are blocked by mid-ground features), sky color and the clarity of viewing clouds may well be the most sensitive scenic element to perceptible changes in visibility impairment. Specific questions include;

- How much of a role do specific details within a scene play in presenting the visibility conditions? For example, when asking questions about their visibility preferences, do the responses differ if the park scene is deserted, shows children playing, or includes a homeless man on the park bench?

- What role do preferences for a clear blue sky have in overall urban visibility preferences? An unresolved issue is whether preferences for visibility quality differ between days with clear skies (with or without isolated clouds) and overcast days with the identical surface level visibility degradation conditions. In general, the question is how much is the preference for good visibility tied to the preference for blue sky conditions, compared with the ability to see surface level features clearly? A related question is what role nighttime visibility impairment of surface level features (i.e., haze degrading views of the skyline and other urban scenes at night) has in urban visibility preferences.

- Another group of scene selection topics pertain to how site specific the presented photographs need to be. For example, while it is likely a "picture postcard" scene would be immediately recognizable to most people (whether it is from their city or not); other potential scenes may not vary so much between cities. For example, a residential street scene photograph from the Midwest may not be recognized as from another location and may be satisfactory for use in many Eastern cities, but that Midwestern residential photograph may not be appropriate for use in Southwestern cities which have very different styles of architecture and vegetation. In contrast, the appearance of urban park scenes, with grass, trees and sport fields may be more universal across various regions. Thus, the questions that must be addressed with respect to implementing an urban visibility study include: Must a unique set of photos be developed for each location in which a study is conducted or could at least some common urban scene photographs (e.g., parks) be successfully used in multiple locations? Would using non-local photographs influence a respondent's answers in a meaningful way? If a respondent is able to understand that a set photograph is meant to represent conditions in their city, does it matter that some or all the photographs actually are from another city?

- In addition to these basic questions about scene selection, other fundamental visibility attributes which are important underlie some of the scene selection questions. For example, do preferences concerning brown colored visibility impairment differ from white visibility impairment (haze viewed toward the sun tends to be white, while the same haze viewed away from the sun tends to be darker)? Are preferences for urban layered or bounded haze (such as the Denver and Phoenix brown clouds) different than preferences for more regionally homogeneous impairment? Are preferences affected by how well you can see at short distances (e.g., under one mile), or is it only longer sight distances that matter?

Issue # 2: Temporal distribution of urban visibility conditions

Key Question: What information about the seasonal or daily distribution of visibility conditions should be used in a focus group or survey study?

Background Discussion:

There are a number of different topics associated with temporal (time related) distribution. These topics deal jointly with "what do people care about" and also "what would a study have to present." Potential time periods of concern are:

- *Annual distribution*: Any realistic policy influencing urban visibility will shift the entire annual distribution, with the largest changes most likely near the upper end of the distribution that describes the worse days. Further investigation is needed about what people's preferences are concerning changes in different portions of the overall annual temporal visibility distribution. Are people most interested in the improvements on bad days? Increases in the number of good days? A design question is what mechanisms can be used, either in a focus group or a survey instrument, to convey what a policy-relevant shift in annual distribution will be. While presenting multiple scenes with multiple visibility conditions is feasible (with hard copy photos at least), a remaining question is how many different combinations of scenes and photographs can a viewer understand and interpret simultaneously (e.g., 5 scenes and 5 photographs).

- *Seasonal distribution*: In Class I visibility research there is concern that the high visitation, summer season may be more important (i.e., people may have stronger preferences for good visibility) than the rest of the year. Certain policies, combined with natural meteorological conditions, will likely influence some seasons more than others. This will vary by location in the country. What are people's preferences for the seasonal distributional change in visibility? Are the preferences equal for all seasons or months, or are certain intra-annual periods more important?

- *Natural visibility impairment***:** A project design question is should any presentation of a visibility distribution include information about naturally occurring reduced visibility days due to rain, natural fog, night time, etc. The amount of time that there is naturally occurring reduced visibility changes throughout the year and varies in different locations. A specific question involves how information about natural visibility obstruction should be conveyed. For example, would a spoken or written description be enough, or do distribution diagrams or photos need to include this information?

- *Partial day visibility impairment***:** A given level of anthropogenic visibility impairment may occur during a portion of the daylight hours, but a very different impairment occurs at other times (due to storms, weather patterns changing, changing light angles, etc.). Are some times of the day more important to people than other times? Do people's preferences differ for early morning visibility, mid-afternoon visibility, or later in the day visibility? How do you treat heterogeneous visibility conditions (in both the day and night) in calculating and presenting the annual or seasonal visibility conditions?

- *Nighttime visibility***:** Visibility impairment of surface features at night is potentially also of interest. Like daytime visibility, particulate matter pollution at night impairs people's ability to see roads, buildings, illuminated areas, city skylines and "city lights", etc. Manmade illumination plays an important role in nighttime visibility impairment, as particles both deflect light (softening the light into a halo like event) and decrease the amount of light transmitted from the source to a scene. Nighttime visibility conditions are frequently different from daytime conditions, due to decreased temperatures, higher relative humidity, changing wind patterns, etc. Do people consider nighttime visibility important in their preferences of overall urban visibility? Should nighttime visibility be excluded from this round of focus group projects (and postponed for future projects)? How do a heterogeneous day in calculating and presenting annual or seasonal visibility conditions?

Issue # 3: Framing the questions about preferences

Key Question: Is the key preference question to find more information about some version of the question "At what level of visibility impairment does it become unacceptable to you?"

Background Discussion:

In the previous three focus group studies, a key question on preferences came down to asking what level of visibility impairment do you find unacceptable. For example, the Phoenix study used the following language;

> In this exercise we are seeking public input on acceptable visibility levels for the greater Phoenix area. Part II involves looking at the slides again and deciding whether a particular view has an acceptable level of visibility for an urban area.
> Please base your decision on the following:
>
> - Consider that this is a view in a city. In other words, please take into account that you are judging the visibility in an urban area, and not a pristine desert area, where standards might be stricter.
> - Consider "unacceptable" as visual air quality that is unreasonable or objectionable visibility. Please do not mark a slide "unacceptable" just because you can see some haze, unless you believe that any amount of haze is more than you would tolerate.
> - The acceptable visibility levels should be based solely on visibility. Do not try to guess what might be the health effects of haze or how much it might cost to have better visibility. Your decision should be based on how the air looks—this is about visibility only.
>
> Please indicate in the spaces provided whether the visibility in a given slide is acceptable to you.

The Washington and Denver focus group studies used variations on the same questions. Is the question of unacceptable the most important concept in preferences to expand our knowledge of urban visibility for use in setting a secondary NAAQS? Is there alternative language, or entirely different concept about preferences, that would also be important to investigate?

Issue # 4: Method of presenting visibility conditions

Key Question: How can photographs showing different visibility conditions be presented in a focus group or in survey?

Background Discussion:

The use of photographs is essential in virtually any study about perception and preferences for visibility. Photographs are especially critical for investigating how much visibility impairment is unacceptable, or for presenting relatively subtle visibility changes such as from a policy-relevant emission control plan. All photographs, no matter how presented, are representations of real world conditions, and do not completely accurately convey all aspects of visibility conditions. Different methods vary in the accuracy of the overall depiction of visibility conditions, and also impact the sheer logistics of presenting multiple scenes and visibility conditions. There are three primary alternatives: projection screens, printed photographs, and images viewed on a computer monitor.

- *Projection Screen*. Perhaps the highest quality way to present photos of visibility conditions is using photographic slide transparencies, projected onto a large, high quality reflective projection screen. The amount of light from the projected scene that is received by the eye, and the relatively wide portion of an individual's field of vision, provides a very high quality viewing situation. A large sized slide projection approach, however, creates practical obstacles for any visibility study. The size alone makes it difficult to show multiple photos simultaneously. You can use a screen very effectively to present a split shot image, with one visibility condition on one side and of the picture, and another condition on the other side (Winhaze, a computer-imaging software program that simulates visual air quality differences of various scenes developed by Air Resource Specialists, Inc., can prepare such images). However it is difficult to use a projection screen to simultaneously show a distribution of visibility conditions (for example using 5 photos to present the quintiles of the distribution) without loosing some of the inherent advantages of using a screen in the first place (large size). Another consideration with this approach is that high quality photographic slides should be used to enable the viewer to perceive small changes in visibility. Slides of this type degrade rapidly, however, so multiple copies are needed in administering focus group sessions.

  A projection screen can be used in a focus group, such as was used in the 2000 focus group project for OAQPS about urban visibility perception and preferences. A large, high quality projection screen, with participants seated 8 to 15 feet away, provides optimal viewing conditions, and can be used in focus group settings. However, a projection screen would be a serious obstacle for use in a full field survey. It is challenging enough in any survey to get an adequate response rate and demographic/economic sample of the target population. However, requiring appropriate survey respondents to come to a specific location to complete the survey in a preference or valuation study create enormous participation and response rate difficulties, even with participation incentives.

- *High quality prints* on photograph quality paper are the other main option. One key question is how large any photographs need to be. Larger size prints do present a better overall depiction of the visibility conditions throughout the scene. Larger sizes are more expensive, of course, and are more cumbersome to present multiple photos simultaneously. Conversely smaller print sizes are less expensive and easier to manipulate. Smaller photos may enable simultaneously showing more scenes and various visibility conditions. Identifying a minimal acceptable print size to adequately convey the visibility situation is an important goal in initial design of an urban visibility project.

- Presenting visibility via a *computer monitor* is a potential third option, but there are significant drawbacks. Using individual home computers in a survey is impractical, because the size, quality and color of the image as presented will vary for every user. Using a computer monitor in a focus group setting may be possible, but may still have presentation quality concerns.

Issue # 5: Differences in regional preferences for urban visibility

Key Question: Do people's preferences for urban visibility vary substantially in different regions of the country?

Background Discussion:

An important question is whether preferences for urban visibility differ in various regions of the country, or even in individual cities within a region. In part due to limited research on urban visibility preferences, this has been often raised as a concern. Without using the same protocol in multiple cities, it is very difficult to know whether this issue is a significant factor.

The leading hypothesis as to why there may be regional differences in visibility preferences is the "good" in question may be fundamentally different in different locations. For example, urban visibility in cities such as Seattle and Denver includes majestic snow-capped mountains as part of the "urban visibility landscape" of the city. Visibility impairment in those cities includes the potential for a degraded quality of the visibility of the iconic symbols of these cities; the high altitude backdrop visible anywhere in the city on a clear day. Layered haze, such as the Denver and Phoenix "brown clouds," become an important aspect of such visibility degradation, creating different visibility impairment for seeing the lower parts of the mountains than for the mountain tops and more distant peaks.

Even while both have mountains within view of the city, residents in Denver and Seattle may well have different preferences for urban visibility. For example, the significant differences in weather between those two cities might make summertime visibility very important in Seattle, but wintertime visibility not as important. Denver, with clear weather on many days throughout the year, may have a very different set of preferences for both winter and annual visibility.

All cities have their own unique special visibility circumstances. Whether because of a well known urban skyline (e.g., Chicago), a famous bridge (e.g., San Francisco) or tall structures (e.g., the St. Louis Arch or Seattle Space Needle), their own unique surrounding terrain or ocean (e.g., the Los Angeles basin mountains and ocean), or many other possibilities, it is possible that location really does matter, and preferences do differ in important ways in different cities or regions.

The practical project design question is how can we determine if visibility preferences do differ by location. A number of specific implications arise from this topic. How many cities are needed as sites for focus group or survey projects in order to provide sufficient data to expand our knowledge in a meaningful way? What methods can be used to investigate this issue? What is the scope, funding and timeframe needed to conduct such investigations?

An alternative approach is whether there are attributes that can be used to group cities in such a way that all cities within a group can be treated as having sufficiently similar preferences. While identifying such groupings (by region or using some other method) would not avoid all uncertainty about precise benefits estimation, it would go a long way to relieving the need to conduct a project in each city. While it may be possible to conduct a high quality investigation in 5 or 10 cities if necessary, it is impractical to conduct detailed projects in 100 or more cities.

A related question is how many focus groups, and how many participants at each, need to be help in any city to obtain sufficient information to meaningfully compare the results from multiple cities.

A significant challenge (and opportunity) is to design project in such as way as to investigate this issue, help reach a conclusion about whether a national approach will be sufficient, and (if necessary) determining what city-specific attributes could be used for eventual groupings.

Issue # 6: Joint Benefit or "Mental Accounts"

Key Question: Can people separate visibility from other air quality related issues, especially health concerns?

Background Discussion:

When looking at an obscured visibility scene, either in a photograph or viewing it live, a viewer receives information about the overall air quality. This information can be used as they consider their preferences for visibility per se, but their preferences for visibility will also be influenced by their concerns about risks to human health. Concerns for other air quality welfare and ecological concerns may play a role as well. To the extent individuals consider air quality or visibility at all, the typical individual has not separated his/her preferences into separate components (or "mental accounts") for individual benefit categories. Understanding the mental accounts of observed air quality and visibility, and disentangling the intertwined preferences, can be a substantial challenge for both visibility preference and valuation analysis.

Many research projects investigating preferences air quality use an overall metric such as Visual Air Quality (VAQ). For the purposes of some VAQ research, it is not necessary to separate the components of the joint benefits (e.g., health and welfare as well as visibility will be improved simultaneously with improving air quality).[1] In these studies, the goal is to understand preferences for overall air quality, without regard for identifying the role of health and visibility individually.

However, for certain of EPA's purposes, isolating the preferences for visibility from preferences for other air quality-related benefit categories may be essential.

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[1] The benefit improvements are not necessarily proportional however. For example, the mix of chemical species involved in an improvement of 1 μg/m3 of $PM_{2.5}$ concentration is not known be important in estimating health risks. The mix does make a difference in visibility, however, because the same mass of sulfate particles scatter light (i.e., degrade visibility) much more than road dust particles.

Failing to adequately identify separable preferences can lead to double counting in an economics benefits analysis, which would diminish its usefulness in the context of estimating the economic benefits or value of improved urban visibility. Economic benefits are relevant both in EPA's policy analysis associated with setting alternative primary and secondary National Ambient Air Quality Standards. The project would also support the subsequent regulatory impact assessment conducted by EPA on other proposed and final rules, including implementation-related rules. An important question for the workshop is whether carefully dealing with intertwined mental accounts is also critical component of conducting a useful preference-oriented project.

While joint benefits are a major challenge in visibility investigations, there are applied approaches that can be used to help address the multiple attribute issue. These methods are referred to as conjoint, or multi-attribute, analytical approaches. This issue may become one of the dominating design considerations for any urban visibility project, particularly a project including visibility valuation. A specific question is which of the available multi-attribute available research methods (especially survey instrument design and question formulation) would be most appropriate for separating the multiple attributes associated with urban visibility and air quality improvements?

Issue # 7: Number and composition of survey respondents

Key Question: How many, and what type, of people would we need to conduct a useful survey project?

Background Discussion:

A number of additional questions about the number of survey respondents, and areas of the country to include in a survey arise when considering the possible next steps beyond an initial focus group approach. Considering these issues may become a factor in developing the initial phase of an investigation, including developing the objectives of a focus group project and selecting locations for focus group.

One fundamental question is how many survey respondents are needed in a full field survey. The potential for heterogeneous preferences between cities was discussed in Issue # 4, but preferences will also differ between people living in the same city. The more people's preferences vary, the larger the number of survey respondents needed to produce a satisfactory estimate of central preference tendencies, or to identify whether substantially different preferences exist among different portions of the population. Without having some information (or estimates) about how widely individual preferences differ, it is impossible to mathematically estimate an appropriate target for the number of completed survey responses.

The sampling strategy, for both a focus group phase and a survey phase project, is another basic design question. The central questions are what is the demographic profile of the desired audience, and how will recruitment (for either phase) be conducted? For example, whether to include non-English speakers in the urban visibility project, and at what stage (focus group or survey), has important ramifications as to how a project could be conducted. Targeting recruitment to include any narrow population group (such as highly educated, low income, racial minorities) has implications for the strategies for selecting focus group locations, recruitment methods, etc. Another question is whether to do new, population-wide recruitment for the survey, and if so what population lists to use (such as phone book, voter or automobile registrations, home ownership, or random digit dialing). Alternatively, some survey-based valuation research uses already established representative groups of consumers (such as provided by Knowledge Networks, Inc. and other vendors), which can offer significant cost and timing advantages.

Specific detailed questions that would have to be addressed in designing a survey include: Do we want both local residents and tourists/visitors? Those who moved to location recently as adults, or only those who were born there? Do preferences differ for people who choose to work the night shift versus day? Indoor workers or outdoor workers? Such survey design questions could be explored in the focus group phase if sufficient variation in participant characteristics were achieved.

Issue # 8: Payment vehicle

Key Question: What type of valuation question can be used for urban visibility?

Background Discussion:

While the inherent joint benefit problem will likely lead to using a conjoint (also known as an attribute-based) approach in investigating valuation, that does not solve the issue of the form the valuation questions will take. Visibility, along with many other environmental effects, is not naturally bought or sold in a marketplace, and people are not accustomed to thinking about values for nonmarket environmental goods. There are many possibilities that have been developed in valuation survey work of environmental topics (as well as other settings involving preferences for complex tradeoffs) to help people to think clearly about monetary tradeoffs.

The context of the survey questions is important, and survey methods work best when there is an understandable connection between the environmental good in question and how the costs of control would be paid. Fitting the question context to the situation is an important aspect of designing a successful survey instrument. There are a wide range of possibilities about how to present the visibility valuation questions, such as in the context of electricity price increases, or in likely voting on a ballot referendum initiative, or acceptability of a transportation-related emission reduction program, or property tax increases, etc.

While more specific questions about exact survey instrument design may be appropriately left for later detailed project development, the type of diverse experts expected to be involved with the expert workshop (including visibility, emissions, air control policy, and stated preference experts) will provide an excellent opportunity to consider the most appropriate context for an urban visibility valuation project.

L. Valuation and Preference Literature

Urban Visibility Valuation and Preference

The Clean Air Act ∫302(h) defines public welfare to include the effects of air pollution on "…visibility, … and personal comfort and wellbeing." Though good visibility conditions in Class I (e.g. National Parks) and wilderness areas have long been recognized as important to the public welfare (see discussions in EPA (2004 and 2005) and Chestnut and Dennis (1997)), visibility conditions in urban areas also contribute to the public welfare. Visibility impairment may be caused by either natural or manmade conditions (or both), but it is only impairment that occurs as a result of air pollution (either alone or in combination with water vapor or other atmospheric conditions) that can be mitigated by regulations such as the Regional Haze Rule (40 CFR 51.300 through 309) or the Secondary National Ambient Air Quality Standards (NAAQS). Visibility impairment resulting from air pollution is referred to as visual air quality (VAQ).

Visibly poor air quality causes people to be concerned about substantive health risks, but degraded VAQ adversely affects people in additional ways. These include the aesthetic benefits of better visibility, improved road and air safety, and enhanced recreation in activities like hiking and bicycling. Because the human health impacts of air pollution are regulated under the Primary NAAQS, it is necessary to separate out the aesthetic and wellbeing components associated with the visibility condition produced by a given level of air pollution when assessing the need for additional regulation to protect the public welfare effect of visibility under the Secondary NAAQS. The degree to which previous human preference and valuation studies for VAQ have adequately made this distinction and separation is an important issue in applying results from available studies in a Secondary NAAQS (or benefits estimation for any policy effecting VAQ) context. The remainder of this discussion is focused on the aesthetic and wellbeing qualities associated with a given VAQ in urban areas.

The term "urban visibility" is used to refer to VAQ throughout a city or metropolitan area. Urban visibility includes the VAQ conditions in all locations that people experience in their daily lives, including scenes such as residential streets and neighborhood parks, commercial and industrial areas, highway and commuting corridors, central downtown areas, and views from elevated locations providing a broad overlook of the metropolitan area. Thus urban visibility, which is sometimes referred to as ‘residential visibility’, encompasses more than the visibility conditions only at an individual’s specific place of residence, but all the VAQ they see on a regular basis. Urban visibility includes not only major cities, but VAQ conditions in smaller towns and cities. The key distinction is between visibility conditions in urban and suburban locations and visibility in rural or wilderness settings such as the Class 1 areas defined by the Clean Air Act, which include National Parks and similar natural settings.

Visibility has direct significance to people’s enjoyment of daily activities and their overall wellbeing. Visibility conditions can be described both as an aesthetic quality as well as a scientifically measurable set of atmospheric conditions. Due to the subjective nature of aesthetics, people’s preferences with respect to visibility are difficult to express or quantify, but people have expressed in many different ways that they enjoy and value a clear view. A number of social science disciplines have undertaken to link perceived urban visibility to an array of effects reflecting the overall desire for good VAQ, and the benefits of improving currently degraded VAQ. This wide range of diverse studies have identified types of benefits of good VAQ in addition to those directly connected with air-pollution related health effects such as respiratory diseases and premature mortality.

For example, psychological research has demonstrated that people are emotionally affected by VAQ such that their overall sense of wellbeing is diminished (e.g., Bickerstaff and Walker, 2001). Researchers have also shown that perception of pollution is correlated with stress, annoyance, and symptoms of depression (Mace et al., 2004; Evans and Jacobs, 1982, Jacobs et al., 1984). Sociological research has demonstrated that VAQ is deeply intertwined with a “sense of place,“ effecting people’s sense of the desirability of a neighborhood quite apart from the actual physical conditions of the area (e.g., Elliot et al, 1999, Howel et al, 2002, Day, 2007, SAMI, 2002). Public policy research finds that people think it is important to protect visibility, and accept the concept of setting standards to protect visibility (e.g., Ely et al., 1991, Pryor, 1996, Abt Associates, 2001, BBC Research and Consulting, 2003). Finally, economic valuation research has measured the amount of money that people are willing to pay to protect or improve both urban visibility (e.g., summary review in Chestnut and Dennis, 1997, and Beron et al., 2001) and natural locations such as National Parks and other locations defined by the Clean Air Act as Class I visibility areas (e.g., summary review in Chestnut and Dennis, 1997).

The purpose of the remainder of this paper is to review four urban preference studies, as well as one new urban visibility valuation study not previously discussed in an EPA Criteria Document or OAQPS Staff Paper. This literature is relevant to the review of a Secondary NAAQS standard concerning VAQ, as well as a review of potentially including urban visibility valuation in a damage function approach (separately estimating individual effect categories) an economic benefit analysis.

Urban visibility has been examined in two types of studies directly relevant to the NAAQS process: urban visibility preference studies and urban visibility valuation studies. Both types of studies are designed to evaluate individuals' desire (or demand) for good VAQ where they live, using different metrics to evaluate demand. Urban visibility preference studies examine individuals' demand by investigating the basic question "what level of visibility degradation is unacceptable," while economic studies examine demand by investigating "how much would you be willing to pay to improve visibility."

Urban Visibility Preference Studies

One group of urban visibility research projects focused on identifying preferences for urban VAQ without necessarily estimating the economic value of improving visibility. This group of preference studies used a common focus group method to estimate the level of visibility impairment that respondents described as "acceptable." The specific definition of acceptable was largely left to each individual respondent, allowing each to identify their own preferences.

There are three completed studies that used this method, and one additional pilot study (designed as a survey instrument development project) that provides additional information. The completed studies were conducted in Denver, Colorado (Ely et al., 1991), two cities in British Columbia, Canada (Pryor, 1996), and Phoenix, Arizona (BBC, 2003). The pilot study was conducted in Washington, DC (Abt Associates, 2001).

Each study collected information in a focus group setting, presenting slides depicting various visibility conditions. All four studies used photographs of a single scene from the study's city; each photo included images of the broad downtown area and spreading out to the hills or mountains composing the scene's backdrop. The maximum sight distance under good conditions varied by city, ranging from 8 kilometers in Washington, DC to mountains hundreds of kilometers away in Denver. Multiple photos of the same scene were used to present approximately 20 different levels of visibility impairment. The Denver and British Columbia studies used actual photographs taken in the same location to depict various visibility conditions. The Phoenix and Washington, DC pilot study used photographs prepared using the WinHaze software from Air Resource Specialists (ARS). WinHaze is a computer-imaging software program that simulates visual air quality differences of various scenes, allowing the user to "degrade" an original near-pristine visibility condition photograph to create a photograph of each desired VAQ level.

One notable finding of the three visibility preference studies and the one pilot study is the general degree of consistency in the median preferences for an acceptable level of visibility degradation. The range of median acceptable preference level from the four studies is 19 to 25 deciviews (dv), the preferred measure[1] of visibility impairment. Measured in terms of visual range (VR), the median acceptable levels in the four studies are between 30 and 55 km.

Table 1 summarizes the primary design and summary results of the four studies. A brief description of each study follows.

[1]There are 3 common visibility metrics. *Extinction*, measured in inverse Megameters (Mm^{-1}), is proportional to the amount of light lost as it travels over 1 million meters (1000 km). *Deciview* (dv) is a unitless metric defined in terms of extinction, but scaled in such a way as to be perceptually correct. A 1 dv change on a day with 20 dv conditions will be perceived as the same change on a day with excellent visibility (5 dv). *Visual range*, measured in km or miles, is inversely related to extinction and measures how far away a large black object against the horizon sky. The colors and fine detail of many objects will be lost at distance than the visual range. The following diagram (from Malm, 1999) shows the relationship between deciview, extinction and visual range.

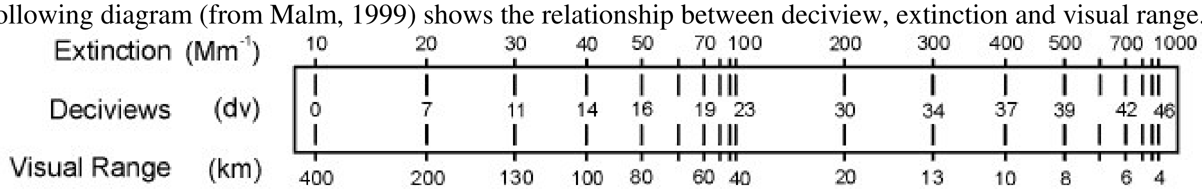

Table 1 Summary of Urban Visibility Preference Studies

	Denver, CO	Phoenix, AZ	2 British Columbia cities	Washington, DC (pilot)
Report Date	1991	2003	1996	2001
Duration of session		45 min	50 minutes	2 hours
Compensation	None (civic groups)	$50	None (class room exercise)	$50
# focus group sessions	17	27 total at 6 locations, Including 3 in Spanish	4	1
# participants	214	385	180	9
Age range	adults	18-65+	University students	27-58
Annual or seasonal	Wintertime	Annual	Summertime	Annual
# total scenes presented	Single scene of downtown with mountains in background	Single scene of downtown and mountains, 42 km maximum distance	Single scene from each city	Single scene of DC Mall and downtown, 8 km maximum sight
# of total visibility conditions presented	20 levels (+ 5 duplicates)	21 levels (+ 4 duplicates)	20 levels (10 each from each city)	20 levels (+ 5 duplicates)
Source of slides	Actual photos taken between 9am and 3pm	WinHaze	Actual photos taken at 1pm or 4pm	WinHaze
Medium of presentation	Slide projection	Slide projection	Slide projection	Slide projection
Ranking scale used	7 point scale	7 point scale	7 point scale	7 point scale
Visibility range presented	11 to 40 dv	15 to 35 dv	13 to 25 dv (Chilliwack) 13.5 to 31.5 dv (Abbotsford)	9 to 38 dv
Health issue directions	Ignore potential health impacts; visibility only	Judge solely on visibility, do not consider health	Judge solely on visibility, do not consider health	Health never mentioned, “Focus only on visibility“
Key Questions asked	a) Rank VAQ (1-7 scale) b) Is each slide “acceptable“ c) “How much haze is too much?“	a) Rank VAQ (1-7 scale) b) Is each slide “acceptable“ c) How many days a year would this picture be “acceptable“	a) Rank VAQ (1-7 scale) b) Is each slide “acceptable“	a) Rank VAQ (1-7 scale) b) Is each slide “acceptable“ c) if this hazy, how many hours would it be acceptable (3 slides only) d) valuation question
Mean dv found “acceptable“	20.3 dv	23 to 25 dv	~23 dv(Chilliwack), ~19 dv(Abbotsford)	~20 dv (range 20-25)

Denver, Colorado Urban Visibility Preference Study

The Denver urban visibility preference study (Ely et al., 1991) was conducted on behalf of the Colorado Department of Public Health and Environment (CDPHE). The study conducted a series of focus group sessions with 17 civic and community groups in which a total of 214 individuals were asked to rate slides. The slides depicted varying levels of VAQ for a well-known Denver vista, including a broad view of downtown Denver with the mountains to the west composing the scene's background. The participants were instructed to base their judgments on three factors:

1) the standard was for an urban area, not a pristine national park area where the standards might be more strict;
2) the level of an urban visibility standard violation should be set at a VAQ level considered to be unreasonable, objectionable, and unacceptable visually; and
3) judgments of standards violations should be based on visibility only, not on health effects.

Participants were shown 25 randomly ordered slides of actual photographs. The visibility conditions presented in the slides ranged from 11 to 40 dv, approximating the 10^{th} to 90^{th} percentile of wintertime visibility conditions in Denver. The participants rated the 25 slides based on a scale of 1 (poor) to 7 (excellent), with 5 duplicates included. They were then asked to judge whether the slide would violate what they would consider to be an appropriate urban visibility standard (i.e., whether the level of impairment was "acceptable" or "unacceptable"). The individual's judgment of a slide's VAQ and whether the slide violated a visibility standard were highly correlated (Pearson correlation coefficient greater than 80%), as were the VAQ ratings and the yes/no "acceptable" response. The participant's median response was that a visibility level of 20.3 dv (extinction coefficient $b_{ext} = 76Mm^{-1}$, or VR ~ 51 km) was judged as "acceptable." The CDPHE subsequently established a Denver visibility standard at this level (defined as $b_{ext} = 76Mm^{-1}$), based on the median 50% acceptability findings from the study.

Phoenix, Arizona Urban Visibility Preference Study

The Phoenix urban visibility preference study (BBC Consulting, 2002) was conducted on behalf of the Arizona Department of Environmental Quality. The Phoenix study patterned its focus group survey process after the Denver study. The study included 385 participants in 27 separate focus group sessions. Participants were recruited using random digit dialing to obtain a sample group designed to be demographically representative of the larger Phoenix population. Focus group sessions were held at six neighborhood locations throughout the metropolitan area to improve the participation rate. Three sessions were held in Spanish in one region of the city with a large Hispanic population (25%), although the final overall participation of native Spanish speakers (18%) in the study was modestly below the targeted level. Participants received $50 as an inducement to participate.

Participants were shown a series of 25 images of the same vista of downtown Phoenix, with South Mountain in the background at a distance of about 40 km. Photographic slides of the images were developed using WinHaze. The visibility impairment levels ranged from 15 to 35 dv (the extinction coefficient, b_{ext} , range was approximately 45Mm^{-1} to 330Mm^{-1}, or a visual range of 87 to 12 km). Participants first individually rated the randomly shown slides on a VAQ scale of 1 (unacceptable) to 7 (excellent). Participants were instructed to rate the photographs solely on visibility, and to not base their decisions on either health concerns or what it would cost to have better visibility. Next, the participants individually rated the randomly ordered slides as “acceptable“ or “unacceptable,” defined as whether the visibility in the slide is unreasonable or objectionable. Better visibility conditions (15 dv and 20 dv) were judged “acceptable“ by 90 percent of all participants. At 24 dv nearly half of all participants thought the VAQ was “unacceptable,“ with almost three-quarters judging 26 dv as unacceptable.

The Phoenix urban visibility study formed the basis of the decision of the Phoenix Visibility Index Oversight Committee for a visibility index for the Phoenix Metropolitan Area (Arizona Department of Environmental Quality, 2003). The Phoenix Visibility Index establishes an indexed system with 5 categories of visibility conditions, ranging from “Excellent“ (14 dv or less) to “Very Poor“ (29 dv or greater). The “Good“ range is 15 to 20 dv. The environmental goal of the Phoenix urban visibility program is to achieve continued progress through 2018 by moving the number of days in lower quality categories into better quality categories.

British Columbia, Canada Urban Visibility Preference Study

The British Columbia (BC) urban visibility preference study (Pryor, 1996) was conducted on behalf of the BC Ministry of Environment. The BC study conducted focus group sessions that were also developed following the methods used in the Denver study. Participants were students at the University of British Columbia , who participated in one of four focus group sessions with between 7 and 95 participants. A total of 180 respondents completed surveys (29 did not complete the survey).

Participants in the study were shown slides of two suburban locations in British Columbia: Chilliwack and Abbotsford. Using the same general protocol as the Denver study, Pryor found that responses from this study found the acceptable level of visibility was 23 dv in Chilliwack and 19 dv in Abbotsford. Pryor (1996) discusses some possible reasons for the variation in standard visibility judgments between the two locations. Factors discussed include the relative complexity of the scenes, potential bias of the sample population (only University students participated), and the different levels of development at each location. Abbotsford (population 130,000) is an ethnically diverse suburb adjacent to the Vancouver Metro area, while Chilliwack (population 70,000) is an agricultural community 100 km east Vancouver in the Frazier Valley.

The British Columbia urban visibility preference study is being considered by the B.C. Ministry of the Environment as a part of establishing urban and wilderness visibility goals in British Columbia.

Washington, DC Urban Visibility Pilot Preference Study

The Washington, DC urban visibility pilot study (Abt Associates 2001) was conducted on behalf of the EPA, and was designed to be a pilot focus group study, an initial developmental trial run of a larger study. The intent of the pilot study was to study both focus group method design and potential survey questions. Due to funding limitations, only a single focus group session was held, consisting of one extended session with 9 participants. No further urban visibility focus group sessions were held in Washington, DC.

Due to the small number of participants, it is not possible to make statistical inferences about the opinions of the general population. The study does, however, provide additional useful information about urban visibility studies, potentially helping to both better understand previous studies as well as design future studies.

The study also adopted the general Denver study method, modifying it as appropriate to be applicable in an eastern urban setting which has substantially different visibility conditions than any of the three western locations of the other preference studies. Washington's (and the entire East) visibility is typically substantially worse than western cities, and has different characteristics. Washington's visibility impairment is primarily a uniform whitish haze dominated by sulfates, relative humidity levels are higher, the low lying terrain provides substantially shorter maximum sight distances, and many residents are not well informed that anthropogenic emissions impairs visibility on hazy days.

The Washington focus group session included questions on valuation, as well as on preferences. The focus group was asked to state their preferences measured in an increase in the general cost of living for certain levels of improvement in visibility on a typical summer day. A general cost of living approach is one payment vehicle approach that can be used in willingness to pay studies, especially for environmental issues arising from multiple diverse emission sources (e.g., transportation, electricity generation, industry, etc.) making a specific price increase potentially misleading.

The first part of the focus group session was designed to be an hour long, and was comparable to the focus group sessions in the Denver and Phoenix studies. A single scene was used; a panoramic shot of the Potomac River, Washington mall and downtown Washington, DC. In the first part of the session people were asked to rate the VAQ of 25 photographs (prepared using

WinHaze, and projected on a large screen), judge the acceptability of visibility level in each slide, and answer the valuation questions. The second half of the session, however, was a moderated discussion session about the format and content of the first phase of the session. In this moderated discussion, participants were asked about their understanding of each questions asked in the first half of the session. Particular issues in designing a focus group session were also explored. Important participant comments included:

1) Participants had been asked how they reacted to the initial direction to base their answers only on visibility, but health was never explicitly mentioned by the focus group moderator. Participants strongly agreed with the decision to not mention that health effects are associated with visibility impairment. They understood the directions as meaning they should ignore health issues, and said their answers would have been different if they included health as well as visibility in their judgments.
2) Differentiating between haze and weather conditions was difficult. Weather was not discussed in the focus group session, and the photographs were WinHaze altered photos with identical weather conditions. Participants mentioned they were still confused about the role of weather and humidity in the different visibility conditions presented in the photos.
3) Questions about how many hours an impairment level would be acceptable were confusing. Most participants were normally indoors during most of the day, so questions about duration of outdoor conditions were difficult to answer.
4) Participants strongly agreed that not mentioning the purpose of the study, or the sponsor, until the very end (after all the questions were answered) was viewed as very important. Most felt this information would have influenced their answers.

Urban Visibility Valuation Studies

The economic importance of urban visibility has been examined by a number of studies designed to quantify the benefits (or willingness to pay) associated with potential improvements in urban visibility. Urban visibility valuation research prior to 1997 was summarized in Chestnut and Dennis (1997), and were also described in the 2004 Air Quality for Particulate Matter (p. 4-186 to 4-190, EPA, 2004) and the 2005 OAQPS PM NAAQS Staff Paper (EPA, 2005). These reviews summarize 34 estimates (based on different cities or model specifications) from six different studies. Since the mid 1990s, however, only one new valuation study of urban visibility has been published.

One urban visibility benefit assessment not included in those reviews is “The Benefits of Visibility Improvement: New Evidence from the Los Angeles Metropolitan Area“ (Beron et al., 2001). Rather than a contingent valuation method (CVM) technique used in the majority of other urban visibility valuation studies, Beron et al. used a housing market hedonic technique. The housing hedonic methods were used in previous urban visibility studies by Murdoch and Thayer, 1988, and Trijonis et al., 1985. A housing market hedonic study views a housing unit as composed of a bundle of attributes, and uses housing sale price data from a large number of units in a metropolitan area to estimate the value of each component. Hedonic pricing has been used to estimate economic values for environmental effects that have a direct effect on housing market values. It relies on the measurement of differentials in property values under various environmental quality conditions including air pollution, visibility and other environmental amenities such as access to nearby beaches and parks, as well as by physical attributes of the house and attributes of the neighborhood.

Beron et al. obtained data on approximately 840,000 owner-occupied, single family housing sales between 1980 and 1995 from the California South Coast Air Basin (composed of Los Angeles and Orange Counties, and the portions of Riverside and San Bernardino Counties in the greater metropolitan area). The real estate data included information on the sale price of the house, 13 housing attributes (square footage, number of bathrooms, etc.), 9 neighborhood attributes (percent poverty, school quality, FBI crime index, etc.), and three air pollution variables: ozone, particulates (measured by total suspended particulates, or TSP), and visibility. Visibility was measured as the annual average of visual range, measured in miles, and was obtained from seven airports within the study region. The visibility range was from 12.4 miles (Los Angeles International Airport, 1991) to 31.9 miles (Palm Springs Airport, 1995). Ozone data (39 monitors) and TSP data (40 monitors) were obtained from the South Coast Air Quality Management District. Annual mean values for each year were calculated for ozone and TSP.

Beron et al. presented results for a hypothetical basin-wide 20% visibility improvement, or an increase from 15.3 to 18.4 miles, which is equivalent to approximately 27.6 dv to 25.8 dv. The initial results reflect the change in the purchase price of a house associated with this difference in VAQ, which can be interpreted as a present value of a stream of annual values over the lifetime of the house. The authors therefore selected a time horizon (30 years) and an interest rate (8%) to calculate an annual per household benefit per dv ranging from $484 to $1,756. The Beron results are higher than the CVM-based values summarized in Chestnut and Dennis (1997), which ranged from $12 to $132 per dv. It should be noted that the $132 CVM values cited by Chestnut and Dennis is from a study in the Los Angeles area (Brookshire et al., 1979). The Beron et al. results are also higher than the Trijonis et al. hedonic study in the Los Angeles area, which had a range of $134 to $360 per dv. All values reported here are in terms of 1994 prices.

A critical question for all urban visibility valuation studies is the extent to which the estimated values strictly reflect preferences for visibility, and do not include a component of preferences for reducing health risk from air pollution. The ability to isolate the value of visibility from within the collection of intertwined benefits from visual air quality, which is inherently multi-attributed, is a challenge for all visibility valuation studies. Each study attempts to isolate visibility from other effect categories, but different studies take different approaches.

Beron et al. include two measures of air pollution directly related to health effects in their housing market hedonic study, ozone and particulates (using TSP as the metric for particulates), as well as visibility. They argue that the presence of the two health-related pollution levels results in a estimated hedonic demand function for visibility that successfully separates the health component of demand for overall air quality from the visibility component. An alternative interpretation is that the estimated visibility function still includes a component of health risk because the housing market data does not support completely isolating the demand for visibility (due to correlated variables, omitted variables, measurement error, model specification error, etc.) from demand for health risk reductions measured by the two health related air quality metrics.

A key issue in interpreting the Beron et al. results is whether the objective measures of air quality characteristics (e.g., visibility, particulate matter concentrations, etc.) capture people's perceptions of the different aspects of air quality in a given location. To the extent the people simultaneously use what they see regarding VAQ as an indicator of the overall air quality including potential health risks, then including all the measures in the equation is not necessarily sufficient to isolate one effect from the other.

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