



Memo

TO: Air Quality and Visibility Advocates
FR: Bruce Hill, Ph.D. Senior Scientist, Clean Air Task Force bruce@catf.us
DA: 10 April 2003
RE: Deciview scale, visibility and "Clear Skies"

I have had a number of requests to convert deciview into visual range in past weeks as people try to understand what the Clear Skies Initiative (CSI) will do for visibility based on EPA's technical analysis. What is a deciview? How do you convert deciview to miles? Does CSI offer potential for very much improvement? I will attempt to answer these questions briefly below. The table below can be used to work between deciview (dv), standard visual range (SVR) in both km and miles. Note on the table: SVR is "standard visual range." It's a theoretical metric calculated from light scattering and absorption measurements, rather than a measured quantity.

EPA's CSI technical analysis states:

"In a large portion of the East and Midwest, visibility would be improved by 2-3 deciviews from current levels (a one deciview improvement is a perceptible change)." [note: current conditions means 1996—this baseline inflates benefits from CSI by incorporating 3 million tons of SO₂ benefits from the acid rain program} and,

"In areas of the southern Appalachian Mountains (e.g. Great Smoky Mountain National Park), visibility would be improved more than 3 deciviews"

WHAT IS A DECIVIEW? Deciview is technically a log function of the light scattering and absorption extinction coefficient. In plain speak, it is a scale that makes changes in visibility linear—that is, each change is equivalent to the last change in terms of what you can see (not in terms of miles). Analogies are pH, Richter and decibel scales. One deciview (dv) is close to but not exactly "one just-noticeable change" in visibility. But for all intents and purposes it can be described as "approximately one noticeable change in what you can see." Higher deciview levels are hazier, while lower deciview levels are clearer. The range of measured daily visibility typically ranges from approximately 3 dv (180 mile visibility and clear blue sky) to 40 dv (4 mile visibility - dense haze). Occasionally visibilities may be less than 4 miles (greater than 40 dv) such as in the Great Smoky Mountains National Park.

HOW MUCH VISUAL RANGE DOES A DECIVIEW REPRESENT? Some people have asked: what is one deciview in miles? The difference in visual range between each deciview is not a constant, so answers can only be given relative to a specific change in visibility (see attached conversion table).

HOW MUCH IMPROVEMENT DOES THE REGIONAL HAZE RULE REQUIRE? The haze rule mandates that states develop visibility SIPs to reduce the haziest (80th percentile) days visibility down a "glide path" to within 1 dv of natural conditions by 2064.

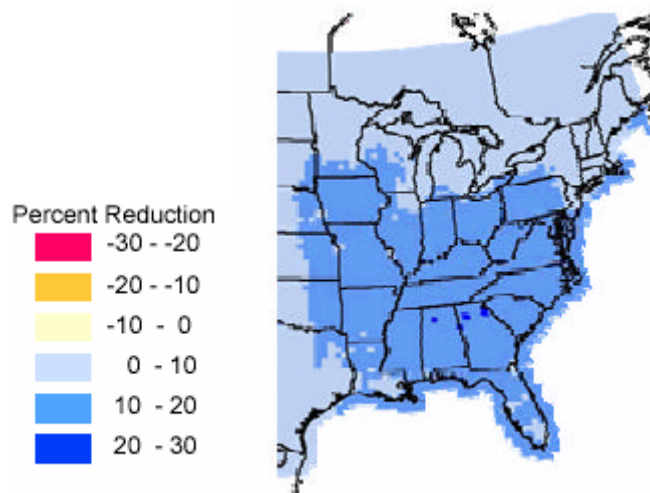
DECIVIEW AND “CLEAR SKIES.” Under CSI, EPA modeled the average national improvement in visibility to be expected: 1-2 dv beyond baseline (baseline includes full implementation of Title IV SO₂ reductions) (See map below.) Translated this means "approximately 1-2 "just- noticeable changes nationwide." Is this progress?

To answer this question you need some background on regional visibility. Haziest 80th percentile visibilities in U.S. parks and wilderness range from 11-33 dv. Generally, East of the Mississippi where visibility is most impaired, haziest days range from 20 dv (upper Midwest) to 25 dv (Northeast)-32 dv (Southeast). In the West 20th percentile haziest days range from 11 (Colorado Plateau) to 23 (CA and Pacific NW). For rough comparison, approximate clear/natural conditions in the US range from about 3 dv (180 mi) (Colorado Plateau) to 7 dv (120 miles) (Northeast) to 10 dv (90 miles) (Southeast).

CSI EXAMPLE: GREAT SMOKY MOUNTAINS NATIONAL PARK. In Great Smoky Mountains National Park, current haziest 80th percentile days are about 30 dv. Natural visibility for that area is approximately 11 dv. This means that a 18 dv improvement is needed to reach the Regional Haze Rule of +1 dv of natural conditions in the park. CSI achieves a mere 3 dv improvement from "current levels" (EPA uses 1996 data to represent current levels, which inflates the benefits), and a 2-3 dv improvement from the base case in the Great Smoky Mountains National Park. Looking at the table, this means that annual average 20th percentile haziest day improves from 30 dv (12 miles) to 27 dv (16 miles). Compared to the 18 dv needed to reach the goal of the Regional Haze Rule target, the CSI 3dv improvement from 1996 can be described as a 'drop in the bucket.'

What’s worse CSI protects power plants from additional reductions need to improve visibility by limiting states rights --states must be able prove the unprovable –that they have tapped all other more cost effective sources first.

However, it should be noted (and you can see from the table) that the first dv reductions will be much harder to obtain than the last. Imagine taking 5 drops food coloring *out* of glass of water. If you could takes the drops out one at a time, the first ones removed would have little effect in lightening the color of the mixture. But removing the last drop, changes the water from colored to clear. By analogy, this means much of the sulfate must be removed from the atmosphere before big visible changes are seen. Thus, each incremental decrease in emissions will have accelerating benefits.



Meager Eastern Visibility Improvements under CSI from Base Case: Average Improvement 1-2 Deciviews Nationwide by 2020 (Post Title IV, NO_x SIP call) Source: EPA.

EPA region by region CSI benefits (<http://www.epa.gov/air/clearskies/where.html>):

- Region 1 (ME, NH, VT, MA, CT, RI): 1-2 dv beyond 1996 levels;
- Region 2: (NY, NJ) 1-3 dv beyond 1996 levels; Adirondacks: 1-2 dv from 1996 levels.
- Region 3 (DC, PA, WV, VA, DE, MD): 1-3 dv from 1996 levels;
- Region 4 (KY, NC, SC, GA, AL, FL, MS, TN): 1-2 dv from 1996 levels, except 2-3 dv for Appalachian ridgeline areas such as Great Smoky Mountains National Park (Great Smokies benefit predicted to > 3 dv from 1996);
- Region 5: (WI, MI, IL, IN, OH, MN): 1-3 dv from 1996 levels;
- Region 6: (NM, TX, AK, LA, OK): 1-3 dv from 1996 levels;
- Regions 7: (NE, IA, KS, MO) No data provided on visibility benefits;
- Region 8-10 (rest of western U.S.) EPA states that the visibility benefits will ‘mirror’ WRAP agreement benefits.

Deciview Conversion Sheet

Km-Deciview

Miles to Deciview

Deciview to Km and Miles

SVR-km	Deciview	SVR-mi	Deciview	Deciview	SVR-km	SVR-mi
1	60	1	55	1	354	219
2	53	2	48	2	320	198
3	49	3	44	3	290	180
4	46	4	41	4	262	162
5	44	5	39	5	237	147
6	42	6	37	6	215	133
7	40	7	35	7	194	120
8	39	8	34	8	176	109
9	38	9	33	9	159	99
10	37	10	32	10	144	89
11	36	11	31	11	130	81
12	35	12	30	12	118	73
13	34	13	29	13	107	66
14	33	14	29	14	96	60
15	33	15	28	15	87	54
16	32	16	27	16	79	49
17	31	17	27	17	71	44
18	31	18	26	18	65	40
19	30	19	25	19	58	36
20	30	20	25	20	53	33

21	29	21	24	21	48	30
22	29	22	24	22	43	27
23	28	23	24	23	39	24
24	28	24	23	24	35	22
25	27	25	23	25	32	20
26	27	26	22	26	29	18
27	27	27	22	27	26	16
28	26	28	22	28	24	15
29	26	29	21	29	22	14
30	26	30	21	30	19	12
31	25	31	21	31	18	11
32	25	32	20	32	16	10
33	25	33	20	33	14	9
34	24	34	20	34	13	8
35	24	35	19	35	12	7
36	24	36	19	36	11	7
37	24	37	19	37	10	6
38	23	38	19	38	9	6
39	23	39	18	39	8	5
40	23	40	18	40	7	4
41	23	41	18	41	6	4
42	22	42	18	42	6	4
43	22	43	17	43	5	3
44	22	44	17	44	5	3
45	22	45	17	45	4	2
46	21	46	17	46	4	2
47	21	47	16	47	4	2
48	21	48	16	48	3	2
49	21	49	16	49	3	2
50	21	50	16	50	3	2
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120	12		120	7			
130	11		130	6			
140	10		140	6			
150	10		150	5			
160	9		160	4			
170	8		170	4			
180	8		180	3			
190	7		190	2			
200	7		200	2			
210	6		210	1			
220	6		220	1			
230	5		230	1			
240	5						
250	4						

Pitchford, M.L. and Malm, W.C. (1994) Development and Applications of a Standard Visual Index.
 Atm. Environment.