Preliminary Air Quality Related Screening Values for Three Class I Areas in North Carolina and Tennessee

Work is currently underway to assist applicants of Prevention of Significant Deterioration (PSD) permits determine if a new source of pollution will have an adverse impact on any air quality related value in Linville Gorge, Shining Rock, or Joyce Kilmer/Slickrock Wilderness (Figure 1). Table 1 lists the red line and green line screening values for several types of pollutants which have the potential to adversely impact the air quality related

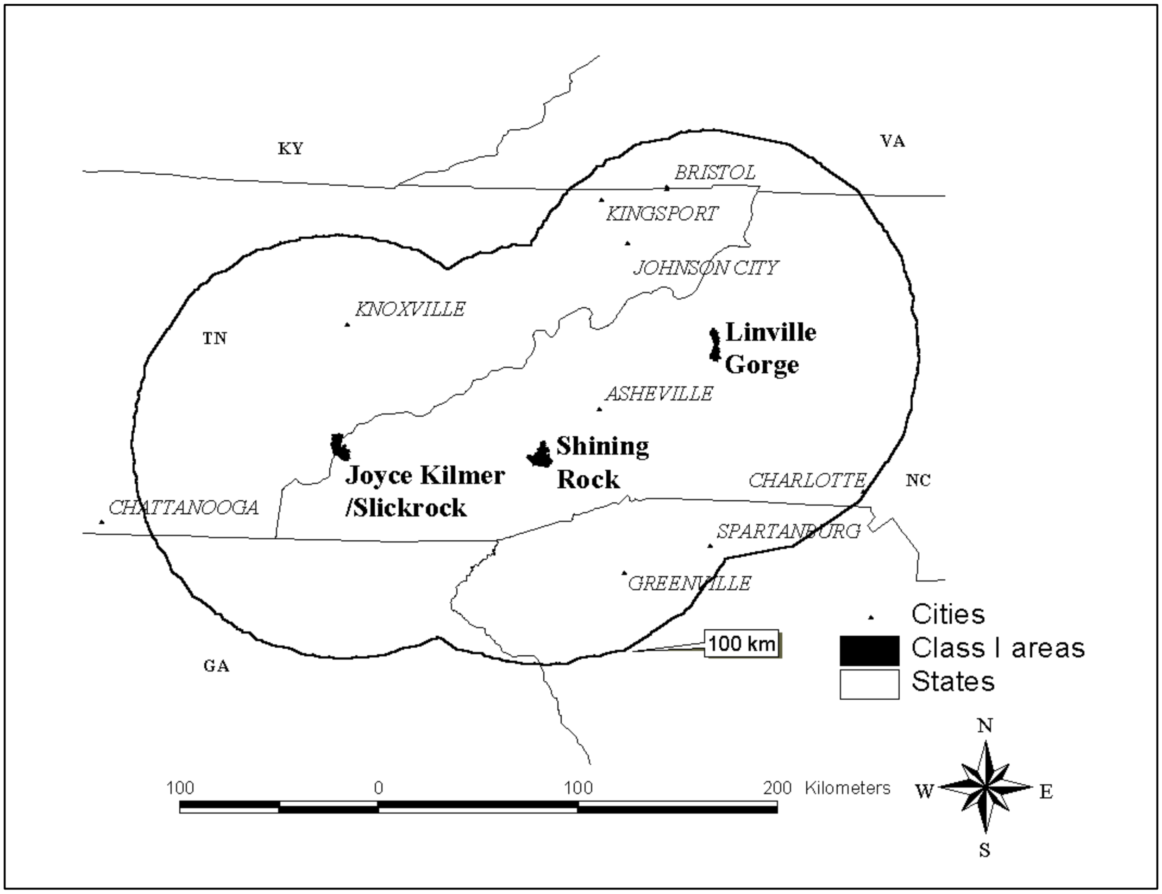

Figure 1. Location of the Class I areas for the National Forests in North Carolina.

values. The red line values indicates a total pollution level (new source plus ambient) where at least one air quality related value has a high likelihood of having an adverse impact; whereas the green line value indicates a total pollution level where there is a low likelihood of an adverse impact to the air quality related values. Values that are between the red line value and green line value are classified as the yellow zone. The yellow zone is an area where there is uncertainty that one or more air quality related values will have an adverse impact. The user of the information needs to understand that the values presented are used by people at the National Forests in North Carolina to assess the risk of a new source of air pollution. The exceeding of a red line value by current monitored or estimated values does not mean the Federal Land Manger will issue an adverse impact determination to the air regulatory authority. Neither does a value between the red and green line values (i.e. the yellow zone) mean that an adverse impact determination will not be recommended to the air regulatory agency. Other data are often used, which are not presented here, before issuing an adverse impact determination. For example, the applicant may want to collect acidic deposition information near the Class I area to estimate the total deposition of sulfate and nitrates for a particular year. Furthermore, an applicant could recommend ways to mitigate, or offset the new emissions of one or more air pollutants.

The sections following Table 1 briefly describe each of the pollutants which have the potential to have an adverse impact on the air quality related values. Another document will be released at a future date which will provide greater detail on how the pollutants impact the resources and how the screening level values were selected.

Table 1. Red line and green line screening values for the Class I areas, and current monitored or estimated values.

					Current Values		
Pollutant Name	**Red Line Value**	**Green Line Value**	**Unit of Measure**	**Averaging Period**	**Linville**	**Shining Rock**	**Joyce Kilmer/ Slickrock**
Ozone	> 23.7	<5.9	W126 (ppm-hrs.)	April - October	36.1	57.7	41.8
Ozone	>50	<6	# hrs. >= 0.10 ppm	April - October	5	1	35
Sulfate	>=60	<15	kg/ha/yr	Annual	50	66	68
Nitrate	>=44	<13	kg/ha/yr	Annual	26	34	32
Sulfate + Nitrate	<25.0	>=25.0	ANC, ueq/L	Spring	NA	40	ND
Sulfate + Nitrate	<0	>0	ANC, ueq/L	Episodic	NA	ND	ND
Sulfate + Nitrate	<=6.0	>6.0	pH units	Spring	NA	6.6	5.6
Sulfate + Nitrate	<=5.5	>5.5	pH units	Episodic	NA	ND	ND
Paticulates and NO_2	>=2.0	<2.0	ΔE	Hourly	NA	NA	NA
Paticulates and NO_2	>=0.05	<0.05	contrast	Hourly	NA	NA	NA
PM2.5	>= 5%	< 5%	b_{ext}	Daily	*	*	*

NA = not applicable
ND = no data available at this time
* Current visibility values are expressed as b_{ext} in inverse megameters (Mm^{-1}). See Table 2 or Table 3 on which values should be used for each Class I area.

Ozone: A high seasonal exposure and frequent occurrence of peak hourly ozone concentrations (>= 0.10 ppm) are needed to reduce the growth of tree species found in the southern Appalachians (Lefohn et al. 1997, and SAMAB 1996). Therefore, a dual parameter screening level value is used to determine if ground level ozone will cause an adverse impact to the vegetation resources at the Class I areas. An adverse impact is likely to occur when the W126, a measure of the seasonal exposure (Lefohn and Runeckles 1987) is greater than 23.7 ppm-hours; and there are more than 50 hours during the growing season (April through October) when the average hourly ozone concentration is 0.10 ppm or greater. Currently, there is no EPA approved method to estimate ozone increases from a single source. The preferred method for addressing ground-level ozone is to reduce emissions on a regional scale. The air regulatory agencies and applicants will be informed early in the application process if ozone exposures are believed to be causing an adverse impact to terrestrial resources. Table 1 shows that the W126 values exceed the red line values for all three wildernesses. The frequency of peak hourly ozone concentrations are below the red line value at Joyce Kilmer/Slickrock Wilderness, and below the green line values at Linville Gorge and Shining Rock Wilderness. These results do not clearly demonstrate that ozone exposures are having an adverse impact on the vegetation. Therefore, other data and/or published results will be used to determine if an adverse impact is occurring to the terrestrial resources at the three wildernesses.

Sulfate: Deposition of sulfates from the atmosphere occur in wet (rainfall), dry, and cloudwater forms. Increases in sulfates have the potential to have an adverse impact on soil chemistry, which could lead to adverse impacts to soil and vegetation air quality related values. Sulfate deposition at the three Class I areas was estimated using the sulfate modeling results reported in the Southern Appalachian Assessment (SAMAB 1996, Lynch and others 1996). The numbers reported represent sulfate from only rainfall which underestimates the total sulfate deposition. Studies conducted at the Great Smoky Mountains National Park have demonstrated that dry sulfate deposition is equivalent to sulfate from rainfall. Sulfate from cloudwater is approximately twice the rainfall plus dry sulfate deposition (Johnson and Lindberg 1992). The total deposition results in Table 1 were obtained by doubling the modeled sulfate results presented in the Southern Appalachian Assessment (SAMAB 1996). The values presented in Table 1 do not include cloudwater. The values may underestimate the total deposition at Shining Rock and Joyce Kilmer/Slickrock Wilderness since these areas may be receiving large amounts of sulfate deposition from cloudwater.

Current sulfate deposition at Linville Gorge Wilderness is estimated to be 50 kg/ha/yr (i.e. in the yellow zone) which is below the red line of 60 kg/ha/yr. Both Shining Rock Wilderness and Joyce Kilmer/Slickrock Wilderness are above the red line value. Applicants will need to follow Section 5.1.3 of the Interagency Workgroup on Air Quality Modeling guidelines (EPA, 1993) when converting the screening model (Level 1) values for sulfate deposition. If the screening model values are predicted to be greater than or equal to 0.05 kg/ha (see Appendix A) then the applicant should use the CalMet and CalPuff models for subsequent analysis.

Nitrate: Deposition of nitrates from the atmosphere occur in wet (rainfall), dry, and cloudwater (SAMAB 1996). As with sulfates, an increase in nitrates has the potential to adversely impact soils, and vegetation air quality related values (Peterjohn and others 1996). The nitrate values in Table 1 were obtained by doubling the wet nitrate estimates found in the Southern Appalachian Assessment data (SAMAB 1996, and Lynch and others 1996). All three Class I areas have values which fall within the yellow zone, which means other information is needed to determine if an adverse impact is likely to occur. Excessive amounts of nitrates have been found to be present at the Great Smoky Mountains National Park (Nodvin and others 1995). There is a possibility that nitrogen saturation could also be occurring at the three Wildernesses. Applicants will need to follow Section 5.1.3 of the Interagency Workgroup on Air Quality Modeling guidelines (EPA, 1993) when converting the screening model (Level 1) values for nitrate deposition.

If the screening model values are predicted to be greater than or equal to 0.05 kg/ha (see Appendix A) then the applicant should use the CalMet and CalPuff models for subsequent analysis.

Sulfate + Nitrate: The red values for sulfate and nitrate numbers presented in Table 1 are given as an indicator where soil and vegetation air quality related values could be adversely impacted. Acidic deposition can also have an adverse impact on water air quality related values because the acidified rainwater or soil water moves into the stream. Adverse effects can occur to water quality and aquatic organisms (especially some fish and aquatic insects) if the acidified soil water is not neutralized. The acid neutralizing capacity (ANC) is a water chemistry measurement which reflects the ability of a watershed to offset the acid inputs. Aquatic biotic are at risk of adverse impacts if the spring stream ANC values are less than 25.0 ueq/l. Furthermore, aquatic biota are at risk if the ANC values are less than 0 ueq/l following a rain storm (i.e. episodic event). Linville Gorge Wilderness does not have water as an air quality related value, but water is an air quality related value at the other two Class I areas. Spring time water chemistry data have been collected for Shining Rock Wilderness. The lowest ANC value (based upon converting alkalinity measurements) recorded is 40 ueg/l, which is above the green line value. The CalMet and CalPuff models should be used if the ANC levels are predicted to decrease equal to or greater than 0.1 ueq/l.

pH is another important water chemistry measurement used to indicate the status of the water as an air quality related value. Streams with a pH value of less than or equal to 6.0 in the spring time could have adverse impacts to the stream biota. Adverse impacts can also occur if the pH is less than or equal to 5.5 following a rain storm. The lowest spring time pH measurement for Shining Rock Wilderness is 6.6, which is above the green line value. The red line value for pH has been exceeded at Joyce Kilmer/Slickrock Wilderness by having a spring time measurement for pH of 5.6. The CalMet and CalPuff model should be used if the pH levels are predicted to decrease less than or equal to 0.01 units.

Particulates and NO_2: Some facilities which emit particulates, nitrogen dioxide (NO_2), and sometimes hydrogen sulfides (H_2SO_4) can produce a plume that can be seen in or outside of the Class I area. The EPA has recommended a method to asses impacts from coherent plumes from sources less than 50 km from the Class I area. The VISCREEN (EPA, 1988) and PLUVUE-II (EPA, 1995) models are recommend to conduct plume blight analysis. These two models calculate the change in color (ΔE) and contrast between the plume and the viewing background. Sources should perform the analysis using the existing emissions plus any additional emissions proposed. The model results are significant if the ΔE value is 2.0 or greater, and/or the contrast value is 0.05 or greater.

PM2.5: New sources emission increases can result in plume blight if they are 50 km or less from the Class I areas, but all sources have the potential to contribute to regional haze. The main type of visibility reductions at Class I areas is regional haze (SAA 1996), and any PSD analysis needs focus on what a new source's contributions will be to regional haze. Fine particles (2.5 microns or smaller) are primarily responsible for reducing visibility at the Class I areas. The most important types of fine particles are: sulfates, organics, nitrates, elemental carbon and soil. In addition, coarse particles (between 2.5 and 10 microns) contribute somewhat to visibility impairment. The Environmental Protection Agency (EPA) has published a document with recommendations for modeling impacts on regional haze (EPA 1993), but the following steps should be followed instead of the guidance given by the EPA (1993):

1. Use the 24-hour modeling results for NO_x and SO_x concentrations for one year. Assume all NO_x forms ammonium nitrate and all the SO_x forms ammonium sulfate. (Multiply the mass concentration of SO_4^{-2} by 1.375 to obtain $(NH_4)_2SO_4$. Likewise, multiply the mass concentration of NO_3^- by 1.29 to obtain NH_4NO_3.)

2. Get the Seasonal Clear-day Aerosol Profile data for all the modeling receptors for Shining Rock (see Appendix B) and Linville Gorge Wilderness (see Appendix C) from Table 2. The numbers in Table 2 are taken from an IMPROVE (Interagency Monitoring of Protected Visual Environments) monitoring site near Shining Rock Wilderness and are the best estimates for fine aerosol mass on the eastern side of the Blue Ridge Mountains in North Carolina. Joyce Kilmer/Slickrock is located on both the sides of the Blue Ridge Mountains in North Carolina and Tennessee. The values in Table 3 (Great Smoky Mountains National Park IMPROVE site) need to be used with the modeling results for receptors 1 through 9; whereas the values in Table 2 need to be used for receptors 10 through 27 (see Appendix D).

Table 2. Seasonal Clear-day Aerosol Profile (background) for Shining Rock IMPROVE monitoring Site. The values should be used all of the modeling receptors in Shining Rock and Linville Gorge Wilderness, and modeling receptors 10 through 27 at Joyce Kilmer/Slickrock Wilderness.

	Spring ($\mu g/m^3$)	Summer ($\mu g/m^3$)	Autumn ($\mu g/m^3$)	Winter ($\mu g/m^3$)	Extinction Efficiency
Ammonium Sulfate	1.54	2.00	0.99	0.73	3xf(RH)
Ammonium Nitrate	0.20	0.23	0.12	0.13	3xf(RH)
Soil	0.33	0.71	0.13	0.13	1
Organics	0.62	1.14	0.82	0.63	4
Elemental Carbon	0.19	0.15	0.18	0.16	10
Coarse Mass	3.27	6.10	2.01	3.36	0.6
10^{th} β_{ext}	32.0	46.5	27.7	26.1	
10^{th} Standard visual range	122	84	141	150	

Table 3. Seasonal Clear-day Aerosol Profile (background) for Great Smoky Mountains National Park IMPROVE monitoring Site. The values should be used modeling receptors 1 through 9 at Joyce Kilmer/Slickrock Wilderness.

	Spring ($\mu g/m^3$)	Summer ($\mu g/m^3$)	Autumn ($\mu g/m^3$)	Winter ($\mu g/m^3$)	Extinction Efficiency
Ammonium Sulfate	2.71	4.46	1.69	1.51	3xf(RH)
Ammonium Nitrate	0.56	0.24	0.30	0.36	3xf(RH)
Soil	0.38	0.77	0.17	0.12	1
Organics	1.57	2.21	1.29	1.21	4
Elemental Carbon	0.33	0.27	0.29	0.25	10
Coarse Mass	5.11	15.45	4.23	3.38	0.6
10^{th} β_{ext}	47.0	62.0	40.9	48.8	
10^{th} Standard visual range	73	52	91	88	

The following months should be used for each of the seasons listed in Tables 2 and 3:

Spring: March, April, and May
Summer: June, July, and August
Autumn: September, October, and November
Winter: December, January and February

3. For each day, calculate reconstructed light extinction with and without the new source, using the data in Tables 2 and/or 3. This calculation is performed assuming an externally mixed aerosol, so that the total extinction of the aerosols present is equal to the sum of the extinctions of each of the species. Each species' concentration is multiplied by a dry extinction efficiency to determine the amount of extinction it causes. For hygroscopic species (ammonium sulfate and ammonium nitrate), this dry extinction must be multiplied by f(RH) to correct for the effects of relative humidity. The f(RH) curve is in the EPA (1993) document. For computer algorithms, interpolate from values in Table B-1 (EPA, 1993).

Note: It is important to calculate f(RH) for each hour of the day being modeled. These 24 hourly f(RH) values should then be averaged to give a 24-hour average f(RH). **Do not** use the 24-hour average RH to calculate the daily f(RH).

4. Calculate the change in β_{ext} for each day. For the purpose of definition:

$$\Delta\beta_{ext} = (\text{source } \beta_{ext} - \text{background } \beta_{ext}) / \text{background } \beta_{ext}$$

The red line value is exceeded when the background β_{ext} change will be greater than or equal to 5 percent for any day during the year (Table 1). Likewise, the atmospheric modeling significance value is also the same as the red line value and the CalMet and CalPuff models should be used if the change in β_{ext} is predicted to be greater than or equal to 5 percent for any day during the year.

The following is for example only:

> The modeling results predict the 24-hour average SO_4 concentration will increase by 0.9 $\mu g/m^3$ on December 10th at one of the receptors at Shining Rock Wilderness. All of the SO_4 increase will be assumed to form ammonium sulfate. Therefore, the increase in ammonium sulfate is predicted to be 1.2375 $\mu g/m^3$. The f(RH) was calculated for each hour on December 10th and the average of the 24 hourly values was 3. Using these values the background β_{ext} is:
>
> [0.73(3(3))]+[0.13(3(3))]+[0.13(1)]+[0.63(4)]+[0.16(10)]+[3.36(0.6)]
>
> 6.57 + 1.17 + 0.13 + 2.52 + 1.6 + 2.02 = 13.88 Mm^{-1}
>
> Adding the increased ammonium sulfate (1.24 $\mu g/m^3$) to the background (0.73 $\mu g/m^3$) would increase the ammonium sulfate to 1.97 $\mu g/m^3$. The new extinction would be:
>
> [1.97(3(3))]+[0.13(3(3))]+[0.13(1)]+[0.63(4)]+[0.16(10)]+[3.36(0.6)]
>
> 17.73 + 1.17 + 0.13 + 2.52 + 1.6 + 2.02 = 25.17 Mm^{-1}
>
> Therefore, the percent change in β_{ext} is:
>
> (25.17 - 13.88) / 13.88 = .81 or 81 percent
>
> A β_{ext} increase of 81 percent would exceed the red line value of 5 percent. If these were the results from a screening model then the applicant should proceed to use the CalMet and CalPuff model to see if the SO_x modeled value would decrease. Another option would be to use a better control technology, or seek emissions offsets that would reduce the visibility impact.

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Appendix A

How the minimal nitrate and sulfate detection levels were calculated: According to Jim Lynch (Pennsylvania State University) the minimal detectable levels for sulfate and nitrate in wet deposition collectors is 0.03 mg/liter. To detect an increase in deposition (kg/ha) at a specific location depends upon the amount of rainfall. Rainfall modeling was conducted as a step in order to estimate the annual wet sulfate and nitrate deposition (Lynch and others 1996). The estimated rainfall for the three Class I areas is 70 inches (1778 mm). The following equation was used to estimate the minimal detectable level of an increase in sulfate or nitrate:

$$D = C * Rain * 0.01$$

where:
D = estimated deposition in kg/ha
C = the concentration of pollutant, which is 0.03 mg/liter
Rain = the rainfall in millimeters, which is 1778

The estimated deposition level for sulfate and nitrate is 0.5 (rounding the value of 0..5334) based upon using the preceding equation. The National Forest in North Carolina receives about 5 to 10 PSD applications per year. Therefore, the significant modeling screening value is being reduced to 0.05 to provide a margin of protection due to the number of PSD applications received over a 2 year period.

Appendix B

Atmospheric Modeling Receptors* for Shining Rock Wilderness

Receptor Number	X (meters)	Y (meters)	Elevation (meters)	Vegetation Class
1	331005	3923090	1024	Rich Cove and Slope Forests
2	332535	3921800	1275	Xeric Evergreen Forests
3	330825	3921080	1381	Acidic Cove and Slope Forest
4	334155	3920120	1312	Xeric Evergreen Forests
5	331335	3919880	1826	High-elevation Mixed Hardwood Forests
6	333555	3919610	1484	Montane Oak Forests
7	330525	3918140	1605	Rich Cove and Slope Forests
8	328695	3918050	1164	Rich Cove and Slope Forests
9	330135	3917300	1693	Spruce-fir Forests
10	330195	3916820	1734	High-elevation Mixed Hardwood Forests
11	324135	3916760	1059	Rich Cove and Slope Forests
12	326235	3916280	1548	Montane Oak Forests
13	331575	3916100	1670	Shrub Balds
14	332325	3915860	1578	Spruce-fir Forests
15	330795	3915230	1824	Shrub Balds
16	328425	3915020	1312	Acidic Cove and Slope Forest
17	330075	3915020	1701	Spruce-fir Forests
18	333195	3914990	1610	High-elevation Mixed Hardwood Forests
19	336375	3914720	1449	Xeric Evergreen Forests
20	327075	3914600	1601	Montane Oak Forests
21	330675	3914450	1788	Shrub Balds
22	334485	3914090	1127	Rich Cove and Slope Forests
23	332505	3914060	1336	Rich Cove and Slope Forests
24	328755	3913130	1642	Grasslands
25	330585	3913130	1845	High-elevation Mixed Hardwood Forests
26	327015	3912560	1198	Alluvial Forests
27	330615	3912560	1694	Non-alluvial Wetlands
28	334635	3911750	1202	Acidic Cove and Slope Forest

* X and Y coordinates are UTM zone 17

Appendix C

Atmospheric Modeling Receptors* for Linville Gorge Wilderness

Receptor Number	X (meters)	Y (meters)	Elevation (meters)	Vegetation Class
1	417525	3979490	1075	Acidic Cove and Slope Forest
2	418905	3978811	1273	Xeric Evergreen Forest
3	416325	3977240	1059	Xeric Evergreen Forest
4	419595	3977210	1271	Xeric Evergreen Forest
5	419895	3976280	1124	Rich Cove and Slope Forests
6	416715	3976160	1086	Acidic Cove and Slope Forest
7	418095	3975080	929	Montane Oak Forests
8	417375	3974900	1243	Xeric Evergreen Forest
9	420075	3974480	1211	Rock Outcrops
10	420345	3973490	865	Acidic Cove and Slope Forest
11	417915	3973100	1021	Acidic Cove and Slope Forest
12	419685	3972500	882	Rock Outcrops
13	418605	3971030	719	Montane Oak Forests
14	419955	3970970	1013	Rock Outcrops
15	419265	3969860	789	Rock Outcrops
16	417525	3969620	1070	Rich Cove and Slope Forests
17	420315	3968600	864	Montane Oak Forests
18	420495	3967490	941	Xeric Evergreen Forest
19	417285	3966800	762	Montane Oak Forests
20	416265	3966700	956	Acidic Cove and Slope Forest
21	419205	3966680	688	Rock Outcrops
22	417585	3966260	483	Alluvial Forests
23	418485	3965420	850	Rock Outcrops
24	416175	3964820	800	Xeric Evergreen Forest
25	419607	3963591	481	Xeric Evergreen Forest

* X and Y coordinates are UTM zone 17

Appendix D

Atmospheric Modeling Receptors* for Joyce Kilmer/ Slickrock Wilderness

Receptor Number	X (meters)	Y (meters)	Elevation (meters)	Vegetation Class
1	230715	3928220	397	Xeric Evergreen Forests
2	226455	3928190	682	Montane Oak Forests
3	226605	3926750	847	Montane Oak Forests
4	229845	3926660	536	Alluvial Forests
5	226575	3924860	829	Non-alluvial Forests
6	228945	3924560	669	Rich Cove and Slope Forests
7	225945	3924400	920	Xeric Evergreen Forests
8	230265	3924170	851	Montane Oak Forests
9	225045	3923000	1010	Montane Oak Forests
10	231495	3922220	994	Acidic Cove and Slope Forests
11	229455	3922070	1116	Xeric Evergreen Forests
12	228195	3921350	880	Acidic Cove and Slope Forests
13	232305	3921200	1201	Montane Oak Forests
14	230235	3920720	1257	Shrub Balds
15	226905	3920630	1119	High-elevation Mixed Hardwood Forests
16	231105	3920540	1382	High-elevation Mixed Hardwood Forests
17	228915	3919910	1376	Shrub Balds
18	229815	3919700	1606	High-elevation Mixed Hardwood Forests
19	233505	3919550	1306	Montane Oak Forests
20	229005	3919100	1348	Rich Cove and Slope Forests
21	230595	3918620	1258	Montane Oak Forests
22	227895	3918500	1632	High-elevation Mixed Hardwood Forests
23	227355	3918350	1611	Grasslands
24	232245	3917690	908	Xeric Evergreen Forests
25	233385	3916700	720	Acidic Cove and Slope Forests
26	233295	3916040	829	Rich Cove and Slope Forests
27	232185	3916010	952	Montane Oak Forests

* X and Y coordinates are UTM zone 17