Explore 5:

Albedo

Background Information:
Albedo is the amount of radiation reflected by a surface and is expressed as a percentage from the equation:

Albedo = (reflected radiation) / (incident radiation)

Reflected radiation means that light is reflected, so when something is bright and shiny. Incident radiation means that light is absorbed, so when something is dark.

Based on this definition, look at the chart shown below that gives the albedo of surfaces and answer the following questions:

1. What surface has potentially the highest albedo?

2. What three surfaces have potentially the lowest albedo?

TABLE 3.1
Average Albedo (Reflectivity) of Some Common Surface Types for Visible Solar Radiation

Surface	*Albedo (% reflected)*
Deciduous forest	15-18
Coniferous forest	9-15
Tropical rainforest	7-15
Tundra	15-35
Grasslands	18-25
Desert	25-30
Sand	30-35
Soil	5-30
Green crops	15-25
Sea ice	30-40
Fresh snow	75-95
Old snow	40-60
Glacial ice	20-40
Water body (high solar altitude)	3-10
Water body (low solar altitude)	10-100
Asphalt road	5-10
Urban area	14-18
Cumulonimbus cloud	90
Stratocumulus cloud	60
Cirrus cloud	40-50

3. Think of a time you've looked at fresh snow? Was it very bright or dull to your eyes? How would this relate to its albedo?

4. What is the albedo of both a deciduous forest and a coniferous forest?

5. How would the albedo of such forests affect the temperature on Earth?

6. If we planted a tree in our schoolyard, would that be better than having grass there? (Hint: Compare the albedo values for deciduous/coniferous forests and grasslands)

Albedo Chart from the American Meteorological Society's Weather Studies

Albedo Worksheet Answers

1. Water body (low solar altitude)

2. Water body (high solar altitude), asphalt road, and soil

3. Fresh snow is very bright because it has a relatively high albedo, which means it reflects a significant amount of visible light

4. The albedo of a deciduous forest is between 15-18 and a coniferous forest is between 9-15.

5. Since both forests have a low albedo, they absorb visible radiation, which is not absorbed by Earth's surface. So, forests help in cooling the surface of Earth.

6. The albedo for grasslands is between 18 and 25. The value for deciduous forests is 15-18 and coniferous forests are 9-15. This means that forests have a lower albedo and thus, absorb more heat from the environment. So, it would be beneficial to plant a tree instead of having grass there because excess heat from the environment would be absorbed better by trees than by grass.

Explain:

Further Explanation on Trees

Students will learn more about the explore activities through a PowerPoint presentation.

Elaborate 1:

Carbon Uptake of Local Michigan Trees

Tree Type and Growth Rate:

- American Basswood: Hard and Fast
- American Beech: Hard and Slow
- American Elm: Hard and Fast
- Black Cherry: Hard and Fast
- Boxelder: Hard and Fast
- Bur Oak: Hard and Slow
- Eastern Cottonwood: Hard and Moderate
- Hackberry: Hard and Fast
- Honey Locust: Hard and Fast
- Northern Red Oak: Hard and Fast
- Northern White Cedar: Conifer and Moderate
- Paper Birch: Hard and Moderate
- Pin Oak: Hard and Fast
- Red Maple: Hard and Moderate
- Shagbark Hickory: Hard and Slow
- Silver Maple: Hard and Moderate
- Sugar Maple: Hard and Slow
- Quaking Aspen: Hard and Fast
- Yellow Poplar: Hard and Fast
- White Ash: Hard and Fast
- Yellow Birch: Hard and Slow

Michigan Trees:
http://www.outdoor-michigan.com/Trees.htm

Table 2: Survival Factors and Annual Carbon Sequestration Rates for Common Urban Trees

Tree Age (yrs)	Survival Factors by Growth Rate			Annual Sequestration Rates by Tree Type and Growth Rate (lbs. carbon/tree/year)					
				Hardwood			Conifer		
	Slow	Moderate	Fast	Slow	Moderate	Fast	Slow	Moderate	Fast
0	0.873	0.873	0.873	1.3	1.9	2.7	0.7	1.0	1.4
1	0.798	0.798	0.798	1.6	2.7	4.0	0.9	1.5	2.2
2	0.736	0.736	0.736	2.0	3.5	5.4	1.1	2.0	3.1
3	0.706	0.706	0.706	2.4	4.3	6.9	1.4	2.5	4.1
4	0.678	0.678	0.678	2.8	5.2	8.5	1.6	3.1	5.2
5	0.658	0.658	0.658	3.2	6.1	10.1	1.9	3.7	6.4
6	0.639	0.639	0.644	3.7	7.1	11.8	2.2	4.4	7.6
7	0.621	0.621	0.630	4.1	8.1	13.6	2.5	5.1	8.9
8	0.603	0.603	0.616	4.6	9.1	15.5	2.8	5.8	10.2
9	0.585	0.589	0.602	5.0	10.2	17.4	3.1	6.6	11.7
10	0.568	0.576	0.589	5.5	11.2	19.3	3.5	7.4	13.2
11	0.552	0.564	0.576	6.0	12.3	21.3	3.8	8.2	14.7
12	0.536	0.551	0.563	6.5	13.5	23.3	4.2	9.1	16.3
13	0.524	0.539	0.551	7.0	14.6	25.4	4.6	9.9	17.9
14	0.512	0.527	0.539	7.5	15.8	27.5	4.9	10.8	19.6
15	0.501	0.516	0.527	8.1	16.9	29.7	5.3	11.8	21.4
16	0.490	0.504	0.516	8.6	18.1	31.9	5.7	12.7	23.2
17	0.479	0.493	0.505	9.1	19.4	34.1	6.1	13.7	25.0
18	0.469	0.483	0.495	9.7	20.6	36.3	6.6	14.7	26.9
19	0.459	0.472	0.484	10.2	21.9	38.6	7.0	15.7	28.8
20	0.448	0.462	0.474	10.8	23.2	41.0	7.4	16.7	30.8
21	0.439	0.452	0.464	11.4	24.4	43.3	7.9	17.8	32.8
22	0.429	0.442	0.454	12.0	25.8	45.7	8.3	18.9	34.9
23	0.419	0.433	0.445	12.5	27.1	48.1	8.8	20.0	37.0
24	0.410	0.424	0.435	13.1	28.4	50.6	9.2	21.1	39.1
25	0.401	0.415	0.426	13.7	29.8	53.1	9.7	22.2	41.3
26	0.392	0.406	0.417	14.3	31.2	55.6	10.2	23.4	43.5
27	0.384	0.398	0.409	15.0	32.5	58.1	10.7	24.6	45.7
28	0.375	0.389	0.400	15.6	33.9	60.7	11.2	25.8	48.0
29	0.367	0.381	0.392	16.2	35.3	63.3	11.7	27.0	50.3
30	0.359	0.373	0.383	16.8	36.8	65.9	12.2	28.2	52.7
31	0.352	0.365	0.375	17.5	38.2	68.5	12.7	29.5	55.1
32	0.344	0.358	0.367	18.1	39.7	71.2	13.3	30.7	57.5
33	0.337	0.350	0.360	18.7	41.1	73.8	13.8	32.0	59.9
34	0.330	0.343	0.349	19.4	42.6	76.5	14.3	33.3	62.4
35	0.323	0.336	0.339	20.0	44.1	79.3	14.9	34.7	64.9

Table 2: Survival Factors and Annual Carbon Sequestration Rates for Common Urban Trees (Cont'd)

Tree Age (yrs)	Survival Factors by Growth Rate			Annual Sequestration Rates by Tree Type and Growth Rate (lbs. carbon/tree/year)					
				Hardwood			Conifer		
	Slow	Moderate	Fast	Slow	Moderate	Fast	Slow	Moderate	Fast
36	0.316	0.329	0.329	20.7	45.6	82.0	15.5	36.0	67.5
37	0.310	0.322	0.320	21.4	47.1	84.8	16.0	37.3	70.1
38	0.303	0.315	0.310	22.0	48.6	87.6	16.6	38.7	72.7
39	0.297	0.308	0.301	22.7	50.2	90.4	17.2	40.1	75.3
40	0.291	0.302	0.293	23.4	51.7	93.2	17.7	41.5	78.0
41	0.285	0.296	0.284	24.1	53.3	96.1	18.3	42.9	80.7
42	0.279	0.289	0.276	24.8	54.8	99.0	18.9	44.3	83.4
43	0.273	0.283	0.268	25.4	56.4	101.9	19.5	45.8	86.2
44	0.267	0.277	0.260	26.1	58.0	104.8	20.1	47.2	89.0
45	0.261	0.269	0.253	26.8	59.6	107.7	20.7	48.7	91.8
46	0.256	0.261	0.245	27.6	61.2	110.7	21.3	50.2	94.7
47	0.251	0.254	0.238	28.3	62.8	113.6	22.0	51.7	97.5
48	0.245	0.247	0.231	29.0	64.5	116.6	22.6	53.2	100.4
49	0.240	0.239	0.225	29.7	66.1	119.6	23.2	54.8	103.4
50	0.235	0.232	0.218	30.4	67.8	122.7	23.9	56.3	106.3
51	0.230	0.226	0.212	31.1	69.4	125.7	24.5	57.9	109.3
52	0.225	0.219	0.206	31.9	71.1	128.8	25.2	59.4	112.3
53	0.221	0.213	0.199	32.6	72.8	131.8	25.8	61.0	115.4
54	0.216	0.207	0.193	33.4	74.5	134.9	26.5	62.6	118.4
55	0.211	0.201	0.188	34.1	76.2	138.0	27.2	64.2	121.5
56	0.207	0.195	0.182	34.8	77.9	141.2	27.8	65.9	124.6
57	0.203	0.189	0.177	35.6	79.6	144.3	28.5	67.5	127.8
58	0.198	0.184	0.171	36.3	81.3	147.5	29.2	69.2	130.9
59	0.194	0.178	0.166	37.1	83.0	150.6	29.9	70.8	134.1

URBAN FORESTRY CARBON SEQUESTRATION WORKSHEET

(Calculate each reporting year on a separate worksheet; photocopy if more than one sheet is required)

Reporting year: 19___

A. Species Characteristics (Refer to Table 1)			B. Tree Age	C. Number of Age 0 Trees Planted	D. Survival Factor (Refer to Table 2)	E. Number of Surviving Trees (C x D)	F. Annual Sequestration Rate (lbs./tree) (Refer to Table 2)	G. Carbon Sequestered (lbs) (E x F)
Name	Tree Type (H or C)	Growth Rate (S, M, or F)						
Total Pounds of Carbon Sequestered								
Total Pounds of Equivalent CO2 Sequestered							X 3.67	
Equivalent CO2 Sequestered in Short Tons							/2000	

Carbon Sequestration by Trees:
ftp://ftp.eia.doe.gov/pub/oiaf/1605/cdrom/pdf/sequester.pdf

Students will be required to come up with three different scenarios and complete the chart as shown above. They will pick three different types of trees that are native to Michigan. Then, the remaining information will be completed with the help of Table 2 located above. Once they find out the CO2 taken up by trees for each separate scenario, students will compare their carbon footprint and see which of the three scenarios matches best to cancel out their individual carbon footprint.

URBAN FORESTRY CARBON SEQUESTRATION WORKSHEET

(Calculate each reporting year on a separate worksheet; photocopy if more than one sheet is required)

Reporting year: ~~19__~~ 2013

A. Species Characteristics (Refer to Table 1)			B. Tree Age	C. Number of Age 0 Trees Planted	D. Survival Factor (Refer to Table 2)	E. Number of Surviving Trees (C x D)	F. Annual Sequestration Rate (lbs./tree) (Refer to Table 2)	G. Carbon Sequestered (lbs) (E x F)
Name	Tree Type (H or C)	Growth Rate (S, M, or F)						
American Beech	H	S	1	2	.798	1.596	1.6	2.55
Red Maple	H	M	1	1	.798	.798	2.7	2.15
Boxelder	H	F	1	3	.798	2.394	4.0	9.576
Total Pounds of Carbon Sequestered								14.276
Total Pounds of Equivalent CO2 Sequestered							X 3.67	52.393
Equivalent CO2 Sequestered in Short Tons							/2000	

Carbon Sequestration by Trees:
ftp://ftp.eia.doe.gov/pub/oiaf/1605/cdrom/pdf/sequester.pdf

My carbon footprint: 2,192 kg x $\frac{2.204 \text{ lb}}{1 \text{ kg}}$ = 4,382 lbs/yr
I would need to plant 92 sets of my trees to cancel my carbon footprint, or 557 trees!

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