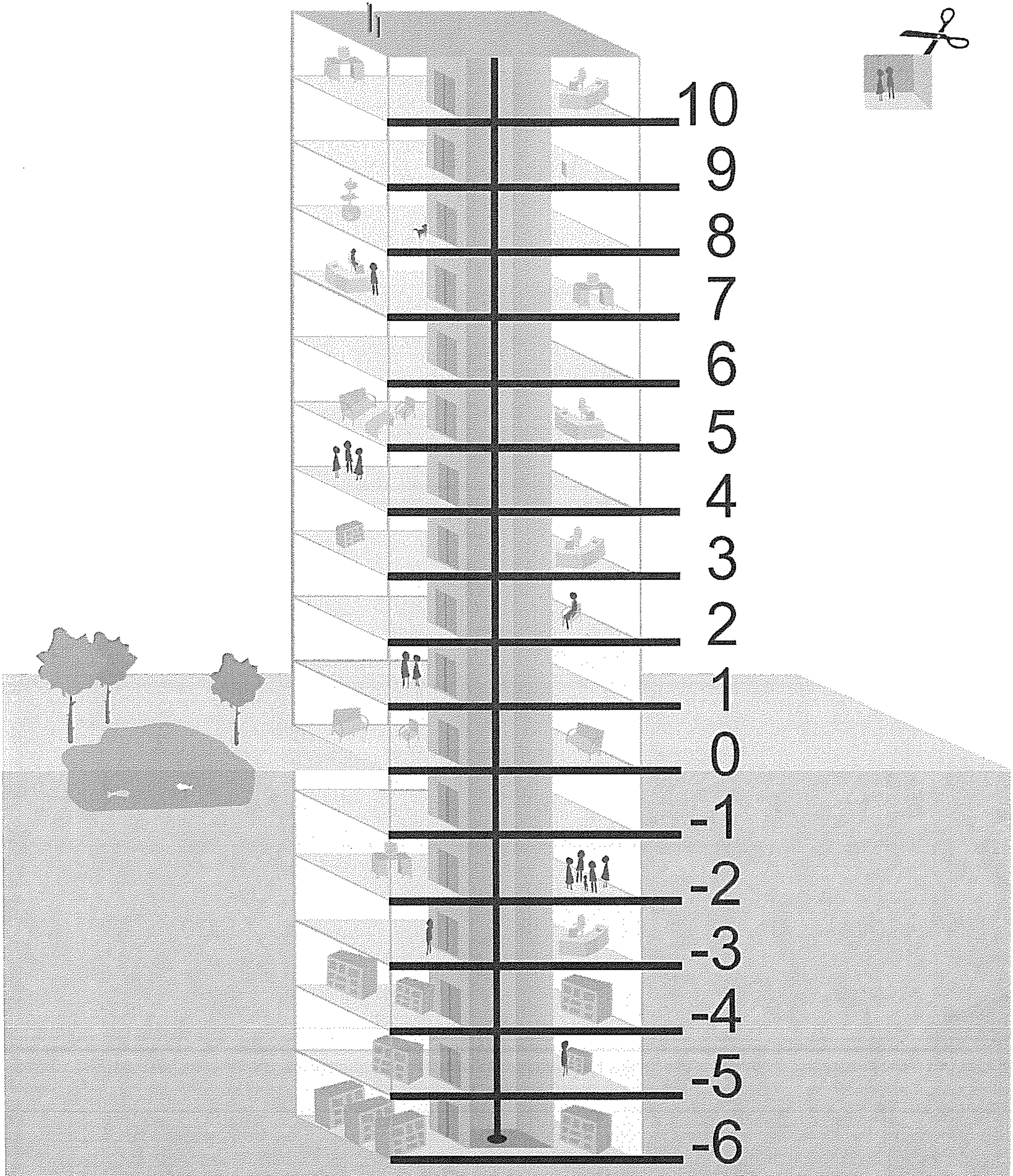
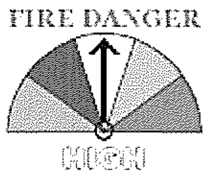


NCTM | ILLUMINATIONS marcopolo

Meet Smokey Bear

NAME ____________________________

In 1950, after a destructive fire in New Mexico, a badly burned bear cub was found by a U.S. Forest Service worker. The cub was healed and named "Smokey." Smokey Bear became an icon for the Forest Service's advertising campaign.



Today, Smokey Bear is often found on signs showing a fire-danger rating. The colors range from green, which indicates a minimal risk of fire, to red, which stands for extreme danger. What determines the risk level of a wildfire? How does Smokey know the fire-danger rating?

1. Working in your group, list all the factors that you think would affect the spread of a forest fire.

2. Which of these factors are most important? Which factors are least important?

3. Do you think that a fire will spread more quickly on a steep hillside or on level ground? Explain your reasoning.

4. Why must rangers know the likelihood that a fire will start? Why must rangers know the likelihood that a fire will spread?

The Angstrom Index

NAME ______________________________

A simple fire-danger rating system, the Angstrom Index, was devised in Sweden and has been used all over Scandinavia. It was designed to be computed mentally.

The index, I, is given by

$$I = \left(\frac{R}{20}\right) + \left(\frac{27 - T}{10}\right)$$

whereR is the percent of relative humidity andT is the air temperature in degrees Celsius.

The values of I translate into fire danger as follows:

I > 4.0	fire occurrence unlikely
4.0 > I > 2.5	fire conditions unfavorable
2.5 > I > 2.0	fire conditions favorable
I < 2.0	fire occurrence very likely

Using the Index

1. Hold R constant at 35 percent, and graphvs. T on your calculator. Describe your results and the window that you used.

2. With the humidity at 35%, how hot would it have to be for fire occurrence to be considered very likely? Unlikely?

The Nesterov Index

NAME ______________________________

The Nesterov Index is a simple fire-danger rating system that came about in 1949. It is as follows:

$$P = \sum_{i=1}^{W} (t_i - D_i) \cdot t_i$$

P represents the ignition index
W is the number of days since the last rainfall greater than 3 mm
t is the temperature in degrees Celsius
D is the dew-point temperature in degrees Celsius.

The computations begin on the first spring day when the high temperature is above freezing after snow melts and continue until a rainfall of 3 mm, whereupon the process starts anew. The index shows the fire danger:

VALUE OF P	FIRE DANGER
Between 0 and 300	Minimal
Between 301 and 1000	Moderate
Between 1001 and 4000	High
Above 4000	Extreme

Using the Index

1. Consult your local newspaper or the Internet to obtain data for the most recent August in your area or state. Compute the Nesterov index for each of the thirty-one days in August (assume that it rained on July 31). Complete the table on the following page.

Evaluating the Index

2. Compare the Nesterov and Angstrom indexes.

   a. Which seems easier to use, and why?

   b. Which seems more comprehensive, and why?

Date	High Temperature (°C)	Dew Point (°C)	% Relative Humidity	Nesterov Index (Value of P)
8/1				
8/2				
8/3				
8/4				
8/5				
8/6				
8/7				
8/8				
8/9				
8/10				
8/11				
8/12				
8/13				
8/14				
8/15				
8/16				
8/17				
8/18				
8/19				
8/20				
8/21				
8/22				
8/23				
8/24				
8/25				
8/26				
8/27				
8/28				
8/29				
8/30				
8/31				

The following table shows weather data for a southeastern state in the United States. Use the data to compute the Nesterov fire-danger index for this area.

DAY	TEMPERATURE AT 1 P.M. (°C)	DEW POINT (°C)	% HUMIDITY
1	27	14	46
2	28	17	51
3	18	17	49
4*	28	21	61
5	28	19	57
6	26	18	60
7	28	18	55
8	26	23	91
9	29	22	63
10	29	16	45
11	26	26	54
12	27	19	62
13*	27	17	54
14	23	17	69
15	28	16	48
16	29	19	53
17	29	19	53
18	30	15	40
19*	32	18	44
20	31	20	53
21	32	19	48
22*	24	22	85
23	30	19	53
24*	27	21	71
25	24	21	82
26	26	18	60
27	21	21	97
28	28	20	61
29	29	18	51
30	27	21	71
31	24	22	88

An asterisk (*) indicates that more than 3 mm of precipitation fell on that day.

Rules of Firefighting

NAME ____________________________

Fire-fighters don't rely completely on the computer-generated indices to control fires. There are some general rules that they incorporate into their tools when predicting how a fire will behave.

Rule #1: Fuel Moisture

When fuel moisture is below 5 percent, fires in both fine fuels and large fuels tend to spread equally quickly. When moisture levels are between 5 and 10 percent, fine-fuels fires spread more rapidly than large-fuel fires. At levels above 10 percent, the rates of spread are about the same again. When fuel moisture is above 15 percent, the fine-fuel fires will tend to extinguish themselves, whereas large-fuel fires will continue to spread.

1. On a single set of axes, draw possible graphs for the rate of spread of fine-fuel and large-fuel fires. Share your graph with another student. Discuss any differences.

Rule #2: Wind Speed

A general rule states that *rate of spread*, a dimensionless index that measures how quickly a fire will grow, will double for each increase of 4 meters per second (mps) in wind speed.

2. What is the nature of the relationship between rate of spread and wind speed? Draw a possible graph that relates rate of spread to wind speed.

3. Assume that the rate of spread is 6 when wind speed is 0 meters per second. Complete the table of values for rate of spread. Plot the graph of spread vs. wind speed.

RATE OF SPREAD	WIND SPEED
6	0 mps
	28 mps

4. How many miles per hour is 4 meters per second? What do you think is the reasonable part of the graph that you just drew?

Rule #3: Slope of Terrain

Several rules concern spread rate and the slope of the terrain on which the fire is spreading. One suggests that the rate of spread will double for every increase of 10° in slope. Discrepancies occur because other factors affect the rate of spread, including how packed the fuel bed is.

5. What is the nature of the relationship in this rule?

6. Use the data in the following chart to create scatterplots for each of the different kinds of fuel. Superimpose on the scatterplots the graphs of the functions previously obtained. How closely do these equations model the given rules?

Relative Rates of Spread

Slope in Degrees	Grass	Loose Litter	Tightly Packed Litter
0	1.0	1.0	1.0
10	2.3	1.7	1.3
20	6.6	3.8	2.4
30	15.0	8.0	4.5
40	30.1	15.8	8.4
50	60.5	30.8	15.9
60	126.7	64.0	32.6