Handout H08A-1. Example Answer Key – using density as example of the experimental variable

Actual answers will vary, depending on students' experimental variables and designs.

A. Our experimental question: What is the effect of density on fire spread?

B. Our hypothesis:

If the matchstick boards are densely packed, then fire will spread more quickly and more matchstick tops will burn than if the fuels are sparse.

C. Our *experimental variable,* the one thing that we will change from one trial to the next.

Stand density (number of matchsticks on the board).

D. Our treatments, the way we change our experimental variable from one trial to the next:

Treatment 1 (high density): 49 matches

Treatment 2 (medium density): 37 matches

Treatment 3 (low density): 25 matches

Treatment 4 (least dense): 12 matches

E. Our *controlled conditions*, things that we will not change from one trial to the next:

Ignition point, slope, moisture, matchstick height, wind, etc.

F. The things (variables) we will observe and measure – which become our experimental *results*:

Maximum flame height, start time, stop time (or duration – using a stopwatch), number of match tips burned.

G. This is our table for recording data from each burn: **Suggest that students do a couple of preliminary trials to fine-tune their measuring procedures and data table. You may ask that each team have you review these before they begin the full experiment.**

	Least dense (12 matches)	Low density (25 matches)	Medium density (37 matches)	High density (49 matches)
Max. flame Height (cm)				
Start time				
End time				
Duration (sec)				
Number of matches burned				

H. When you have finished your experiment, project your results or copy them onto the board.

I. Describe your experiment and results to the class. Indicate if there are any changes that you would make if you were to redo you experiment. Create two questions to ask the class about the data you collected. These questions should make your peers think critically about your experiment.

J. **Formal Report:**

1. What is your question about fire? That is, what are you trying to find out about fire behavior?
   How does stand density affect fire behavior?

2. What is your hypothesis?
   The denser the "forest," the faster fire will spread, the higher the flames will be, and the more match tips will be consumed.

3. Do you accept or reject your hypothesis? Show how your results justify your answer.
   I accept my hypothesis because, as predicted, the model forest with only a few matches burned more slowly, had shorter flames, and burned fewer matches than the forest with lots more matches.

4. Did your results help answer your question about fire? If so, how?
   Yes, my results showed three ways in which stand density affects fire behavior.

5. Did any new experimental questions emerge during your experiment? If so, what are they?
   What if there's wind? What if the trees are different heights? How do real trees differ from matches?

6. Based on your results, what practices would you recommend to (a) firefighters, (b) people with homes in forests, and (c) wildland managers?

   (a) Firefighters should use extreme caution when fires are burning in dense forests. They may not be able to work safely on these fires when it is very dry or hot, or if the wind is strong. (In fact, firefighters are cautioned against "direct attack" when flame lengths are high. That is, they cannot work right at the edge of the fire, especially not at the leading edge. Instead, they might use other techniques such as setting backfires or using water drops from aircraft. (National Wildfire Coordinating Group. 2014. Incident response pocket guide. PMS 461. National Wildfire Coordinating Group. 112 p.))

   (b) People with homes in the forest (especially dense forest) should clear an area around their homes and perhaps thin the forest nearby. (It is recommended that home owners reduce fuels for at least 200 feet from their house (National Fire Protection Association, Firewise Communities. 2016. The basics of defensible space and the "home ignition zone. National Fire Protection Association. Available: https://www.nfpa.org/Public-Education/By-topic/Wildfire/Preparing-homes-for-wildfire)).

(c) Wildland managers could consider thinning forests or creating wide fuel breaks to reduce flame heights and slow the spread of fire in dense forests that are near homes or other valuable resources.

7. (a) What are some limitations of the matchstick forest model? (b) What "real-world" influences on fire spread could not be tested with this model? (c) Could you revise the model or develop a different model to test them?

   (a) The model doesn't include surface fuels. The model tree crowns are much easier to ignite than actual tree crowns. Trees are distributed uniformly in the model, unlike in real forests. The topography is completely uniform – no gullies or ridges. Trees tilt with the slope. The board is very small, whereas real forests can extend for many miles…

   (b) Real wildland fuels were not tested. Uneven topography could not be tested. Large-scale fire spread was not tested…

   (c) I would revise the model to use a larger board, perhaps add uneven terrain. I would use real wildland fuels. I would add surface fuels…