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Simplified Volcano Hazard Maps User-Experience (UX) Study Results

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OVERVIEW & TOP FINDINGS

The purpose of this research is to identify any usability issues and opportunities to improve the design for superb communication of volcanic hazards and risks. From this research, insights into the intuitiveness and risk-communication deficiencies of these hazard maps will help create a new methodology for evaluation map-based communication products implemented by USGS and its partners/stakeholders, Risk COP members, and practitioners around the world to alleviate volcanic risk and hazards.

This study utilized three previously developed hazard maps for Newberry Volcano, Lassen Volcanic Center, and Crater Lake (Image 1, 2, 3). Each of the maps was evaluated through a usability test to determine how well the communication objective for risk-communication was met and measure utility. From this evaluation, the study also looks to pinpoint the user's needs and opportunities for design changes that allow for greater risk-communication. Furthermore, the study gathered feedback from six students from the University of Tennessee. They were shown two volcano maps (Newberry Volcano and Lassen Volcanic Center) and asked questions about their impressions and understanding of the map, and then they were shown a video of a lahar hazard in Japan (Participants viewed the video on a separate web page, but this is the video as available through YouTube: https://www.youtube.com/watch?v=kznwnpNTB6k). After viewing the video, they were asked questions about their impressions of the Crater Lake map. This was to evaluate how the video impacted their understanding of the map and the lahar hazard.

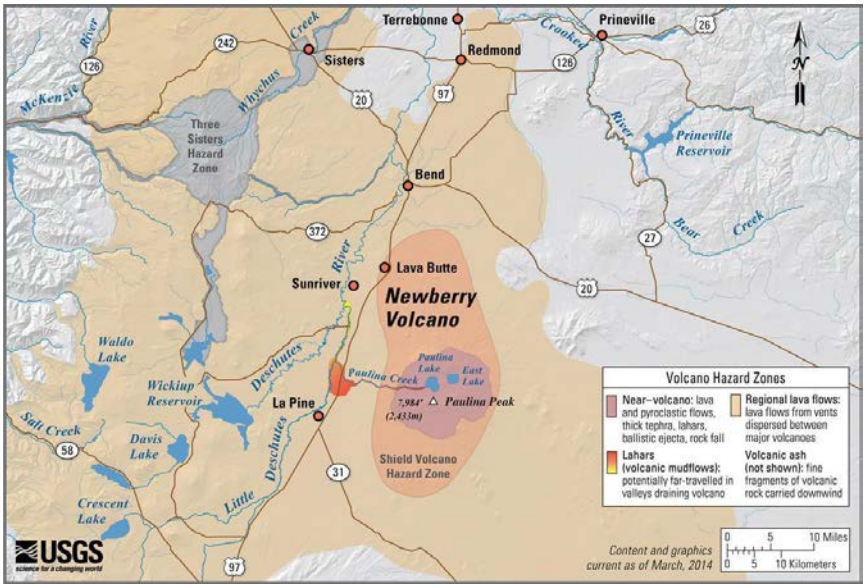


Image 1. Newberry Volcano, OR simplified hazards map

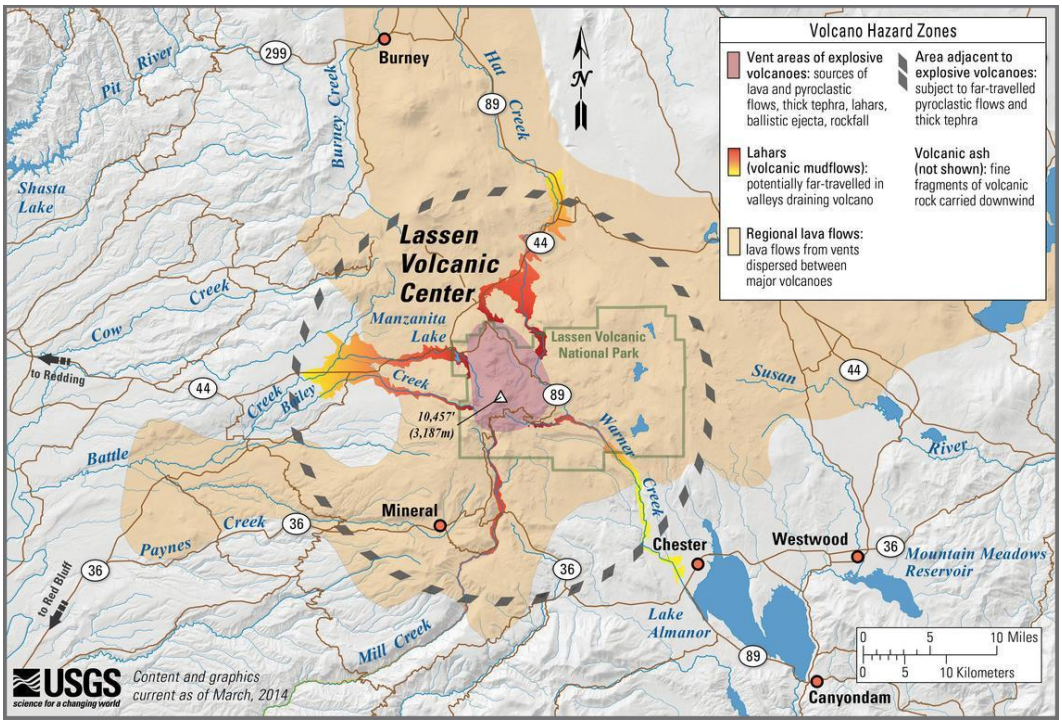


Image 2. Lassen Volcanic Center, CA simplified hazards map.

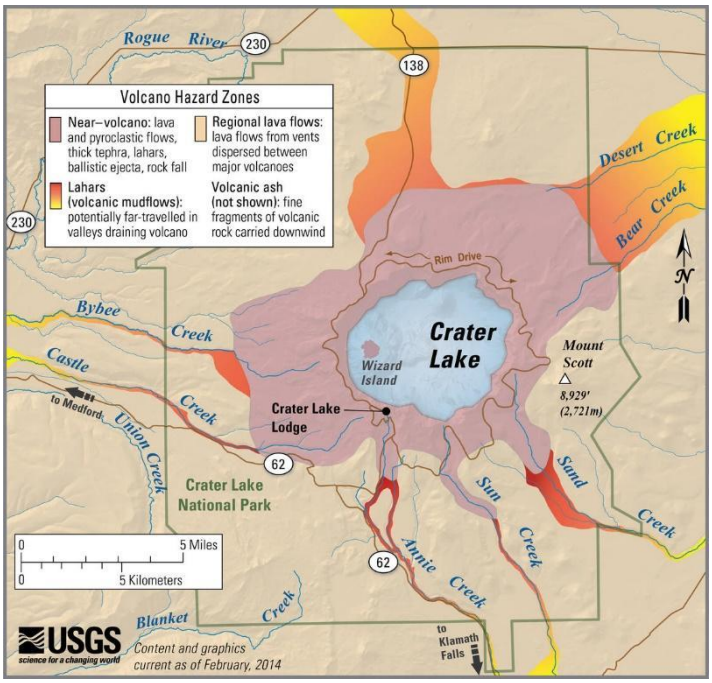


Image 3. Crater Lake, OR simplified hazards map.

This usability study was conducted using Loop11, a remote UX software. First, the participants received a URL that took them to the unmoderated usability test (they completed the study on their own without guidance from a usability researcher). Then, participants went through a series of questions and tasks for these maps at their own pace. These questions and tasks for

the study were designed to evaluate the hazard maps' utility and risk-communication. The study examined how the hazard maps communicate risk and how the users use and understand the volcanic hazards within each map.

TOP FINDINGS

The lahar video helped users better understand the severity of the volcanic hazard.
We asked the users if the video changed their impression of the lahar hazard represented in the maps. One user stated, "Yes. In the prior maps, the lahars seemed smaller and maybe easier to avoid. [The video] makes them very clear. And after watching the video, I fully understand the danger."

Some colors were confusing for users.
Users did not express difficulty with the lahar hazard colors, but colors such as beige for regional lava flows and light pink/blush for near volcano or vent areas implied safety and they did not think it adequately showed the danger of these areas. Additionally, brown roads were hard to see in the map color scheme.

Users felt some map elements were not clearly represented in either the map legend or in the main map.
Many suggested the maps portrayed elements that were not adequately described in the legend, such as outline of national park, roads, and evacuation routes. As a result, the users were not sure of the importance of some elements, and therefore, did not find them useful.

This report includes the details of how we conducted our research, the results found, and a list of recommended changes for the maps used in the study.

PROJECT METHODOLOGY

Outreach & Screening

For the study, our participants were college students actively attending the University of Tennessee. Six students accepted the invitation and completed the study in its entirety. This number of users who participated met the range of participants one would want for a usability study.

Participant Profiles

Of our six participants, most considered themselves either “Not familiar” or “Slightly familiar” with volcano hazard maps and their ages mostly fell between eighteen and thirty-two with just one above that range. Only one participant considered themselves “Moderately familiar” with volcano hazard maps. In terms of general maps exposure, our participants interacted with maps on various frequencies, as shown in Tables 1. The backgrounds of our participants mainly consisted of those involved in Information Sciences with a few in fields such as Mathematics and International business. The study duration ranged from just under eighteen minutes to twenty-three minutes.

Table 1. Participant profiles

USER #	FAMILIARITY WITH VOLCANO HAZARD MAPS	GENERAL MAP EXPOSURE	DISCIPLINE/ FIELD OF STUDY	STUDY DURATION
1	Not familiar	Monthly	Mathematics	17:43
2	Slightly familiar	Weekly	Geology, Information Science	20:21
3	Not familiar	Weekly	Data Coordinator	17:42
4	Slightly familiar	Occasionally	Information Sciences - UX Design	23:25
5	Slightly familiar	Daily	Information Sciences	20:29
6	Moderately familiar	Occasionally	Supply Chain Management, International Business	20:57

Testing Setup & Post-Test Questions

In partnership with the USGS Cascades Volcano Observatory, the User-experience Lab at the University of Tennessee conducted a remote usability study from March 23rd to April 17th, 2021. This study was unmoderated and conducted virtually using Loop11, a tool for remote usability

tests. Loop11 uses an interface that leads the participants through the tasks and questions within a pop-up window that was displayed over the hazard maps and video (Image 4).

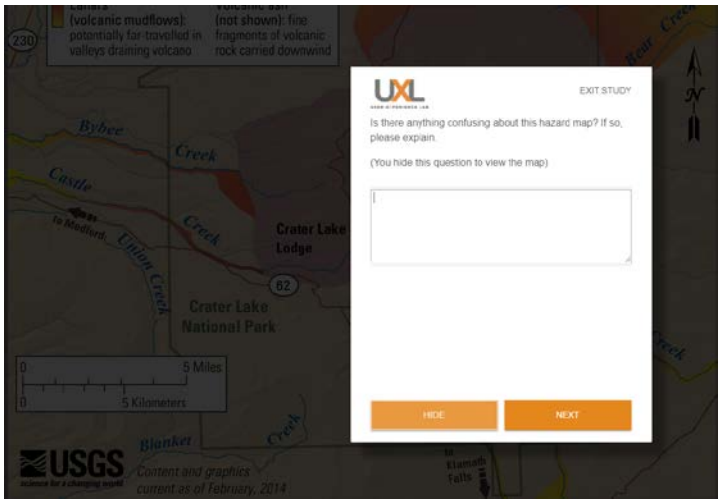


Image 4. Screenshot of Loop11 interface

Our study consisted of three volcano hazard maps. Two (Newberry and Lassen) were shown before the participants viewed a video of a lahar, and one map (Crater Lake) after they viewed the video. We constructed the study to examine the effect a video showcasing a lahar hazard would have on the users' thoughts on the hazard maps' description of this hazard and how they would use the map for the real-world scenario within the study.

Participants were asked to complete nine tasks, including viewing the hazard map, identifying high and low hazard risk on the map, locating valleys near the volcano, and clicking on useful elements of the map and points of interest. After each task, the user answered post-task questions; there were a total of 24 that asked about what the user liked, disliked, and what they would want to see on the hazard map to help provide more utility for them.

The complete usability study can be found in Appendix A.

RESULTS

The sessions were recorded for each participant and these recordings were reviewed and the data was analyzed. This data included time on task, task success rate, user satisfaction, and visible mouse movements. Below is a description of the findings found for each task and question associated with each of the maps.

Newberry Volcano

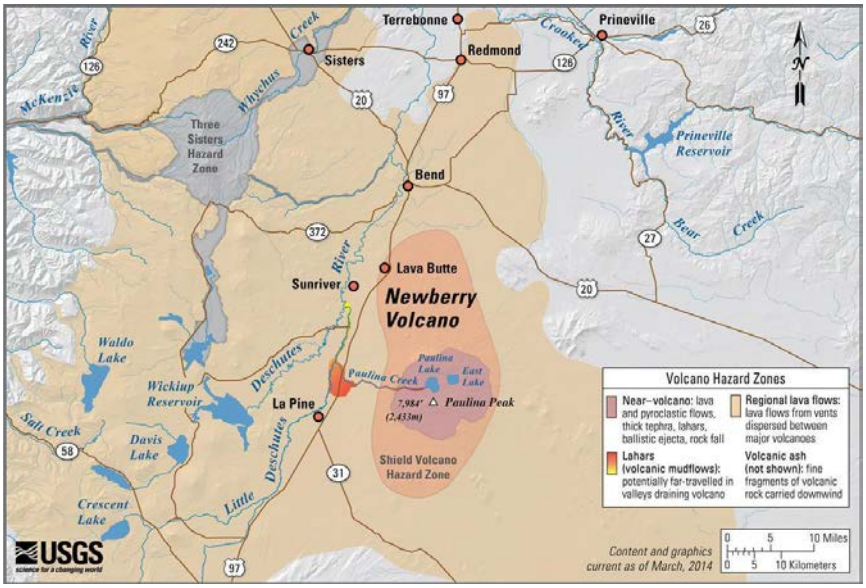


Image 5. Newberry Volcano, OR simplified hazards map

The first task we asked participants was, “You will be shown a hazard map for 30 seconds. Take that time to review it. Go at your natural pace and where your attention is drawn. After 30 seconds, we’ll ask about your first impressions.” We then asked participants, “What information do you think this map is trying to convey?” They said:

- The potentially dangerous zones which would exist if a volcano erupted
- Various areas with different types and extensions of lava flow
- places that are dangerous in the case of a volcano, and the level of impact for an area.
- The areas/towns that would be affected if a volcano erupted.
- Where the danger zones are if a volcano erupts.
- Showing where the lava is from a volcano that erupts and then where the possible areas that could be severely/mildly affected

The next task asked the user to click on the area where their attention was first drawn. This task was chosen to emulate eye-tracking and to see what visual elements gained the user's attention. Their attention was drawn to the near-volcano area (image 6). All of their attention was drawn to the center of the map.

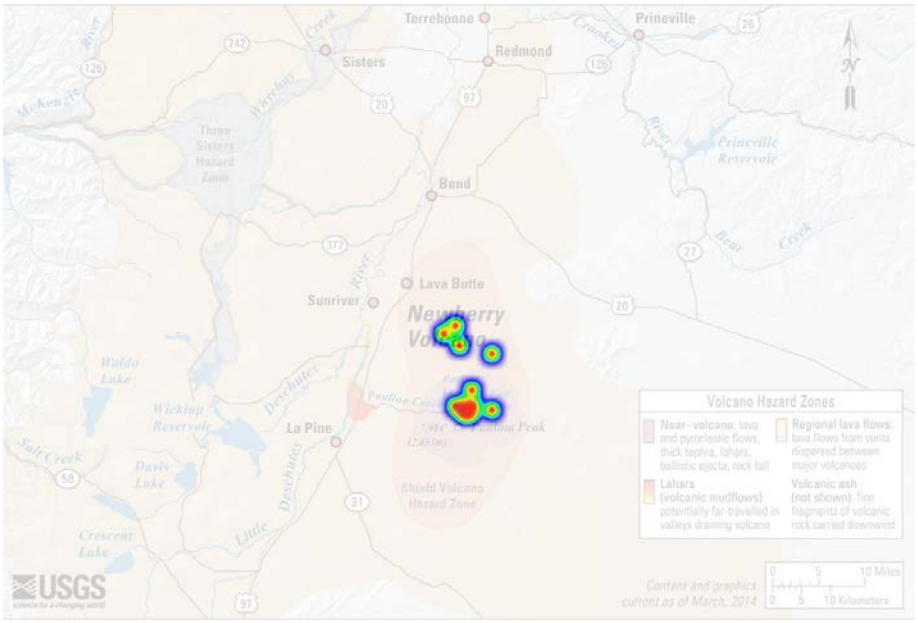


Image 6. Newberry Volcano: Element that first drew your attention

We then asked them to select one of three choices for what best described a lahar. Five of the 6 participants correctly said "A far-traveling volcanic mudflow or debris flow that moves violently along a valley," and only one said "A collection of stationary volcanic debris found within a valley."

We then asked them several questions about the colors used in the hazard map and any suggestions for improving the map. Their full responses can be found in Appendix B.

Participants pointed out that not all the map features are identified in the map legend. For instance, the peach color for the Shield Volcano Hazard Zone is not described in the legend (as is the purple area for Three Sisters Hazard Zone). One said, "I couldn't find what the dark peach color meant (outside of the near volcano color). I noticed after looking at it further that it says "Shield Volcano Hazard Zone" on the map, but I was looking for this information in the legend." Similarly, participants were not sure why ash was described in the legend but not represented in the map. One said, "I would also like to know why the volcanic ash is not shown (or why it is included in the legend if not shown)."

One participant thought the beige color for the regional lava flow zone seemed like a “safe” color, and more cautionary colors might be more useful. Another participant thought the red dot color that identified the towns was too similar to the hazard zone colors. They said, “The color of the lahars seems similar to the color of the dots that are next to town names (i.e. La Pine, Sunriver, etc.). I'm not sure if that is intentional or not, but it is a bit confusing.”

The last feedback some users had was on the lack of context for the Newberry Volcano (e.g. Where is it in the US?). This might have been a disadvantage of how we portrayed it during the usability study, but it is important to keep in mind that providing additional regional information (e.g., state, location within a state, etc.) could help people understand where the volcano is located.

While participants had some questions about the colors, participants thought the map adequately described the lahar hazard. All participants thought the map described lahar well to very well, including 33% who considered the description to be “very well”.

Lassen Volcanic Center

The next map we showed the participants was the Lassen Volcanic Center (image 7). On this map we focused on asking them to identify map elements (e.g., high or low risk and valleys).

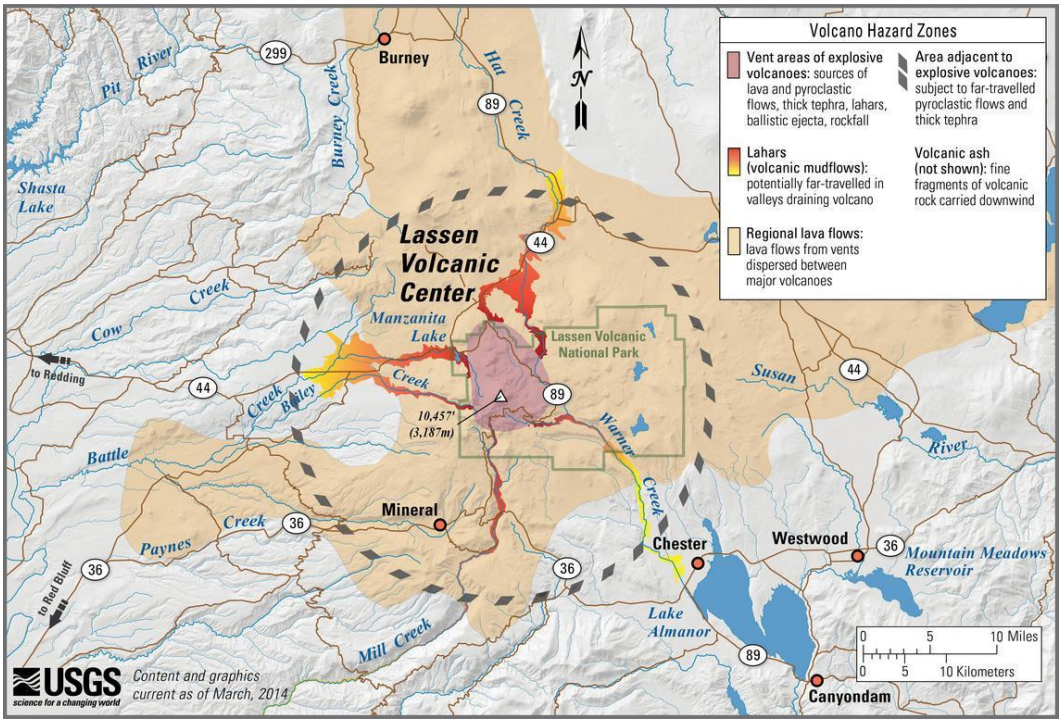


Image 7. Lassen Volcanic Center, CA simplified hazards map.

We first asked participants to click on an area that has a high risk of experiencing a lahar if the volcano erupted.

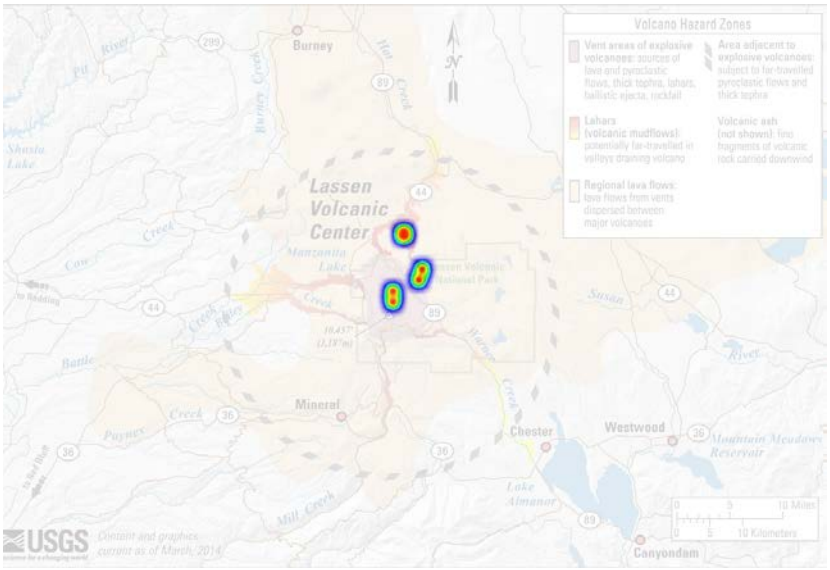


Image 8. Areas participant considered high risk of experiencing lahar

Four of the participants clicked on a deep red of the lahar hazard, and two participants clicked on the "vent areas of explosive volcanoes." Then we asked them to click on an area they considered at low risk of experiencing a lahar if the volcano erupted (image 9).

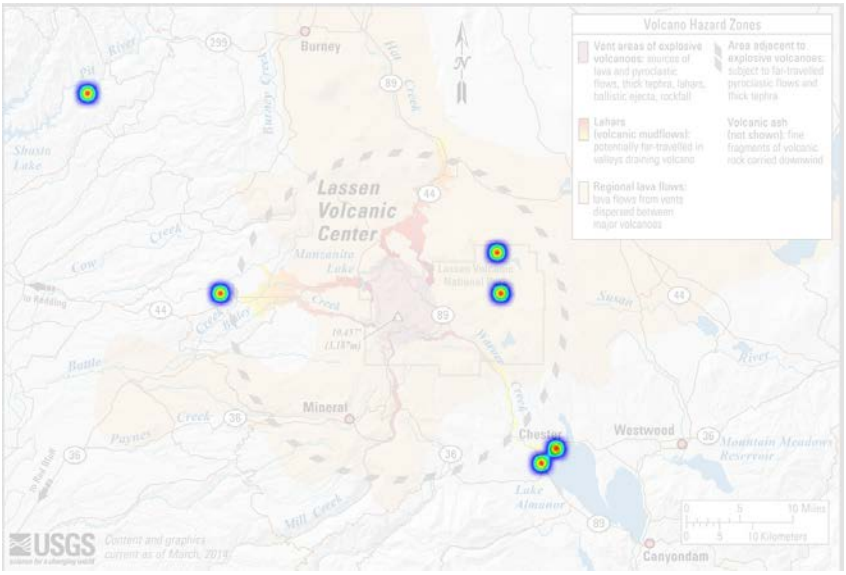


Image 9. Areas participants considered low risk of experiencing lahar

While all participants clicked on areas that were not at a high risk of lahar, half of the areas were outside the lahar hazard zone, so they had no risk of lahar. This response could be a result of 1) misunderstanding low risk versus no risk in the task wording or 2) not understanding

the gradient color of the lahar legend. Unfortunately, we did not ask a follow-up question to provide additional context for their response.

However, the next task asked users to "click on an area on the map where a valley or river valley near the volcano resides." Their responses indicate that they had a difficult time identifying valleys (image 10). First, participants took nearly twice as long to identify valleys as they did to identify high or low risk areas. On average, participants identified a high risk or low risk area in 20 seconds, while they took an average of 38 seconds to identify a valley.

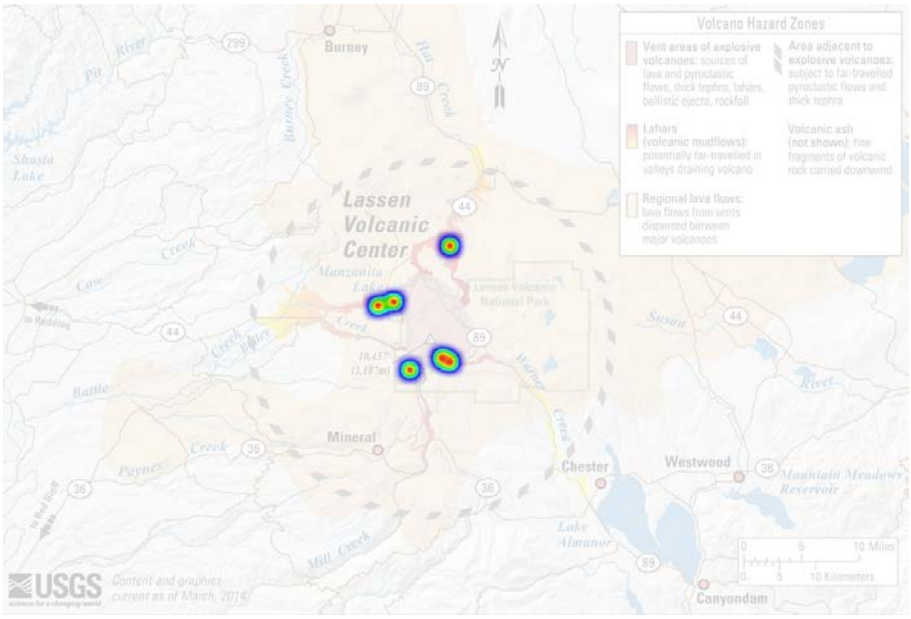


Image 10. Valley or river valley identified by participants

Secondly, only half the participants identified a river valley that also was affected by lahar hazard. The other three participants selected a river near the volcano that was not affected by lahar. In a previous response about the Newberry Volcano map, one participant said, "It is also a little hard to see the topography beneath the colored sections," and this might still be true for this map. This might have affected their ability to easily identify river valleys on the Lassen Volcanic Center map.

While participants seemed to struggle to identify valleys, four of the six participants identified that high ground was safer from a lahar hazard. One participant said neither high ground or river valley was safer and one thought the river valley was safer from lahar hazard. Half the participants said the map legend informed their decision, and the other three selected sections of the map (town of Chester, Hat Creek in the North, and Warner Creek to the West) as having informed their decision about lahar safety.

We wrapped up the section on the Lassen Volcanic Center map by asking for feedback on the map colors, elements, and additional comments. Participants had less to say about this map

than the first map (Newberry Volcano). This might be because many of their comments about Newberry volcano also applied to this map or participants might have become more familiar and comfortable with volcano hazard maps by the second map. Their full responses can be found in Appendix B.

However, they pointed out that roads and the National Park outline are represented in the map but not in the map legend, a similar issue to what they described in the first map (Newberry). One participant said, "My only thought is that the roads are not included in the legend - I was able to figure out what the brown lines were through seeing them with the highway numbers, but there may be some confusion there," and another said, "If the green outline for the National Park section is significant, I think it should be mentioned in the key. If not, it should be outlined in a more muted color."

Only one participant was confused by the "area adjacent to explosive volcanoes." no other participants expressed confusion or suggestions for improving the map.

Lahar Hazard Video

After the tasks and questions about the Lassen Volcanic Center, each participant viewed a video of a lahar hazard.

First, we provided the USGS definition of a lahar: A lahar is a hot or cold mixture of water and rock fragments that flow quickly down the slopes of a volcano. They move up to 40 miles per hour through valleys and stream channels, extending more than 50 miles from the volcano. Lahars can be extremely destructive and are more deadly than lava flows.

Then they viewed the video of a lahar hazard from an eruption that occurred in Japan. The video was on its own web page for this study, but the same video was posted on YouTube: https://www.youtube.com/watch?v=kznwnpNTB6k. It is titled "Lahars in Japan" and was posted on Jan 29, 2012 by Apolline Project.

After viewing the one minute and 24 second video, the participants were asked, "What is your main takeaway from this video?" Their responses showed that the video portrayed how dangerous and fast lahars could travel. Their responses are listed below:

- Lahars are very fast-moving currents of hot (or cold) rock which are a very dangerous aspect of a volcanic eruption
- Lahars are extremely powerful and destructive. They also move very quickly through valleys or stream beds. Frightening videos!
- Nature is scary. That was a really alarming video.
- Lahars can be extremely destructive and dangerous to the people and land surrounding a volcano.
- Lahars are extremely dangerous and fast paced

- It comes very fast and takes out everything in its path. It happens in lower areas as we[ll]

Crater Lake

After viewing the map, we showed one last volcano hazard map (Crater Lake: Image 11). We first showed them the map for 30 seconds and asked them to "Take the time to review it. Go at your natural pace and where your attention is drawn." We then asked them to identify what part of the map first drew your attention, and 5 of the 6 participants identified Crater Lake, and one participant identified Desert Creek lahar area.

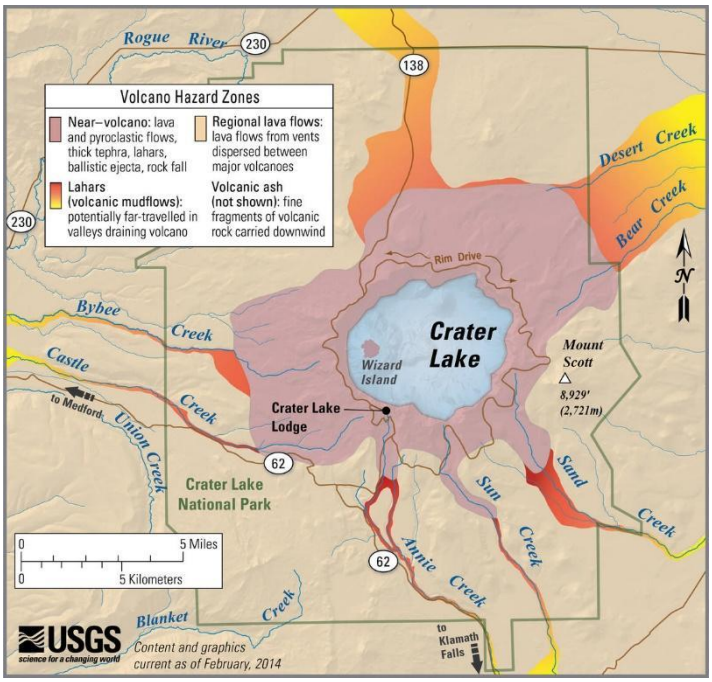


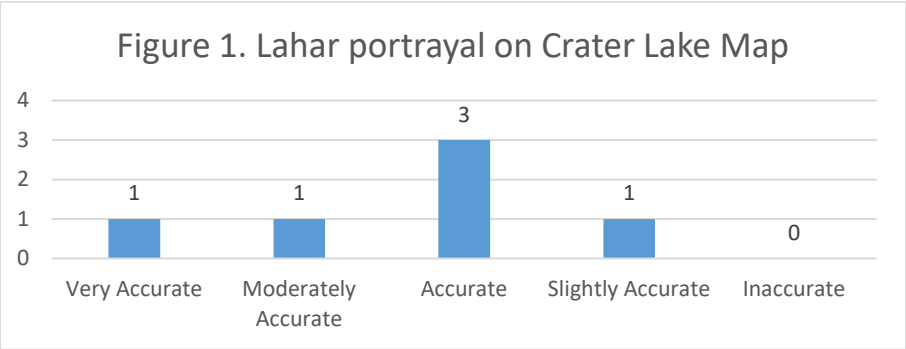
Image 11. Crater Lake, OR simplified hazards map.

We wanted to evaluate how the video influenced their understanding and interpretation of the volcano hazard map. We first asked them directly, "Did the previously shown video change your impression of the lahar hazard represented on these maps?" All the participants said the video impacted their understanding by showing exactly how impactful/dangerous they are and also helped them realize how it could impact people in the hazard zones. Their responses are below:

- The previous video helped to put into perspective how dangerous these lahars are, and why they are important to pay attention to in a graphic about volcano hazards
- Yes, it gave me more context and explained why/how these areas could be so far reaching down riverbeds.
- OH yes. In the prior maps, the lahars seemed smaller and maybe easier to avoid? THis makes them very clear. and after watching the video? I fully understand the danger

- Yes, it did. Because the lahar is represented with orange and yellow, I thought that it consisted of lava even though the description said otherwise. After watching the video, I now realize its contents. I also understand how dangerous it is to the surrounding area.
- After watching the video, I looked more closely at the lahars on the map and thought about all the people that could be impacted along the routes of those lahars.
- It shows they are in or by mostly rivers

We then asked if the video influenced how accurate they thought the map portrayed the dangers of lahars. While the video seemed to influence their understanding of lahars (see previous comments), they all thought the map accurately showed lahar hazards (figure 1).



Next, we wanted to see how the video might influence how they would use the information on the map to make a decision. We gave them this scenario:

> Your friend suggests that you should continue driving down towards Klamath Falls on Route 62 after hearing at Crater Lake Lodge warnings for a potential eruption. They claim that even if the volcano did erupt you all would make it out of the lahar hazard zones in time. Based on this map and the video you previously watched - Do you agree? Please explain.

They all adamantly said no, including one participant who exclaimed, “No, I do not agree. The video showed how fast and dangerous the lahar can be. A large overflow could come unexpectedly and we would have little time to make it out.” Their full responses are below:

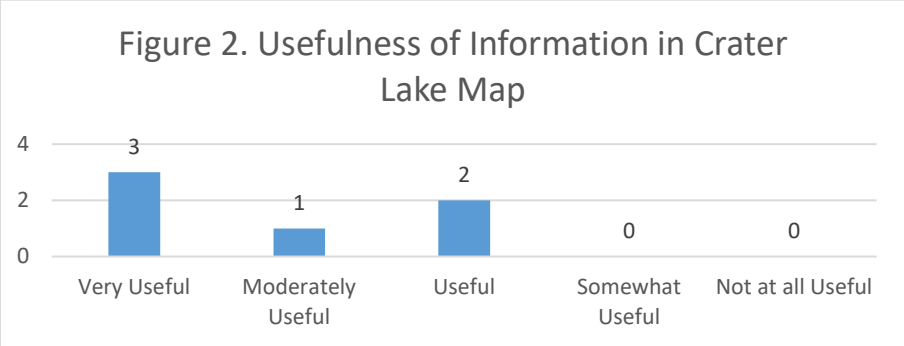
- I don't believe it'd be a good idea to do this, as the map clearly indicates that there are likely to be lahar zones running right around route 62 in that direction
- Nope, nope, nope. The road to Klamath Falls travels right along the Annie Creek creek bed.
- Wow. hard to say. I guess so? Or maybe not. the lahars move so quickly. I can't see a better route though (actually, 62 to medford looks ok?)
- No, I do not agree. The video showed how fast and dangerous the lahar can be. A large overflow could come unexpectedly and we would have little time to make it out.
- No. We should not travel on 62, we would get caught in a lahar. I'm not sure what route we should take, but I know for sure we should not take route 62 towards Klamath Falls from Crater Lake Lodge. The lahar would be too fast and we would get caught in it.

- I would choose another route that is not near a river

This section is the only section that mentions Group 2 (group 2 usability analysis is in a separate report)

The video seemed to greatly influence their decision making. In Group 2, their responses to the same scenario, but without viewing a lahar video beforehand, were not as adamant. They said things like "I'm not sure how much time we'd have but this seems like the best option," and "I do not agree; lahars seem to intersect with Route 62 at multiple points, sometimes for several kilometers." So while both groups (those shown the video before the scenario and those shown the video afterwards) identified that Route 62 was not the best option, those who viewed the video seemed to be more firm and more aware of the danger this route could pose.

All participants considered the information contained on the map to be useful (Figure 2).



We ended the Crater Lake section by asking them for any feedback on colors, map elements, and additional suggestions. Most of their feedback for the Crater Lake map reflected their earlier feedback for the previous two maps. Their full responses can be found in Appendix B.

They mentioned things like the near-volcano hazard color did not well identify its danger level, volcano ash is not shown on the map, and identifying safe/evacuation routes.

Additionally, one participant wondered why the near-volcano hazard zone was not directly next to Mount Scott. They thought there must be something about the area's topography that is not accurately portrayed in the hazard map. Another participant also thought it was hard to identify the actual volcano since it was not in the center of the near-volcano area like the other maps.

USABILITY FINDINGS & RECOMMENDATIONS

ISSUE SEVERITY RATING KEY

The symbols below are used to rate each usability issue or finding in terms of its importance or impact to the usability of the simplified hazard map. Ratings are based on the number of users who had the problem and also how seriously the problem affected the user or kept the user from completing the task. Usability issues are also determined by how they measure to the usability guidelines recommended by usability.gov[1] and Nielsen Norman Group's 10 usability heuristics for user interface design.[2]

Each UX issue documented in this section was assigned a priority level based on the following criteria:

Low: User may experience insignificant time delays or mild frustration, but will be able to complete the task.
Medium: User may experience noticeable delay or frustration, but will be able to complete the task with added effort.
High: User will experience noticeable delay or frustration, may not be able to complete the task.
Success: Users were able to easily perform their desired task
Data: Describes summarized data of interest

[1] https://guidelines.usability.gov/
[2] https://www.nngroup.com/articles/ten-usability-heuristics/

1. Intentional Use of Colors — Medium

There were several usability issues about the use of color in the map. The use of colors could incorrectly link map elements or cause inaccurate interpretations. These issues include:

- The dots that represent cities/towns are orange-red, which is the same color that is used to indicate lahars.
- Beige is typically a neutral color and users could overlook that it indicates a hazard and is not a "safe" or background color. Especially maps where the entire map is beige, it could be easy to overlook that beige has a hazard meaning.
- Brown road lines blend into the other hazard zone colors.

Recommendations:

- Use colors intentionally
- Remember color has an implied meaning.
    - Red often represents hazard/danger, but colors like beige are often viewed as neutral or safe, this could result in users misinterpreting parts of the maps.
- Brown may not be the best color to represent roads. Consider alternative colors (e.g., black) that will stand out against the background.

2. Representation on Map and Map Legend — High

There were several usability issues with the map and map legend. Some items on the map were not displayed in the legend. This created confusion about what the map elements or colors meant. This included:

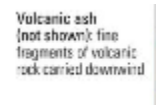
- Shield volcano hazard zone (Newberry)
- Three Sisters hazard zone (Newberry)
- Roads/evacuation routes (all maps)
- White triangle (Peak)
- National Park lines (Lassen Volcanic Center and Crater Lake)

Recommendations:

- All elements that are presented on the map should be identified in the legend. Currently the legend only displays volcano hazard zones, but there are other elements that need clarification.
    - Shield Volcano hazard zone on the Newberry map should be identified in the legend.
    - Road color/symbol should be identified in the legend.
    - The volcano or mountain peak (white triangle symbol) should be identified in the legend. It could be easy to overlook, especially on maps like Crater Lake where the peak is not in the near-volcano hazard zone.

- Specifically, for the Three Sisters Hazard zone, it is not clear that the Newberry volcano is so close to another volcano (Three Sisters) that its hazard zones are appearing on the Newberry volcano map. This relationship and how each volcano appear on the other hazard map should be marked clearly in the legend.

3. Representation on Ash — Medium

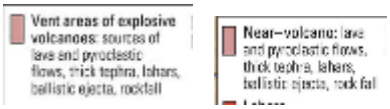


Ash is presented in the legend but not displayed on the map. Users struggled to understand why it could not be displayed on the map. Identifying that volcanic ash is "not shown" in the map is not a strong enough indicator to identify 1) how ash could affect the map areas 2) why ash is not shown.

Recommendation:

- Add text to the legend that explains that ash could affect all shown areas of the map or similar wording to indicate how ash is part of the hazard map. Currently, the legend only gives a description, which is not useful when identifying volcano hazards.

4. Uniformity Among Maps — High



Some maps (e.g. Newberry and Crater Lake) use the salmon/pink color to represent near-volcano hazards, while other maps (e.g. Lassen Volcanic Center) use the salmon/pink color to represent vent areas of explosive. If a user is viewing multiple maps, they may not closely read each map legend, and instead, infer information portrayed on one map based on previous map legend.

Recommendation:

- Each volcano hazard map should be uniform. Each should use the same color/symbol to mean the same thing. If maps have different elements, then a new color/symbol should be used.
    - Or if the color/symbol indicates the same thing, the wording should also be the same. If near-volcano hazard zone and vent areas of explosive volcanoes are the same thing they should use the same wording.

5. Novice Users Understanding of Lahar — Data

While the simplified volcano hazard maps identify lahar hazards with an understandable definition and with clear colors that indicate hazard, users unfamiliar with the region or volcano hazards might still miss the importance signified by the hazard maps. The video showing the

lahar in Japan seemed to greatly impact how the participants viewed the information on the map. Many indicated that they did not realize how dangerous and fast-moving lahars were or how hard a lahar would be to escape before viewing the video.

Recommendation:

- It might be useful to always provide information or links to information near the simplified hazard maps to provide additional context.
- As you design hazard maps, keep in mind that many users are unfamiliar with the content and terminology that may be common for the map-creator (e.g., lahar, pyroclastic flow, tephra, ballistic ejecta, etc.).

CONCLUSION

Overall, the simplified volcano hazard maps accurately portrayed the volcano hazards present in the area. Making simple changes like adding additional elements to the legend and changing the color of roads and towns could help improve the usability of the maps. Additionally, keeping things consistent between maps, including colors and terminology, will improve their usability. It is also important to keep in mind that many users of these hazard maps will not be familiar with volcano hazards and using clear and simple language and providing additional context (e.g., more description, additional links, identifying the small map on a larger map) could help even the most novice correctly interpret the map elements and its purpose.

APPENDIX A: UX TEST SCENARIO

- **Question 1 - Measuring Hazard Map Proficiency [Rating Scale]**
    - How familiar are you with hazard maps for volcanoes?
- **Question 2 - Measuring General Map Exposure [Rating Scale]**
    - How often do you interact with maps in general?
- **Question 3 - User's Background [Open Ended: 1 Item]**
    - What is your discipline/field of study?
- **Question 4 - User's Age [Rating Scale]**
    - What is your age?
- **Task 1 - First Impression - Newberry Volcano [Time Bound]**
    - You will be shown a hazard map for 30 seconds. Take that time to review it. Go at your natural pace and where your attention is drawn. After 30 seconds, we'll ask about your first impressions.
- **Question 5 - User's Understanding [Open Ended: Comment Box]**
    - What information do you think this map is trying to convey?
- **Task 2 - User's First Observation [First Click]**
    - Click on a part of the map that first drew your attention.
- **Question 6 - User's Recollection [Multiple Choice: 1 answer]**
    - Which one of these statements below best describes a lahar?
        - A flow of lava found near a volcano. (1)
        - A collection of stationary volcanic debris found within a valley.(2)
        - A far-traveling volcanic mudflow or debris flow that moves violently along a valley. (3)

- **Question 7 - Colors on Map - Newberry**
    - How do you feel about the use of colors in this hazard map?
- **Question 8 - Discussing Perplexity -Newberry**
    - Is there anything confusing about this hazard map? If so, please explain.
- **Question 9 - Comments/Suggestions - Newberry**
    - Are there any other comments or suggestions for how we could improve this map?
-
- **Question 10 - Effectiveness of the Map's Lahar Description [Rating Scale: 1 answer]**
    - How well does this hazard map adequately describe a lahar?
- **Task 3 - High Risk Lahar Hazard - Lassen Volcanic Center [First Click]**
    - You will be shown another hazard map. When shown, click on the area that has a high risk of experiencing a lahar if the volcano erupted.
- **Task 4 - Low Risk Lahar Hazard - Lassen Volcanic Center [First Click]**
    - You will be shown another hazard map. When shown, click on the area that has a low risk of experiencing a lahar if the volcano erupted.
- **Task 5 - Valley/River Valley Near Volcano - Lassen Volcanic Center [First Click]**
    - Click on an area on the map where a valley or river valley near the volcano resides.
- **Question 11 - Lahar Safety - Lassen Volcanic Center [Multiple Choice: 1 answer]**
    - Which of the two options is safer from a lahar hazard?
        - High ground
        - River valley
        - Neither

- **<u>Task 6 - Click on Useful - Lassen [First Click]</u>**
    - Click on an area on the map that informed your decision for the previous question.
- **Question 12 - Colors and Symbols on Map - Lassen [Open Ended: Comments box]**
    - Are there any particular elements (colors and symbols) on this map that make it difficult to understand? If so, which ones?
- **Question 13 - Discussing Perplexity - Lassen [Open Ended: Comments box]**
    - Is there anything confusing about this hazard map? If so, please explain.
- **Question 14 - Comments/Suggestions - Lassen [Open Ended: Comments box]**
    - Are there any other comments or suggestions for how we could improve this map?
- **<u>Task 7 - Lahar Video [Time Bound]</u>**
    - The USGS provides the following definition of lahars.
        - Definition:
            - A lahar is a hot or cold mixture of water and rock fragments that flow quickly down the slopes of a volcano. They move up to 40 miles per hour through valleys and stream channels, extending more than 50 miles from the volcano.
            - Lahars can be extremely destructive and are more deadly than lava flows.
    - You will be shown a short video of a lahar hazard from an eruption that occurred in Japan. After reviewing the video, we will then ask about your impressions.
- **Question 15 - User's Takeaway [Open Ended: Comments box]**
    - What is your main takeaway from this video?
- **<u>Task 8 - Second Impression - Crater Lake [Time Bound]</u>**

    - You will be shown another hazard map for 30 seconds. Take the time to review it. Go at your natural pace and where your attention is drawn. After 30 seconds, we'll ask about your thoughts on it in relation to the video you just watched.

- **<u>Task 9 - User's First Observation - Crater Lake [First Click]</u>**
    - Click on the part of the map that first drew your attention.
- **Question 16 - User's Opinion of Map After Video [Open Ended: Comments box]**
    - Did the previously shown video change your impression of the lahar hazard represented on these maps? Please explain.
- **Question 17 - Hazard Map Accuracy - Crater Lake [Rating Scale: 1 answer]**
    - Based on the previous video, how accurate do you feel the map shows the dangers that lahars pose?
- **Question 18 - Scenario - Crater Lake [Open Ended: Comments box]**
    - Your friend suggests that you should continue driving down towards Klamath Falls on Route 62 after hearing at Crater Lake Lodge warnings for a potential eruption. They claim that even if the volcano did erupt you all would make it out of the lahar hazard zones in time.
        - Based on this map and the video you previously watched - Do you agree? Please explain.
- **Question 19 - User's Thoughts on Map - Crater Lake [Open Ended: Comments box]**
    - Is there other content or information that's missing on this hazard map that would have been helpful for this scenario?
- **Question 20 - Measuring Usefulness - Crater lake [Rating Scale: 1 answer]**
    - How useful is the information provided in this hazard map?
- **Question 21 - Colors on Map - Crater Lake [Open Ended: Comments box]**

    - How do you feel about the use of colors in this hazard map?

- **Question 22 - User Thoughts on Clarity - Crater Lake [Open-ended: Comments Box]**
    - Is the information conveyed clearly? If not, what do you feel is missing?
- **Question 23 - Discussing Perplexity - Crater Lake [Open-ended: Comments Box]**
    - Is there anything confusing about this hazard map? If so, please explain.
- **Question 24 - Comments/Suggestions - Crater Lake [Open-ended: Comments Box]**
    - Are there any other comments or suggestions for how we could improve this map?
- **Question 25 - Study Feedback [Rating Scale: 1 answer]**
    - How was your experience with the task and questions within this research study?

Appendix B. User Comments

Newberry Volcano

- How do you feel about the use of colors in this hazard map?
    - I think that they are well-chosen to convey the meanings they are trying to
    - I liked them, and found them useful. However, I couldn't find what the dark peach color meant (outside of the near volcano color). I noticed after looking at it further that it says "Shield Volcano Hazard Zone" on the map, but I was looking for this information in the legend.
    - the colors are fine. not to alarming.
    - I think the use of colors was effective in this map. They were not overly vivid, but my eyes were still drawn to the areas that would be most effected. It may be better to use a different color for the regional lava flows zone because beige seems like a "safe" color. These areas are still affected so a more cautionary color may be more useful.
    - The color of the lahars seems similar to the color of the dots that are next to town names (i.e. La Pine, Sunriver, etc). I'm not sure if that is intentional or not, but it is a bit confusing. I'm not sure what the lighter color surrounding Newberry Volcano is supposed to indicate. Because the legend makes it seem like the smaller circle that encompasses Paulina Lake matches the "Near Volcano" part of the legend.
    - They are quite similar but they match the colors of lava. They are not too similar to differentiate. The ash should have been shown in some way too.
- Is there anything confusing about this hazard map? If so, please explain.
    - No, I don't believe there is anything confusing about the map
    - Please see the last comment. I would also like to know why the volcanic ash is not shown (or why it is included in the legend if not shown).
    - Not really
    - i did not find anything confusing about this map
    - Besides the colors, I think everything else looks clear.
    - This map doesn't show where is it well. I know none of these places so I am at a disadvantage. Again, why talk about volcanic ash if its not shown
- Are there any other comments or suggestions for how we could improve this map?
    - I can't think of any improvements to be made to this map!
    - See previous two comments. It is also a little hard to see the topography beneath the colored sections.
    - I can't think of any improvements to be made to this map!
    - I think the Volcanic Ash zone should also have some sort of visual on the map since it is mentioned in the key.
    - There are two different "Hazard Zones" - Three Sisters and Shield Volcano. I think it would be helpful to distinguish what those mean from what is on the legend.

    - Show the regions of volcanic ash and make sure viewers know what area they are looking at. I don't personally know where any of these markers are, so I do not know where this volcano is.

Lassen Volcanic Center

- How do you feel about the use of colors in this hazard map?
    - No, I believe the map portrays its information well
    - My only thought is that the roads are not included in the legend - I was able to figure out what the brown lines were through seeing them with the highway numbers, but there may be some confusion there.
    - No
    - I wasn't quite sure why the National Park was outlined so clearly.
    - no
    - No
- Is there anything confusing about this hazard map? If so, please explain.
    - No, I think I understand everything that was meant to be conveyed
    - No I dont think so
    - No
    - I find the symbol used for the "Area adjacent to explosive volcanoes" to be a little confusing. I would have preferred just a normal outlined circle
    - No
    - No
- Are there any other comments or suggestions for how we could improve this map?
    - I dont' believe so
    - Nothing else for me
    - could be clearer on where exactly to go?
    - If the green outline for the National Park section is significant, I think it should be mentioned in the key. If not, it should be outlined in a more muted color.
    - No
    - Show the volcanic ash areas and give a location to where this volcano is.

Crater Lake

- How do you feel about the use of colors in this hazard map?
    - Again, I think they are great representations of the hazards they are associated with.
    - I like that the lahars are colored in red and yellow gradient to indicate danger.
    - really good. clear
    - Like I stated earlier, the orange and yellow for the lahar shows that it is hazardous but also gives the first impression that it is made up of lava. Overall, the colors give a clear picture of where the real danger is.
    - The colors are clear
    - The near - volcano color should be changed to draw more attention to it.

- Is the information conveyed clearly? If not, what do you feel is missing?
    - I believe all information is conveyed clearly.
    - Again, I am left wondering about the volcanic ash. I would like to know the extent of this, how dangerous it is, etc. Actually, the danger level of each hazard would be helpful.
    - I mean, aside from a clear escape route, but I guess if you avoid the lahars you'd be ok.
    - I think the actual volcano should be highlighted more clearly. It took me a little while to find it since it was not in the center of the "near-volcano" section.
    - If there are safer routes to take to get away from the volcano, I'm not sure what they are from this map. I'm not familiar with the area, however.
    - Volcanic ash is not shown
- Is there anything confusing about this hazard map? If so, please explain.
    - No, nothing is confusing to me
    - I don't think so
    - Not at all confusing
    - I am confused as to why there is no near-volcano zone right around the volcano. I think it is confusing what the direct surrounding area to Mount Scott is truly like.
    - It is hard to tell where is safe on this map.
    - No
- Are there any other comments or suggestions for how we could improve this map?
    - If I had to pick something, I would only wonder if the roads could be made a little more obvious as to what they are. But I think that even that is nitpicky
    - None except those already stated
    - Just the clearly noted escape routes
    - I believe I shared all the suggestions I have
    - N/A
    - the ability to zoom out and see more of the area and make notes to people with this map of safety routes.