EVALUATING THE USEFULNESS AND RESPONSE TO GRAPHICAL INFORMATION USED TO COMMUNICATE UNCERTAINTY-DRIVEN AND PROBABILISTIC WINTER WEATHER FORECASTS

Jacob Morse NOAA Hollings Scholarship Penn State Schreyer Honors College Thesis

Survey Results from U.S. General Public

833 Responses

Section 1: General/Background Questions *(starts on slide 2)*

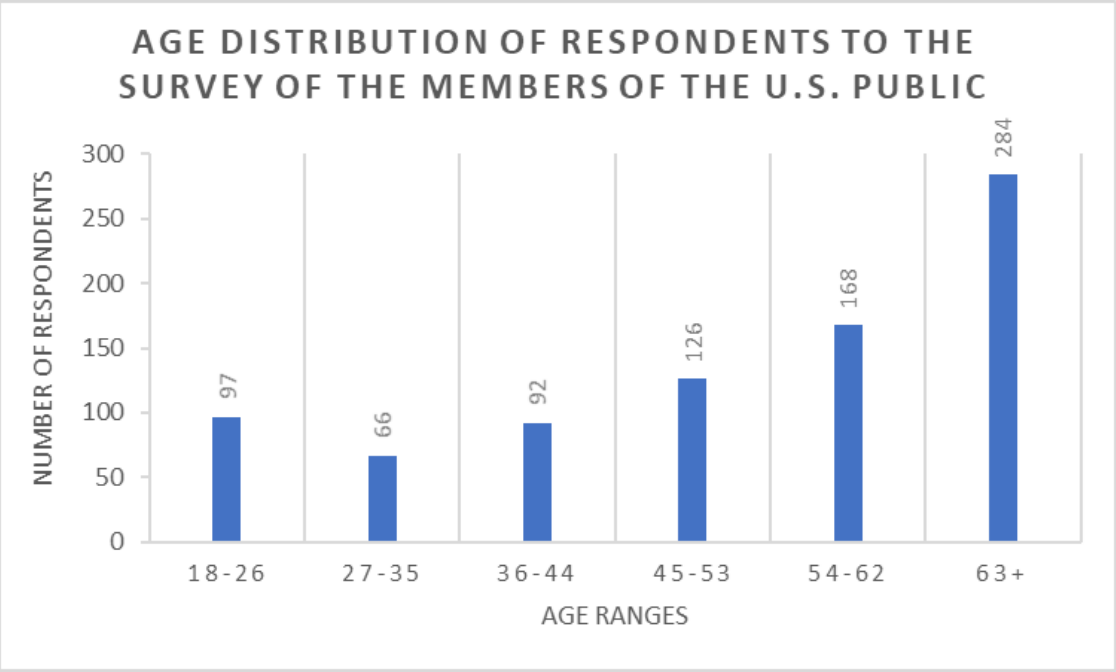
Section 2: Four Scenarios (Past Real Examples of Graphics Used By NWS Offices to Communicate Upcoming Winter Storms) *(starts on slide 6)*

Section 3: Specific Questions About the Graphics *(starts on slide 22)*

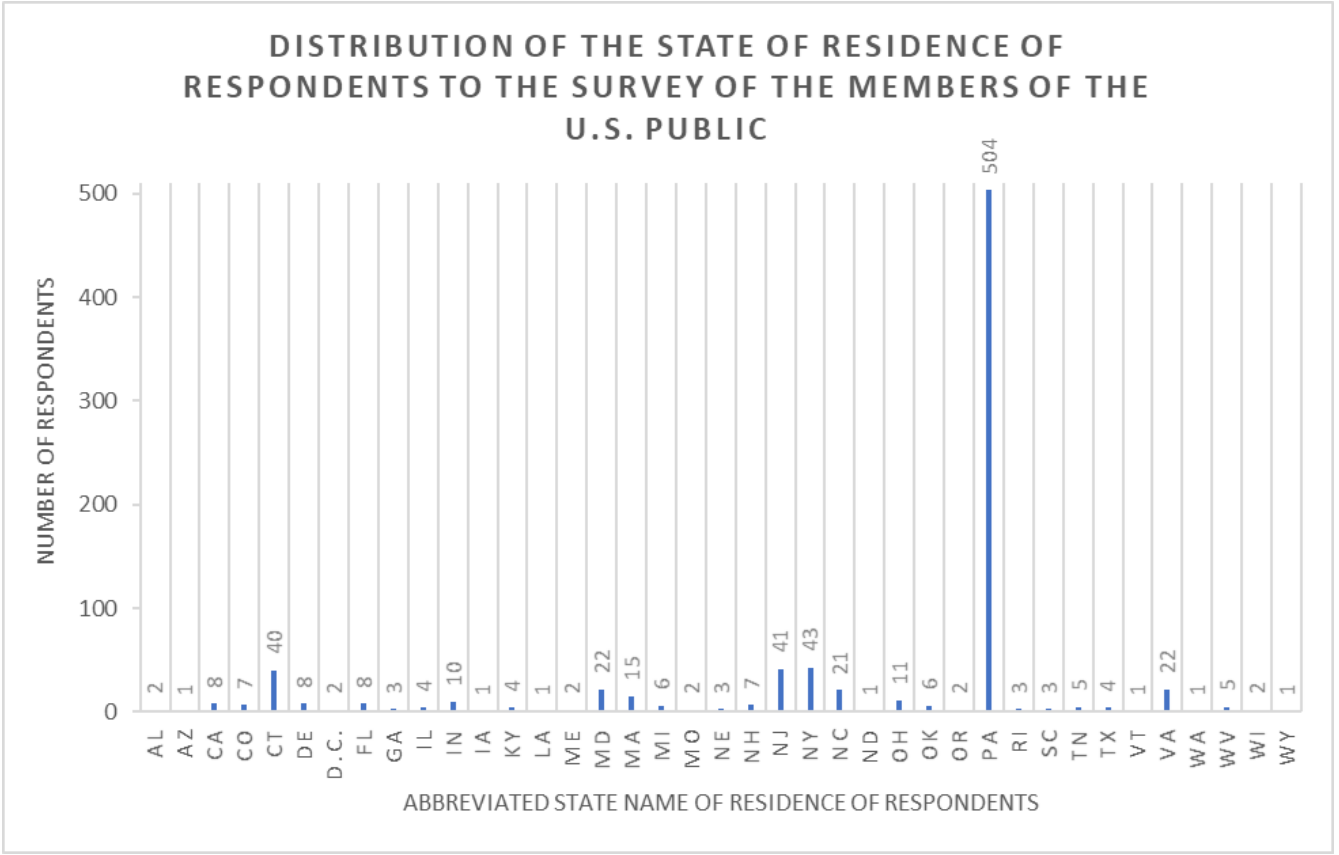
(look at upper right of each slide to know what section you're in)

N = number of respondents for each question

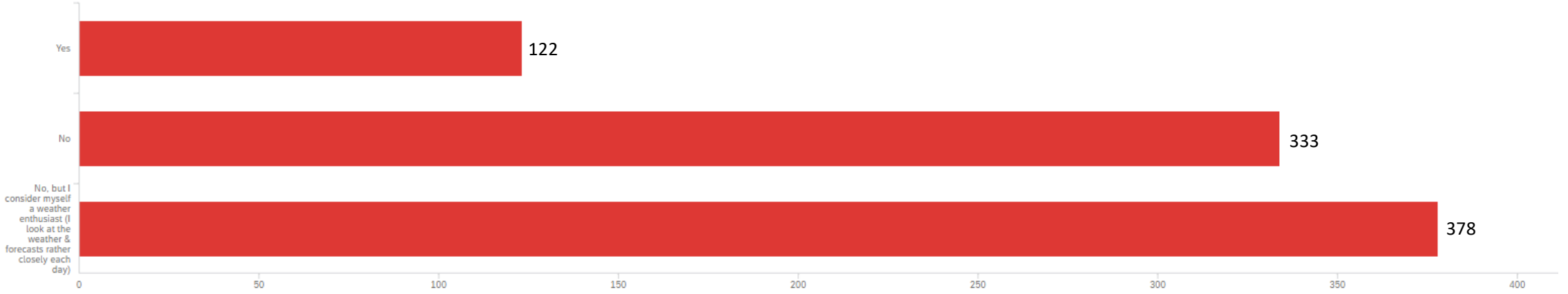
Please select your age group
(N=833)



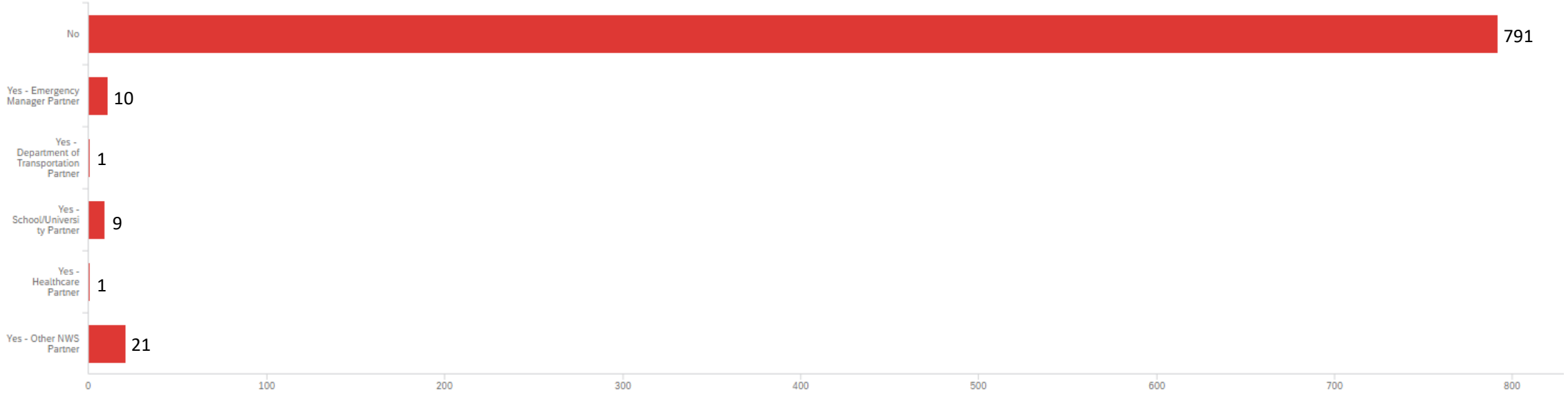
In which state do you currently reside?
(N=832)



Do you have a background in meteorology? (working towards a degree, have a degree, etc.) *(N=833)*

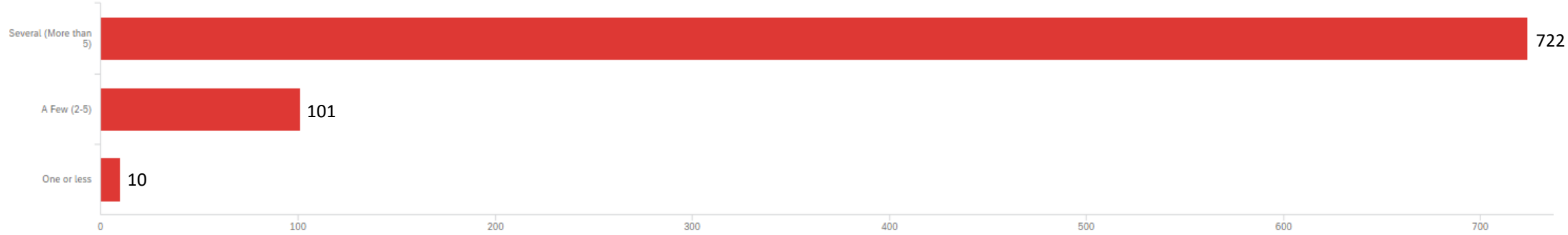


Are you a partner of the National Weather Service? *(N=833)*

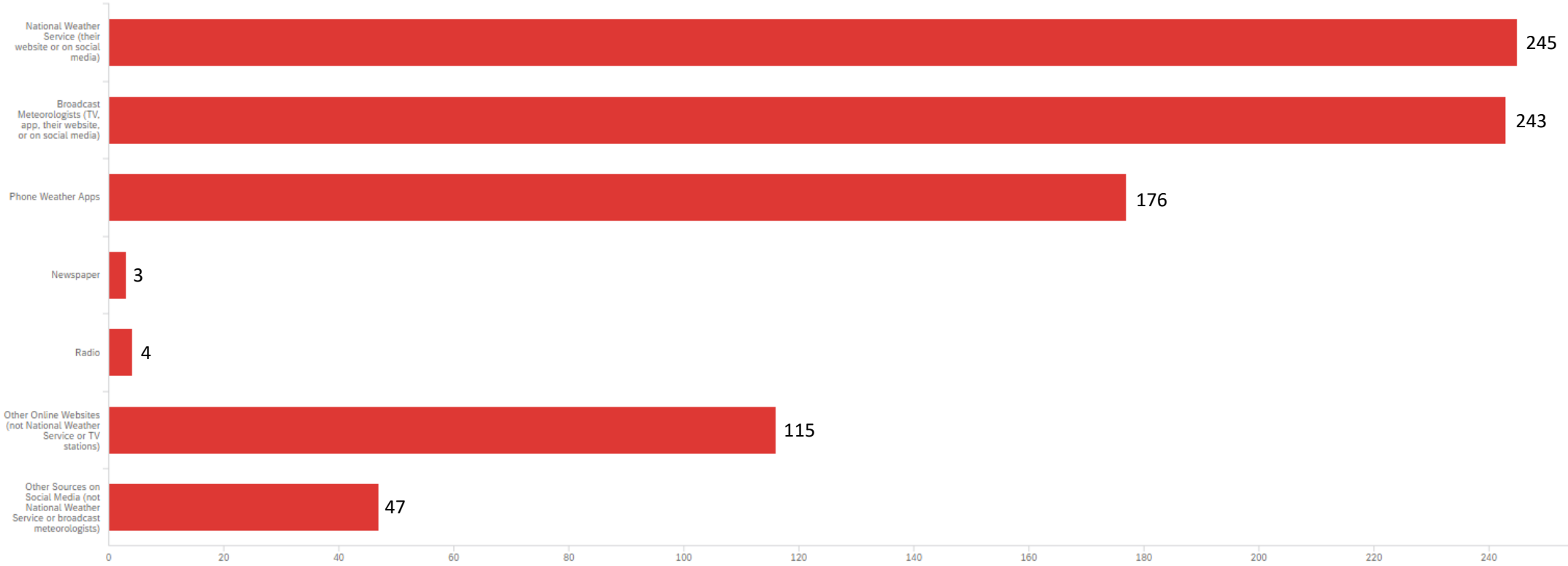


Section 1: General/Background Questions

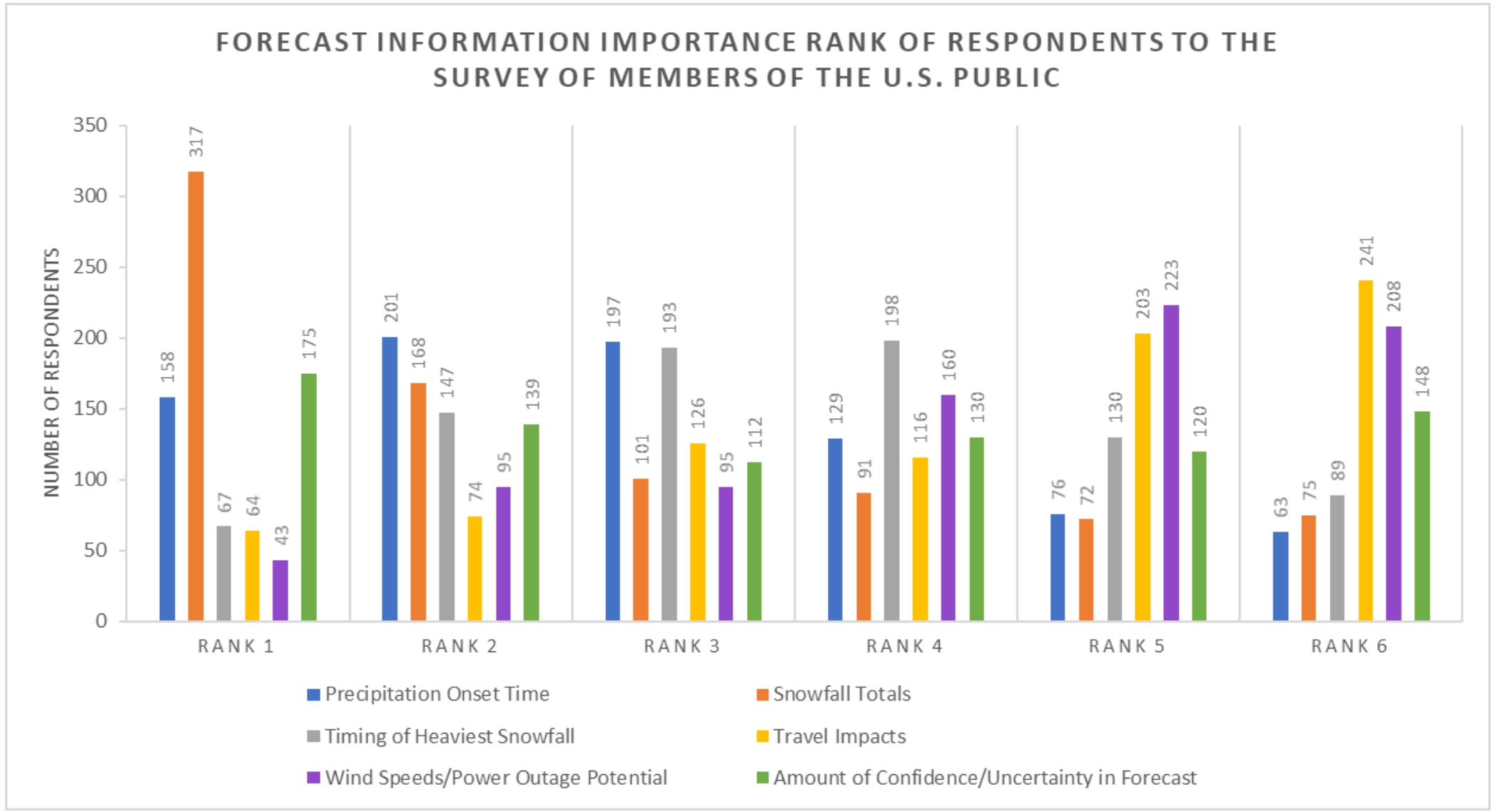
How many winter storms have you experienced within the past 10 years?
(N=833)



During the WINTER SEASON, what source of weather information do you look at most?
(N=833)



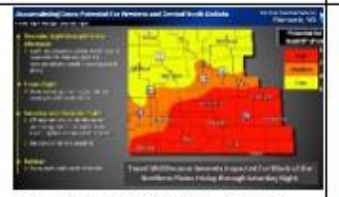
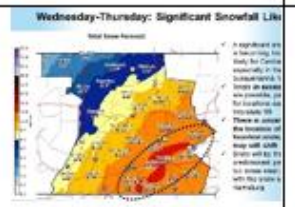
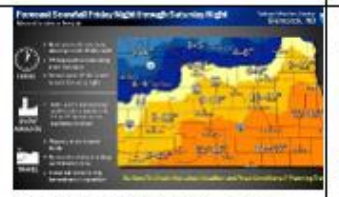
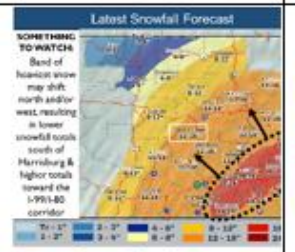
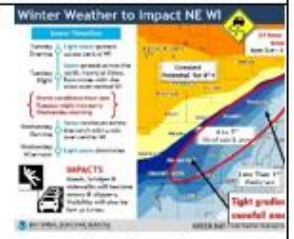
Rank the following types of forecast information in terms of importance to you before a winter storm? (rank 1 is most important, rank 6 is least important)
(N=824)

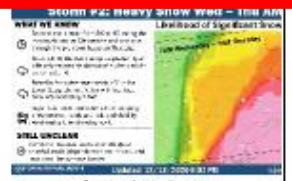
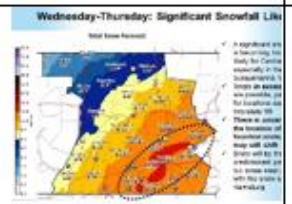
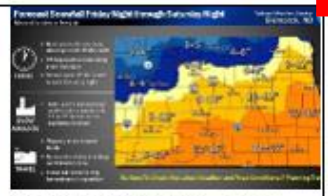
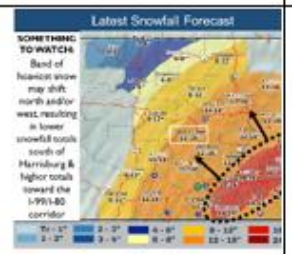
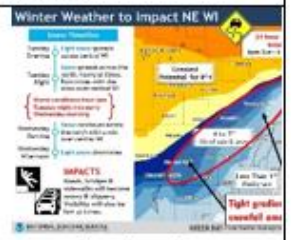


Section 2 of Survey Explained:

Four scenarios were created, and respondents were randomly placed in ONE of them by the survey software.

Within each scenario, a series of graphics used to message winter storms that were posted to Twitter and Facebook by NWS offices during the 2019-2020 or 2020-21 winter seasons were presented to respondents individually with a series of questions asked about each graphic. Sequences of three or four graphics were selected based on the types of graphics used to message the upcoming winter storm, with the goal to include as many different types of graphic styles at the long-range lead time and as many different types of risk probability graphics in the survey. Additionally, for the aspect of communicating uncertainty on snowfall forecast maps, graphic sequences were selected to get the public's feedback on how circled areas of uncertainty were used on snow maps. Based on these objectives, a series of graphics used by NWS Omaha from January 22-24, 2021, to communicate an upcoming winter storm were used as the first scenario in this survey *(N=187).* A series of graphics used by NWS State College from December 15-17, 2020, were used as the second scenario in this survey *(N=212),* a series of graphics used by NWS Bismarck from November 24-28, 2019, were used as the third scenario in this survey *(N=221),* and a series of graphics used by NWS Green Bay from November 23-25, 2019, were used as the fourth scenario in this survey *(N=213).* Many of the same questions were asked across all four scenarios to allow for easy comparison of the results.

	Scenario #1 – NWS Omaha	**Scenario #2 – NWS State College**	**Scenario #3 – NWS Bismarck**	**Scenario #4 – NWS Green Bay**
First Graphic Presen-ted	 Posted 1/22/21 – three days before storm	 Posted 12/11/20 – five days before storm	 Posted 11/24/19 – five days before storm	 Posted 11/23/19 – three days before storm
Second Graphic Presen-ted	 Posted 1/23/21 – two days before storm	 Posted 12/13/20 – three days before storm	 Posted 11/27/19 – two days before storm	 Posted 11/24/19 – two days before storm
Third Graphic Presen-ted	 Posted 1/23/21 – two days before storm	 Posted 12/14/20 – two days before storm	 Posted 11/28/19 – one day before storm	 Posted 11/24/19 – two days before storm
Fouth Graphic Presen-ted	 Posted 1/24/21 – one day before storm	 Posted 12/15/20 – one day before storm		 Posted 11/25/19 – one day before storm

	Scenario #1 – NWS Omaha	Scenario #2 – NWS State College	Scenario #3 – NWS Bismarck	Scenario #4 – NWS Green Bay
First Graphic Presen-ted	 Posted 1/22/21 – three days before storm	 Posted 12/11/20 – five days before storm	 Posted 11/24/19 – five days before storm	 Posted 11/23/19 – three days before storm
Second Graphic Presen-ted	 Posted 1/23/21 – two days before storm	 Posted 12/13/20 – three days before storm	 Posted 11/27/19 – two days before storm	 Posted 11/24/19 – two days before storm
Third Graphic Presen-ted	 Posted 1/23/21 – two days before storm	 Posted 12/14/20 – two days before storm	 Posted 11/28/19 – one day before storm	 Posted 11/24/19 – two days before storm
Fouth Graphic Presen-ted	 Posted 1/24/21 – one day before storm	 Posted 12/15/20 – one day before storm		 Posted 11/25/19 – one day before storm

First, focusing on these “long range” graphics

(slides 8-11 highlight the questions asked about them)

Question asked for all five of the graphics shown below:

(respondents selected a number from 1 through 10)

How easy is this graphic to interpret?

Not easy at all — Very easy

0 1 2 3 4 5 6 7 8 9 10

3 Days Before Storm

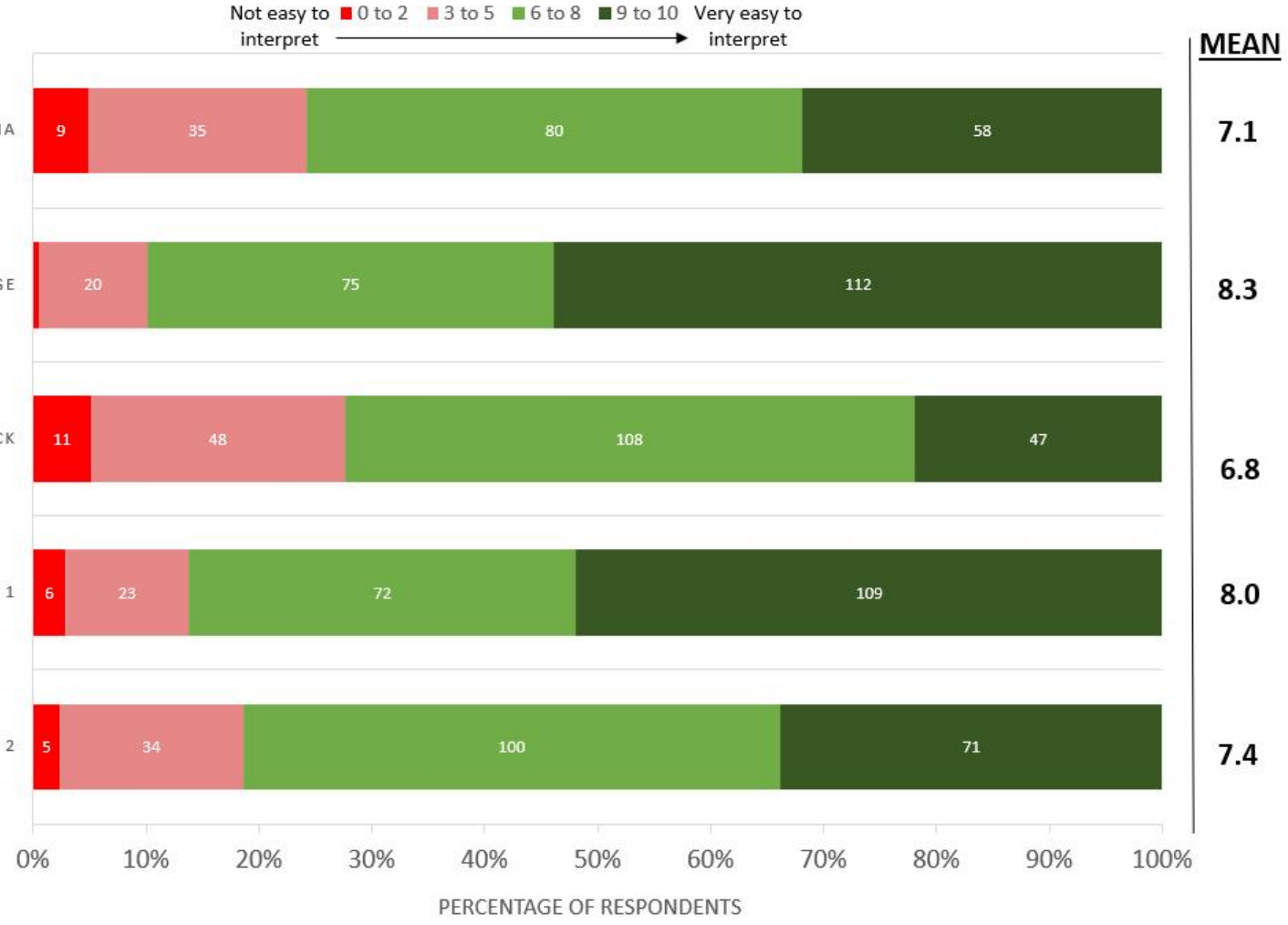
5 Days Before Storm

5 Days Before Storm

3 Days Before Storm

2 Days Before Storm

LONG RANGE FORECAST GRAPHICS: EASE OF INTERPRETATION COMPARISON - SURVEY OF U.S. PUBLIC



See Appendix C of thesis for full-size graphics

Question asked for all five of the graphics shown below:

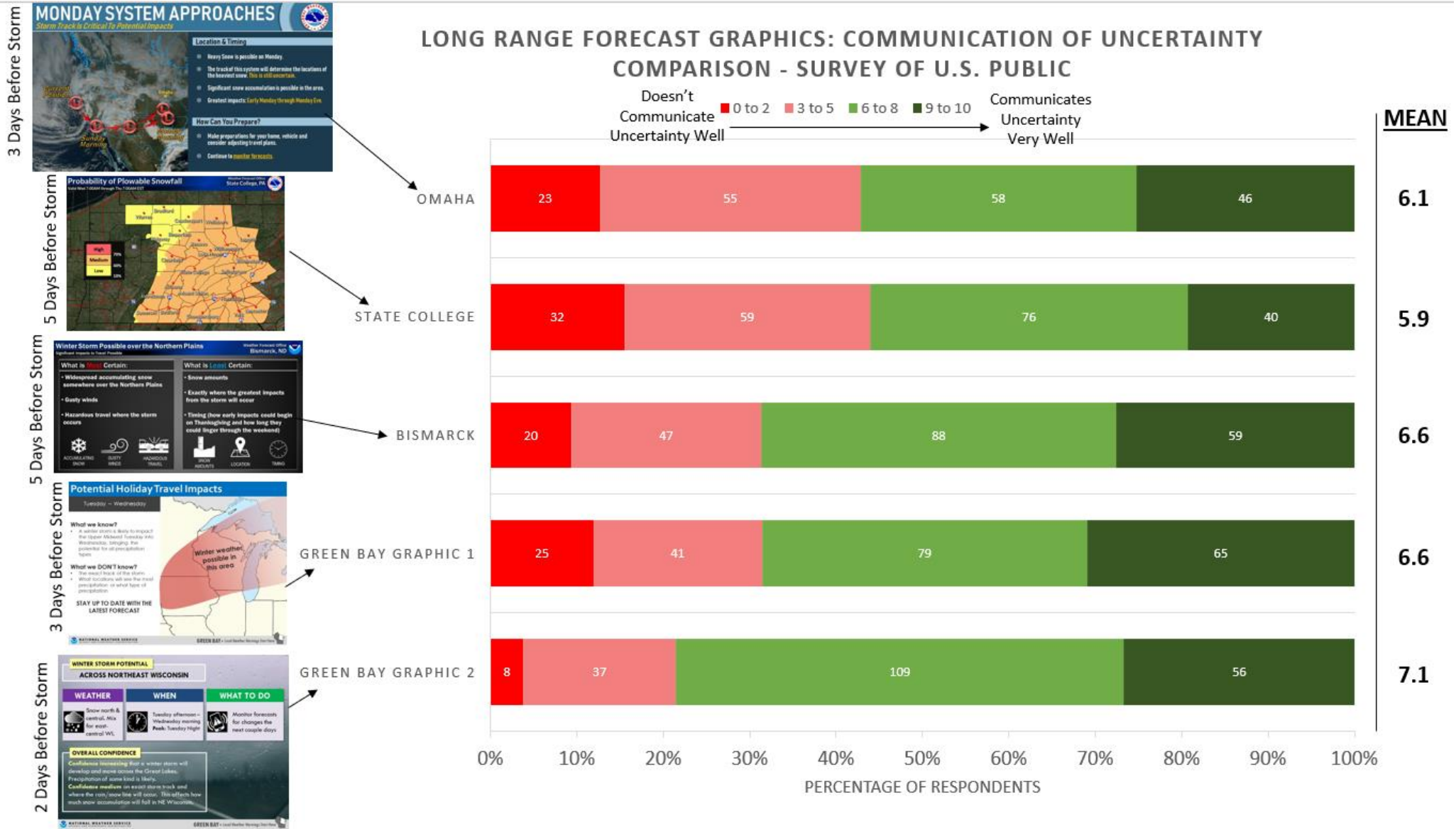
(respondents selected a number from 1 through 10)

How well does this graphic communicate the uncertainty with the forecast?

Not well at all — Very well

0 1 2 3 4 5 6 7 8 9 10

See Appendix C of thesis for full-size graphics



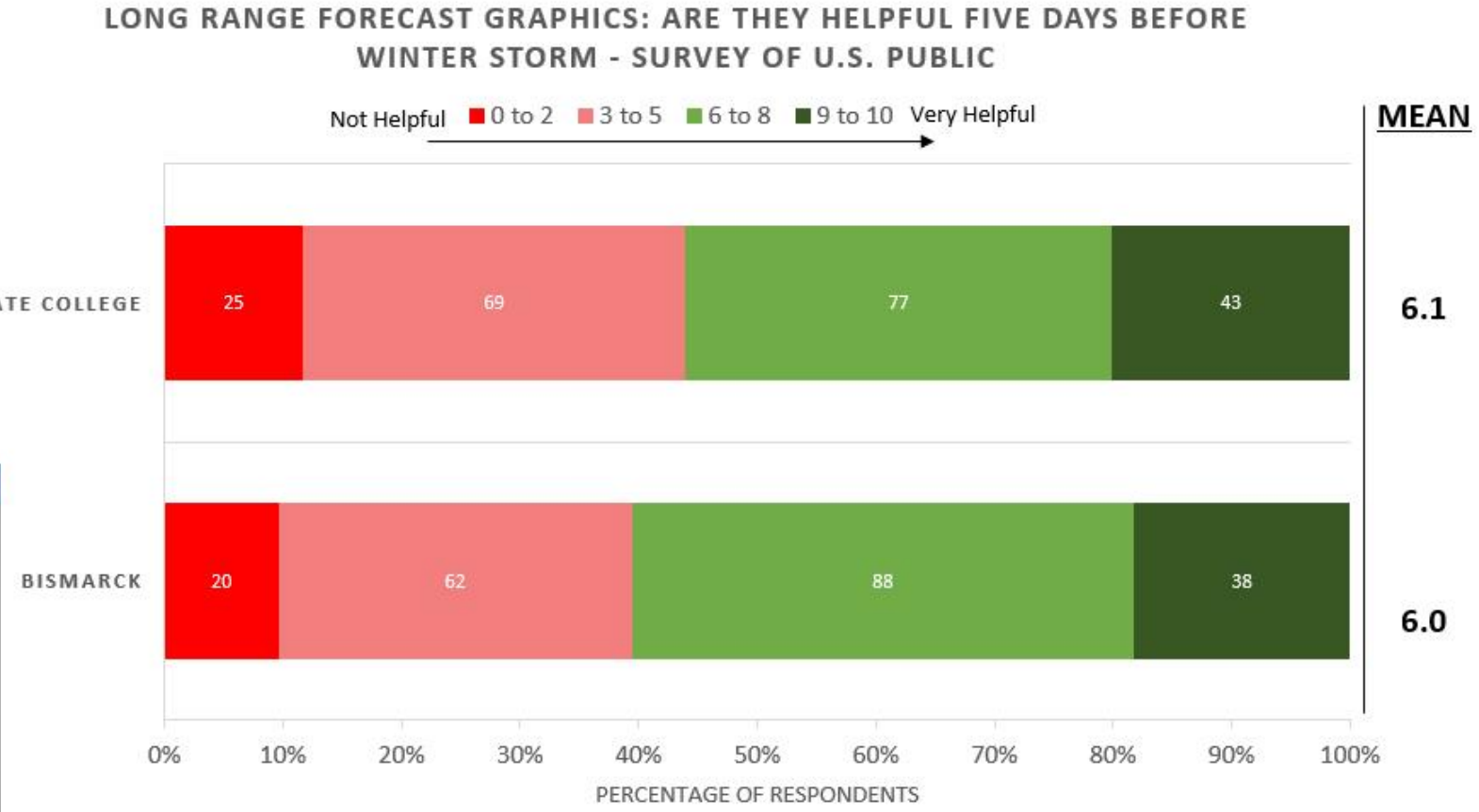
Question asked for both of the graphics shown below:

(respondents selected a number from 1 through 10)

How useful is it that this forecast information is given to you five days before the winter storm?

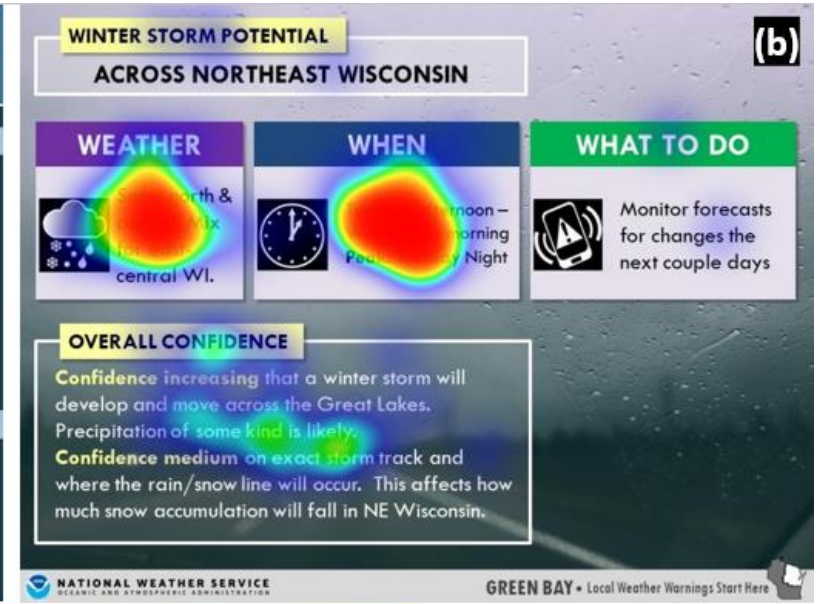
Not useful at all — Very useful

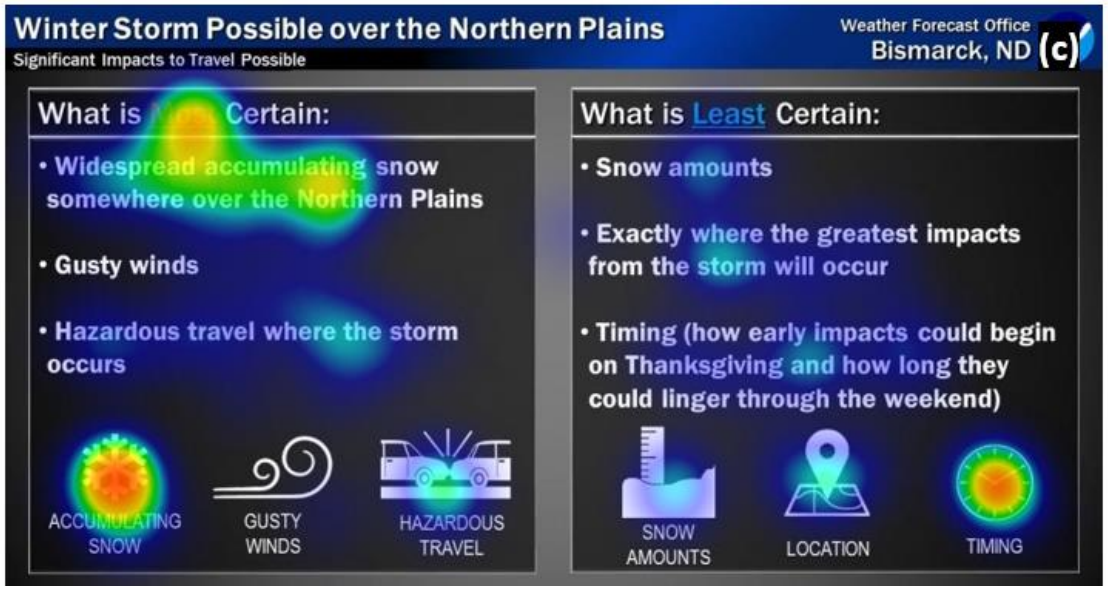
0 1 2 3 4 5 6 7 8 9 10



See Appendix C of thesis for full-size graphics

Heat Map Question Results: Respondents chose what part of each graphic they thought provided them with the *most important and helpful information*, and results are displayed as a heat map with blue and green shadings indicating that not many people selected that part of the graphic while red, orange, and yellow shadings indicate that many people selected that part of the graphic. (a) NWS Omaha graphic, (b) NWS Green Bay graphic #2, (c) NWS Bismarck graphic.





	Scenario #1 – NWS Omaha	Scenario #2 – NWS State College	Scenario #3 – NWS Bismarck	Scenario #4 – NWS Green Bay
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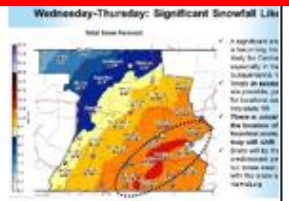
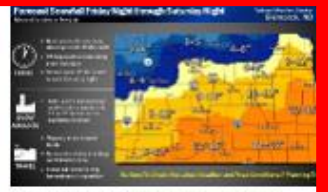
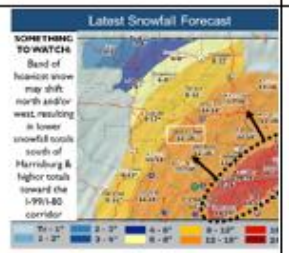
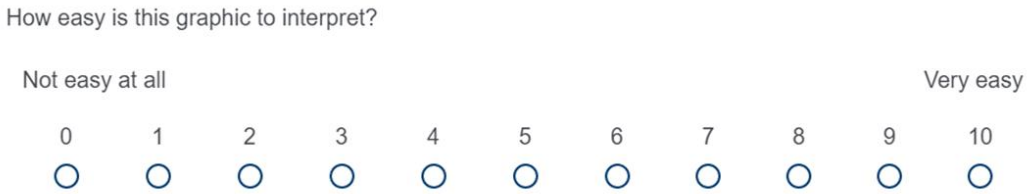
Third Graphic Presen-ted	 Posted 1/23/21 – two days before storm	 Posted 12/14/20 – two days before storm	 Posted 11/28/19 – one day before storm	 Posted 11/24/19 – two days before storm
Fouth Graphic Presen-ted	 Posted 1/24/21 – one day before storm	 Posted 12/15/20 – one day before storm		 Posted 11/25/19 – one day before storm

Next, focusing on these "risk probability" graphics

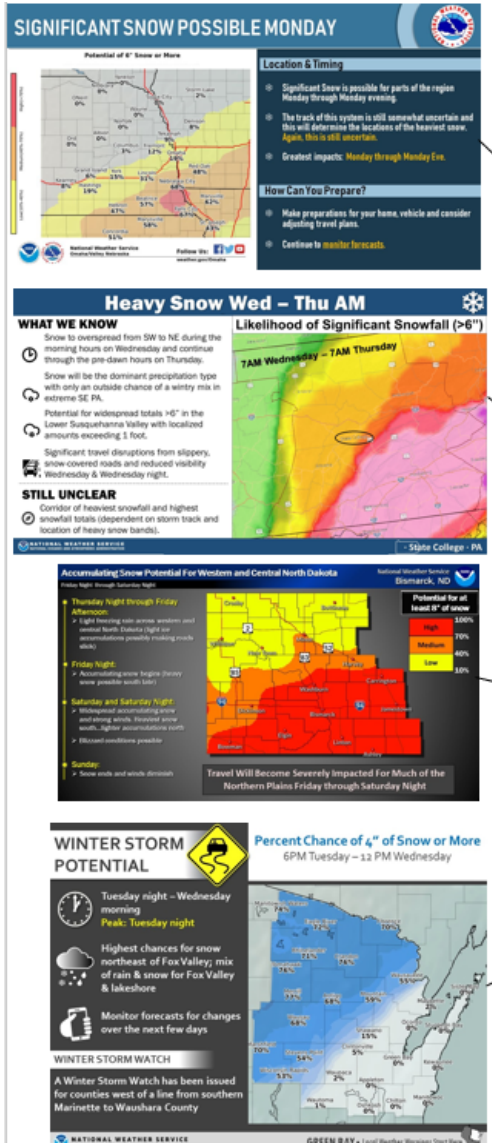
(slides 13-20 highlight the questions asked about them)

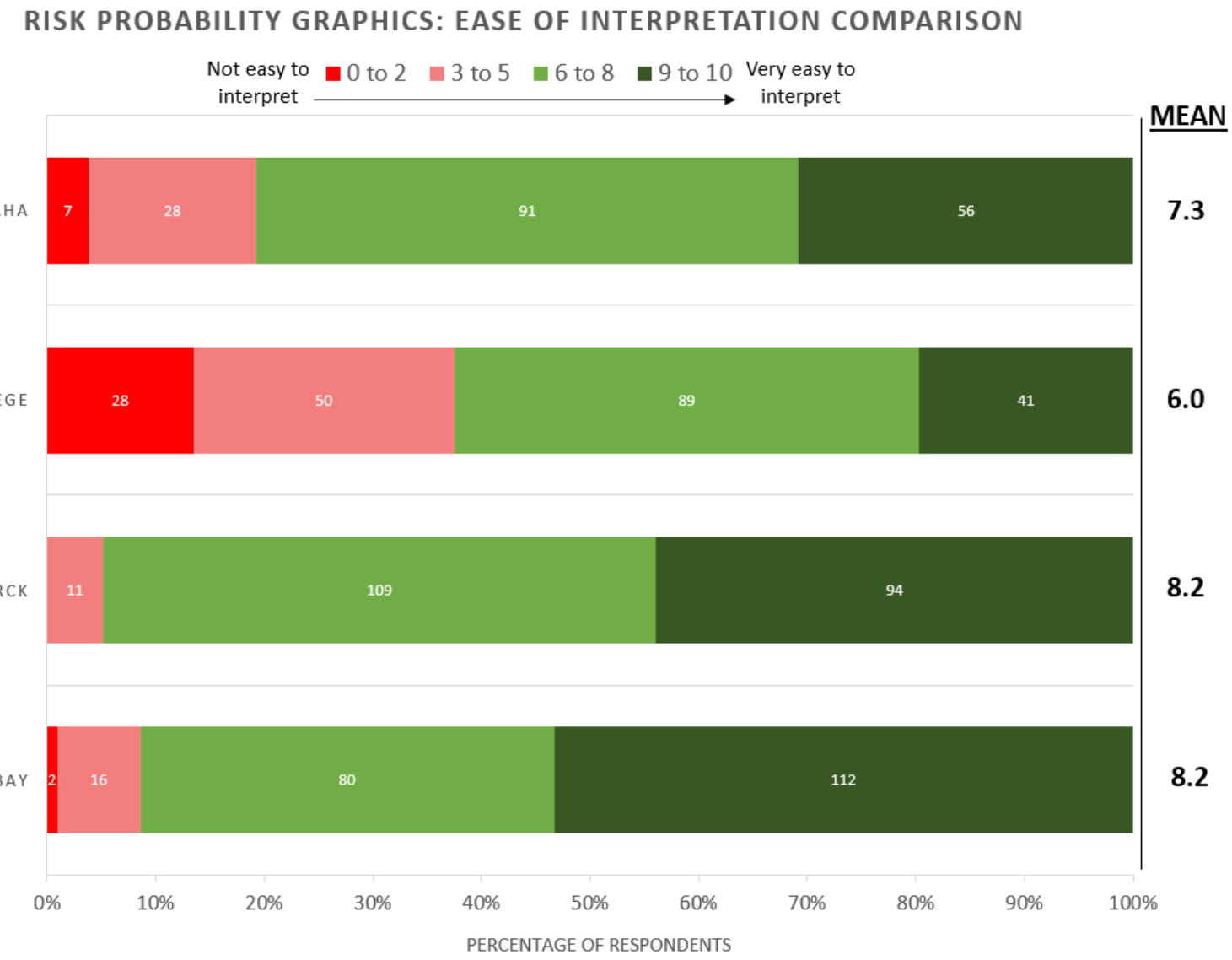
Question asked for all four of the graphics shown below:

(respondents selected a number from 1 through 10)



See Appendix C of thesis for full-size graphics





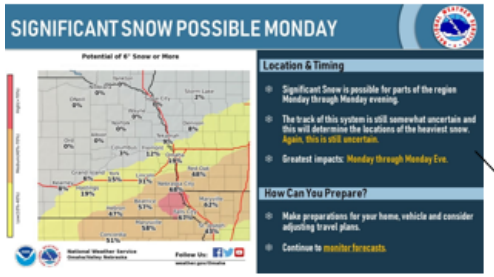
Question asked for all four of the graphics shown below:

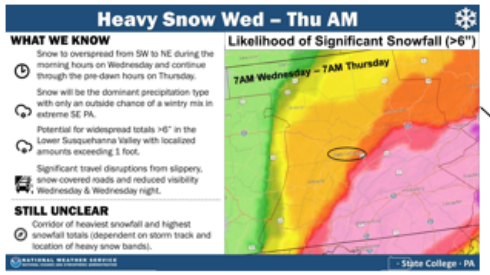
(respondents selected a number from 1 through 10)

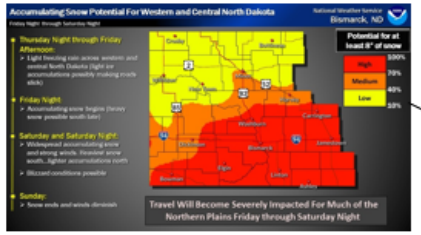
How well does this graphic communicate the uncertainty with the forecast?

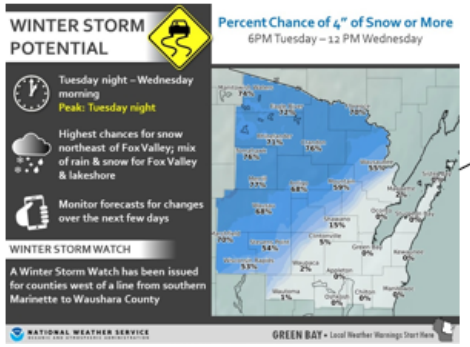
Not well at all — Very well

0 1 2 3 4 5 6 7 8 9 10

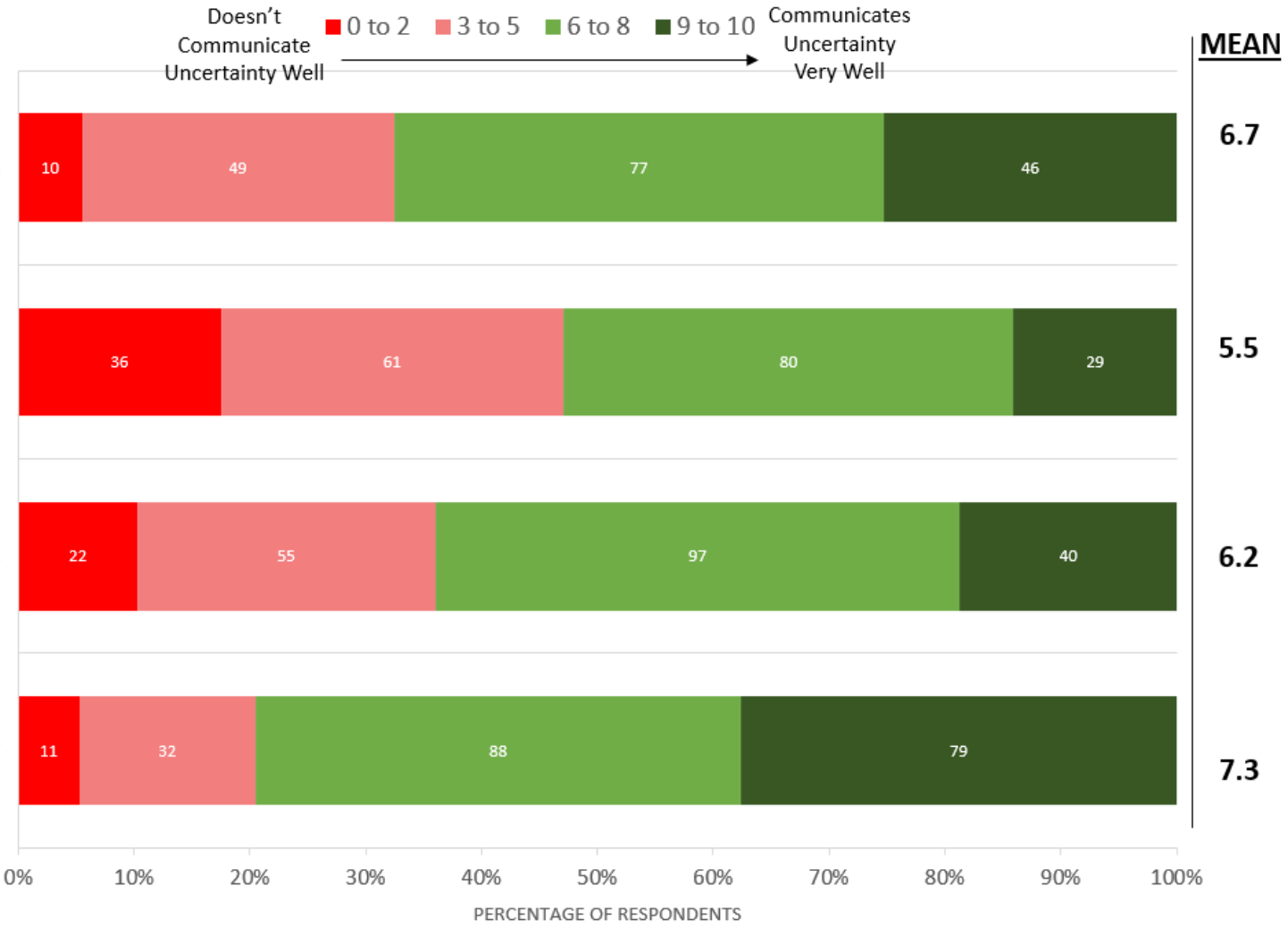








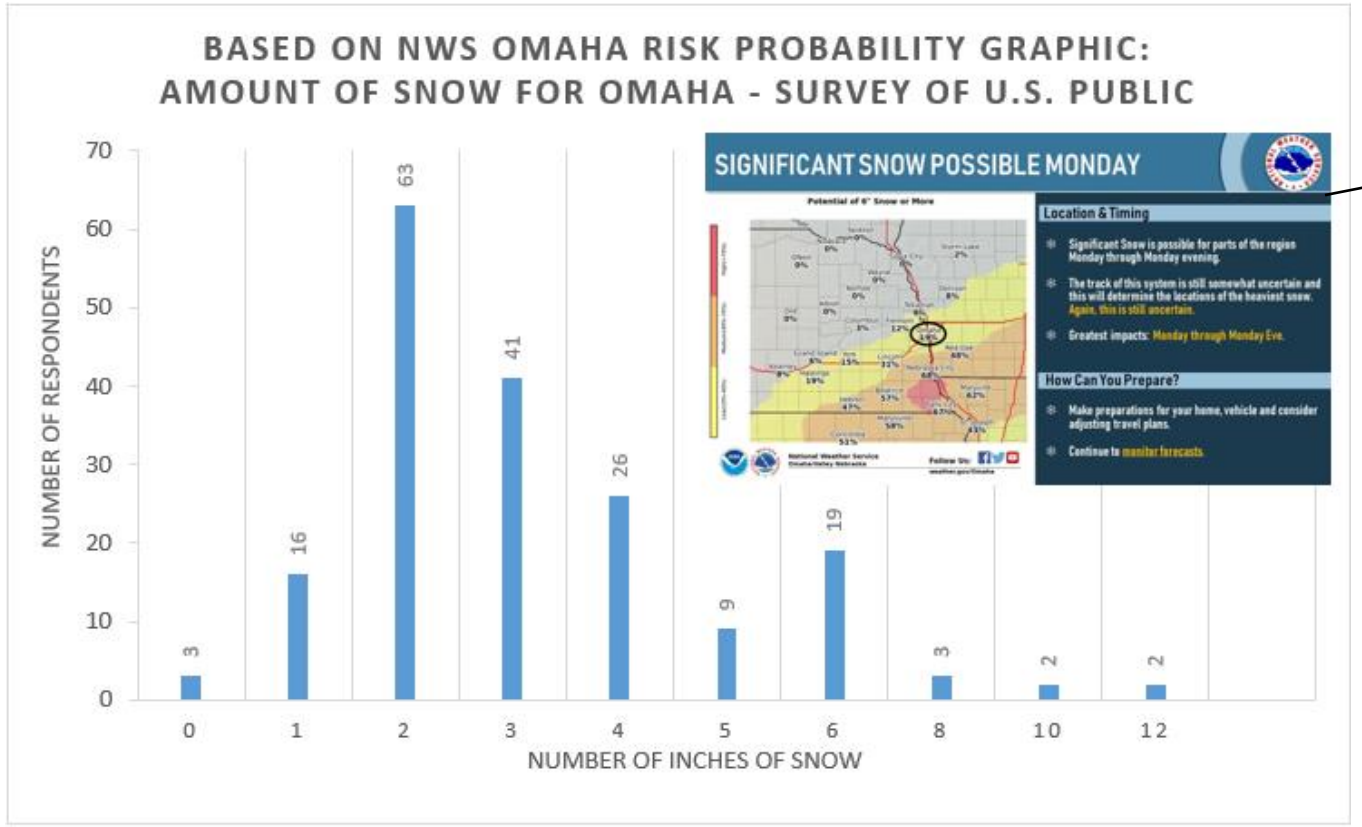
RISK PROBABILITY GRAPHICS: COMMUNICATION OF UNCERTAINTY COMPARISON - SURVEY OF U.S. PUBLIC



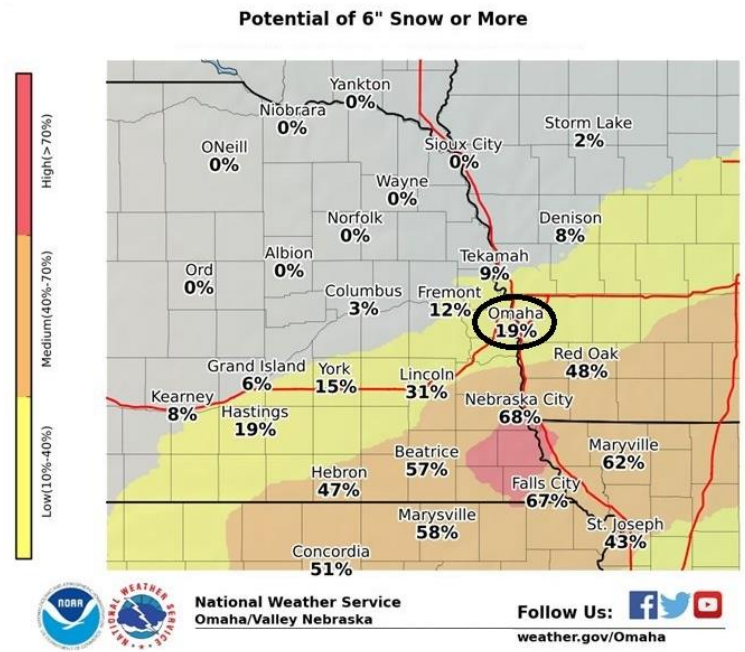
See Appendix C of thesis for full-size graphics

Next, in each scenario, *a city was circled on the risk probability graphic and respondents were asked to enter how much snow they thought the city would receive from the upcoming winter storm* **based on the information to them on the risk probability map**. Cities were chosen to test respondents' understanding of the risk probability map, with some being selected with lower probabilities and others being selected with higher probabilities

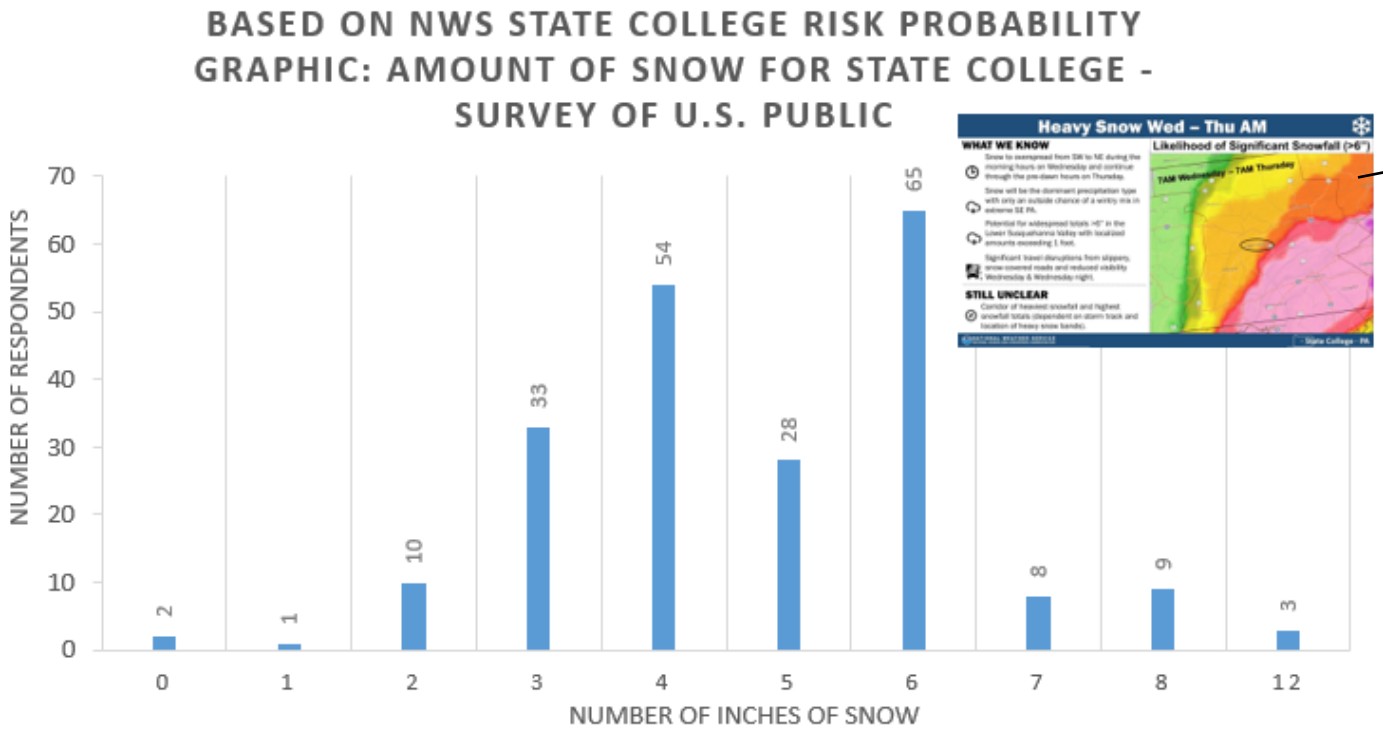
For NWS Omaha Scenario:



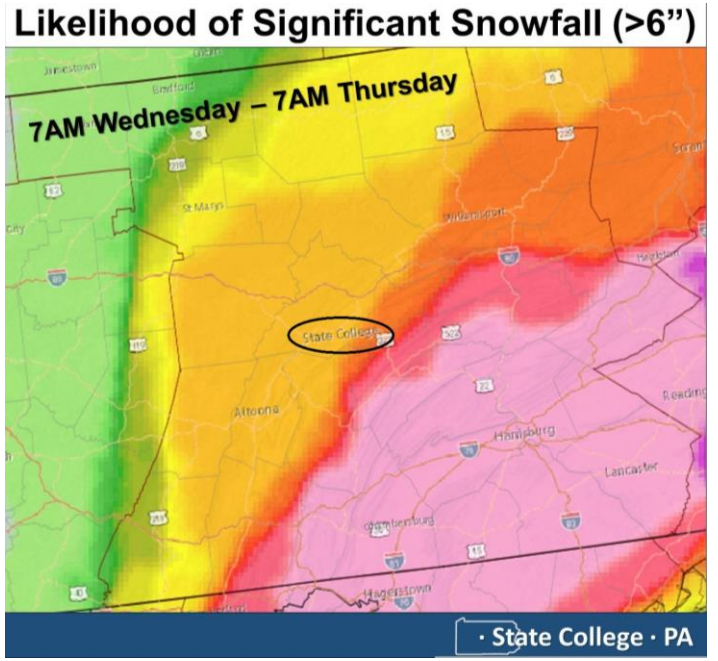
Zoomed in view of the risk probability map used in this question



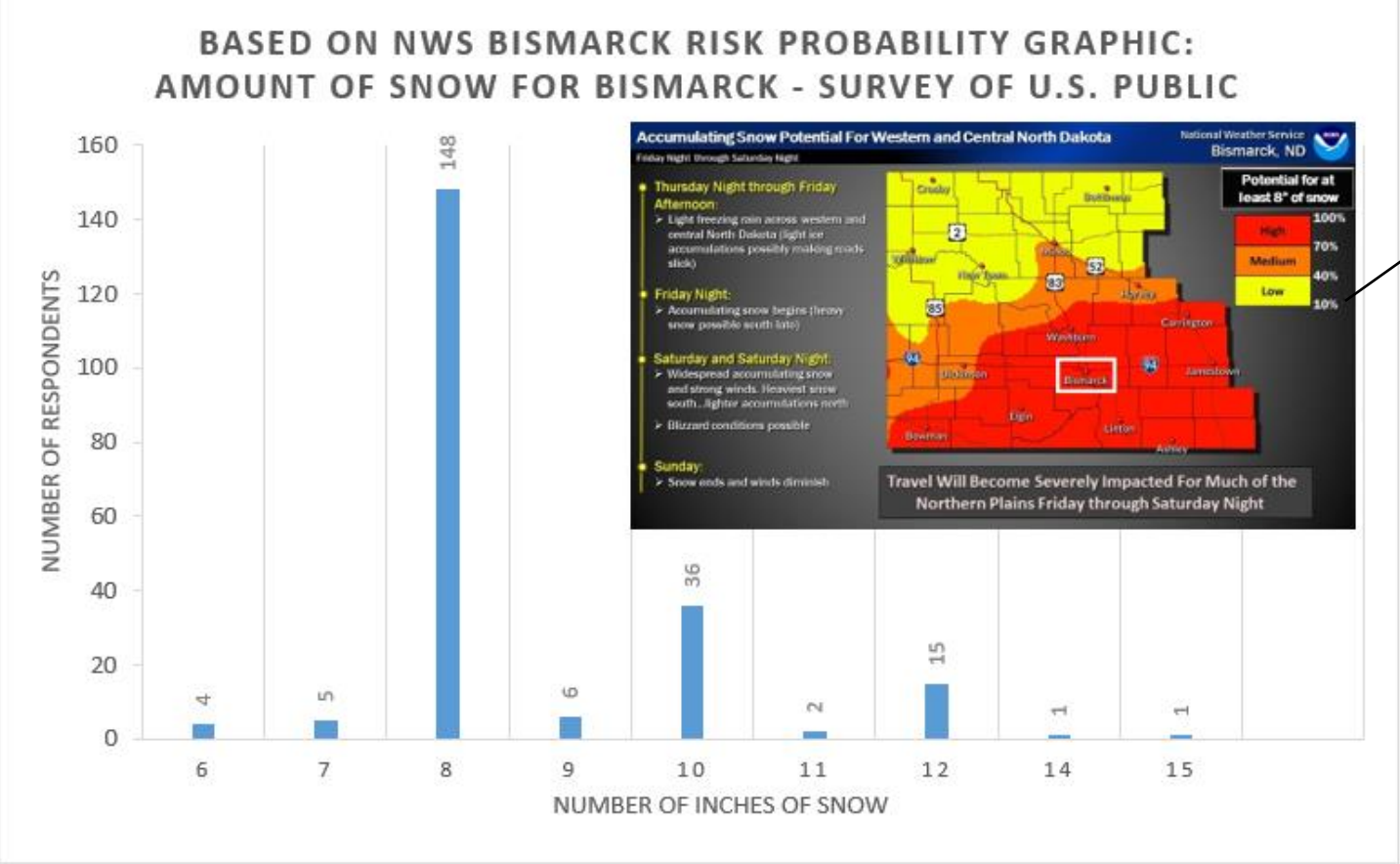
For NWS State College Scenario:



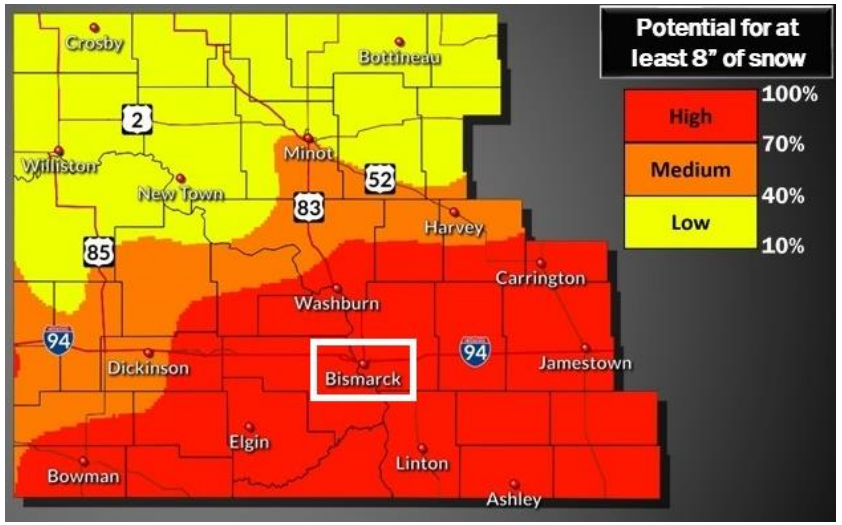
Zoomed in view of the risk probability map used in this question



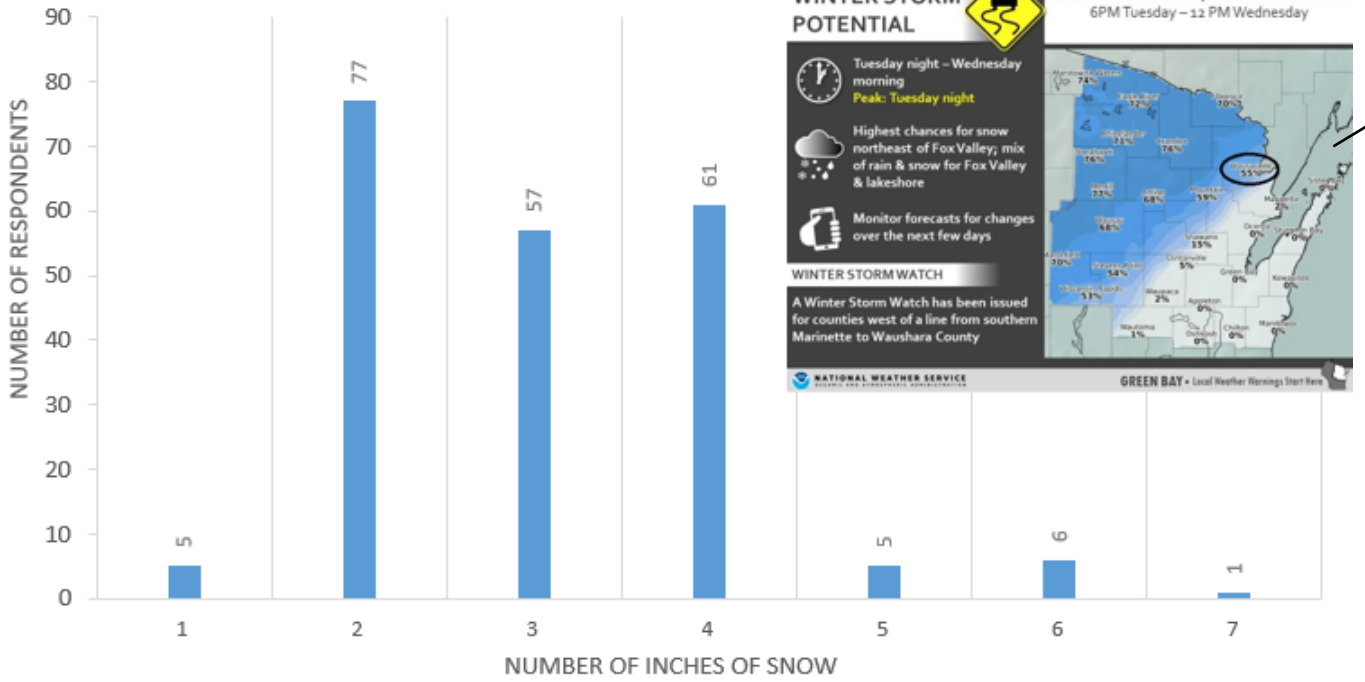
For NWS Bismarck Scenario:



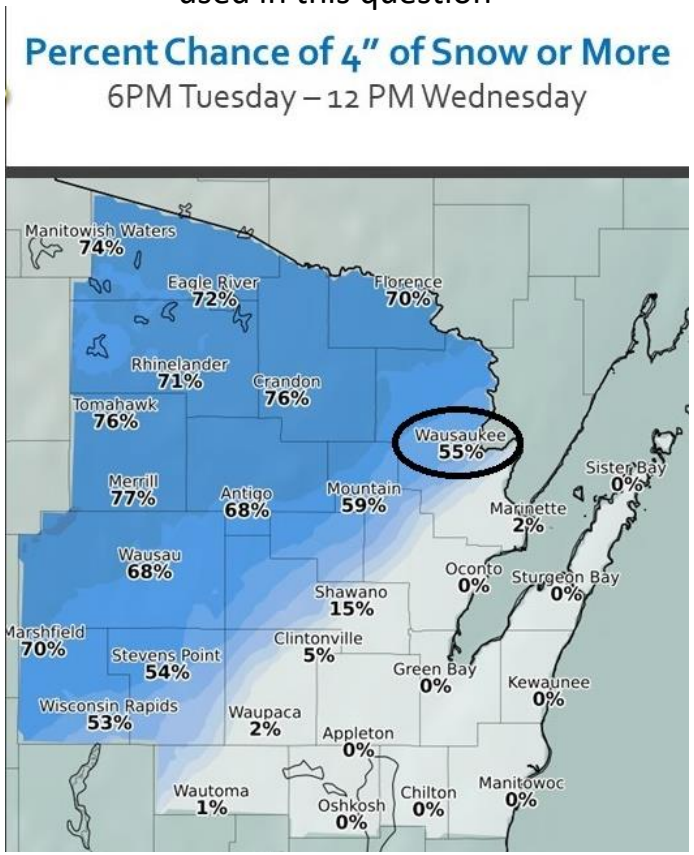
Zoomed in view of the risk probability map used in this question



BASED ON NWS GREEN BAY RISK PROBABILITY GRAPHIC: AMOUNT OF SNOW FOR WAUSAUKEE - SURVEY OF U.S. PUBLIC

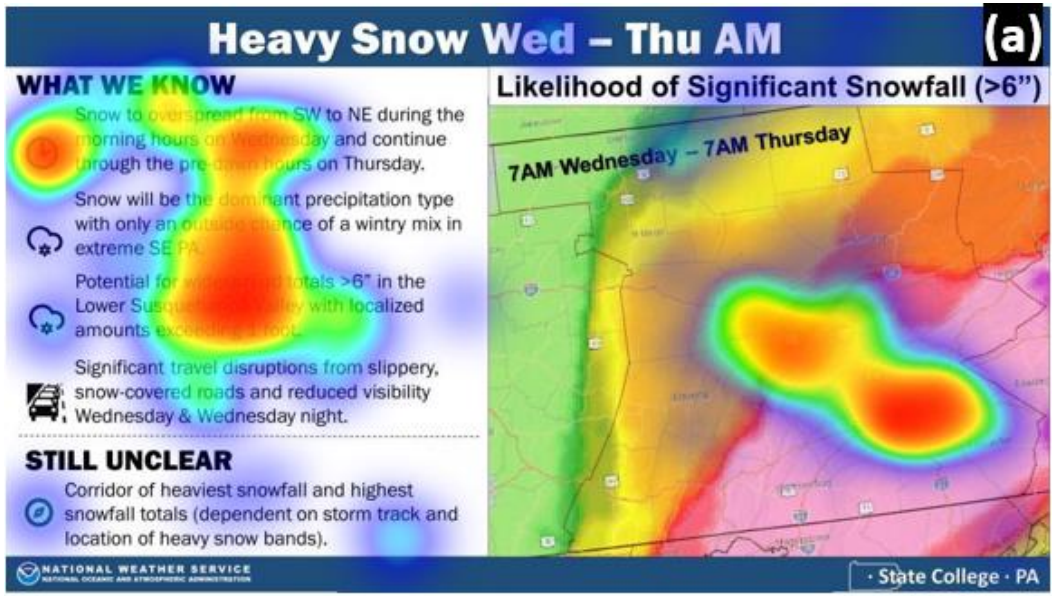


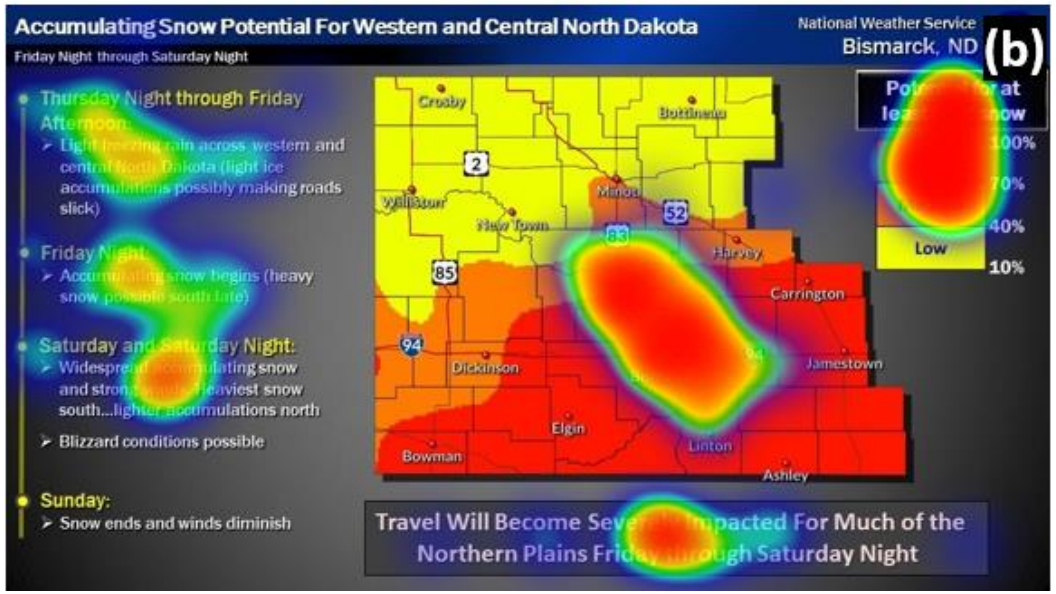
Zoomed in view of the risk probability map used in this question



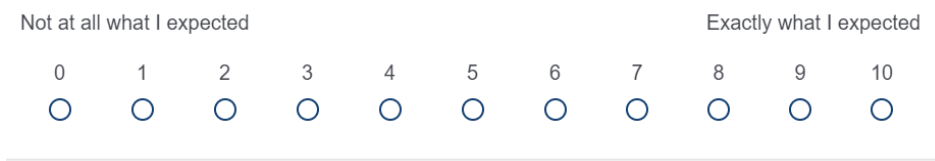
Section 2: Four Scenarios (Risk Probability Graphics)

Heat Map Question Results: Respondents chose what part of each graphic they thought provided them with the *most important and helpful information*, and results are displayed as a heat map with blue and green shadings indicating that not many people selected that part of the graphic while red, orange, and yellow shadings indicate that many people selected that part of the graphic. (a) NWS State College graphic, (b) NWS Bismarck graphic.

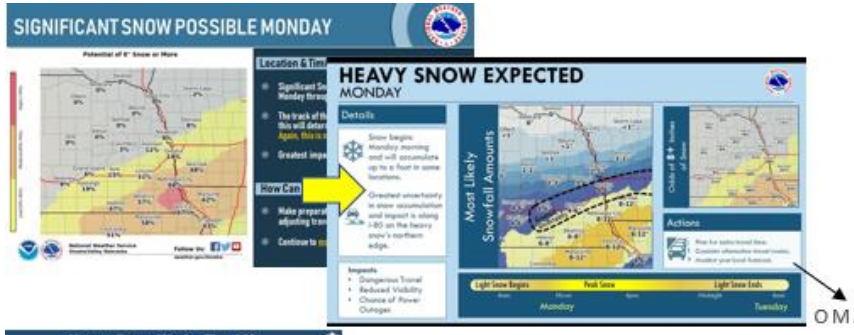




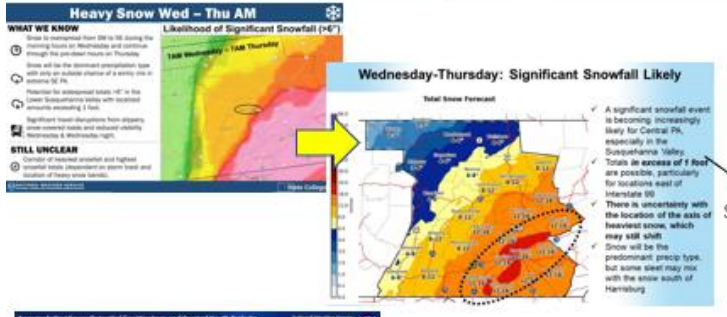
Respondents were then given the snowfall forecast map that was released by the respective NWS office and asked if the snowfall forecast map was what they expected to see ***based on the prior risk probability graphic*** (essentially determining if the risk probability map "prepared them" for the snowfall forecast map that was released)



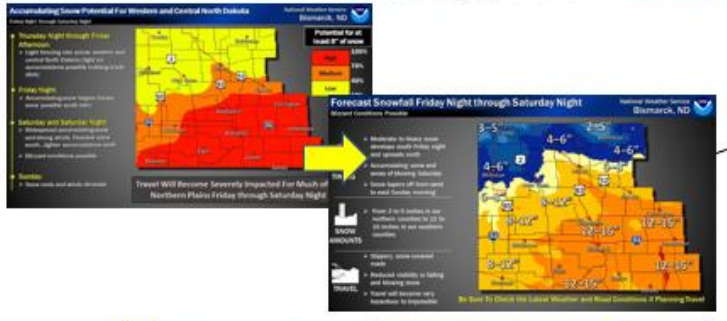
See Appendix C of thesis for full-size graphics



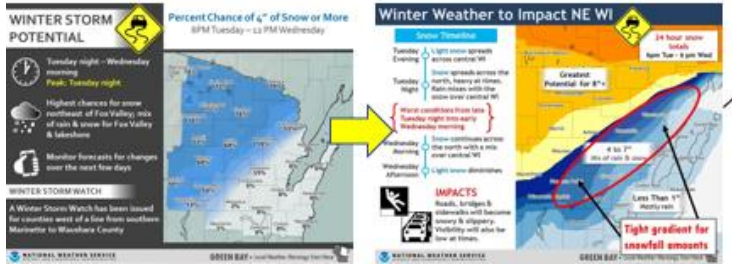
OMAHA



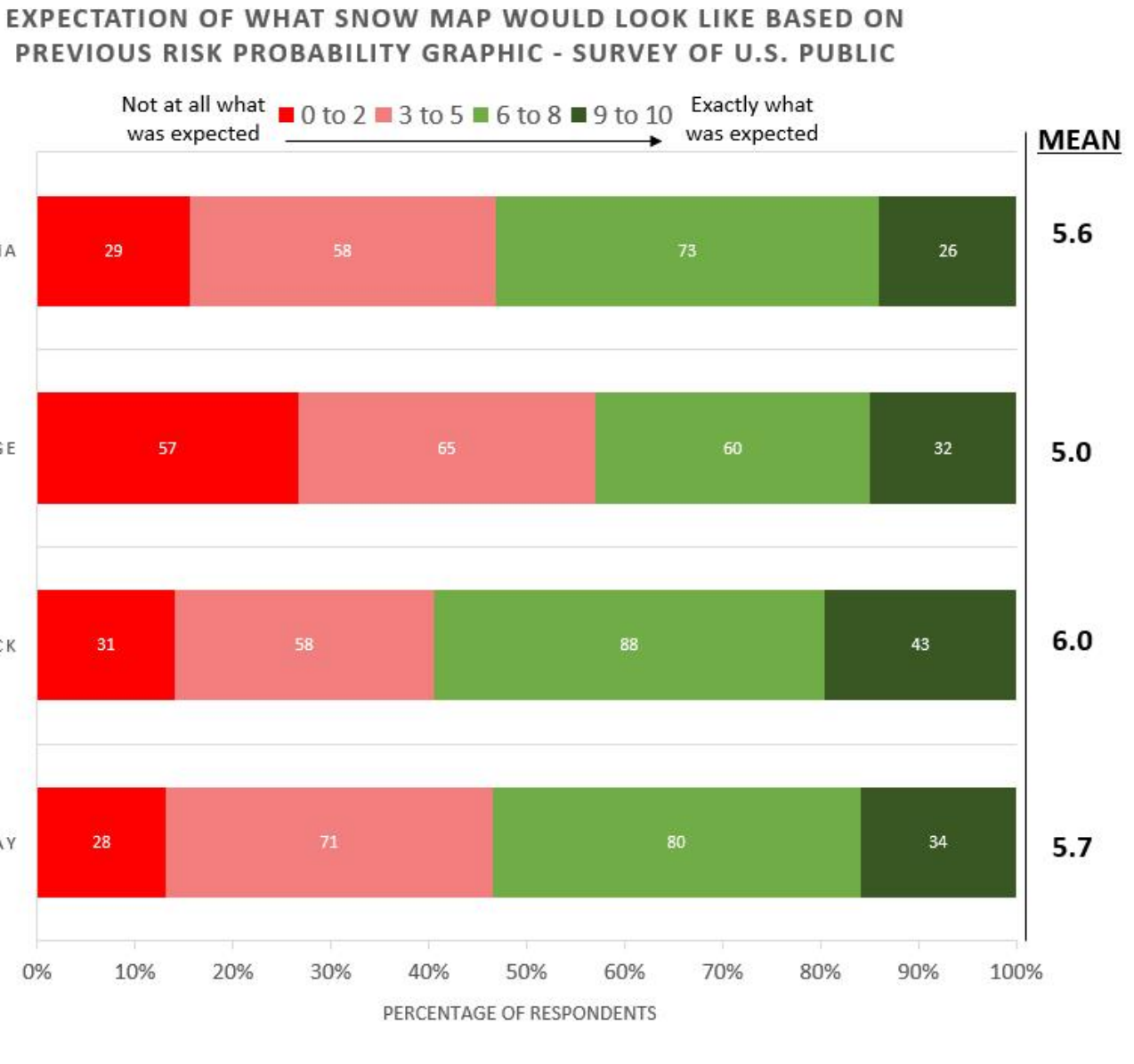
STATE COLLEGE

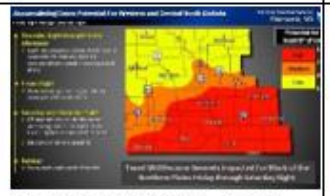
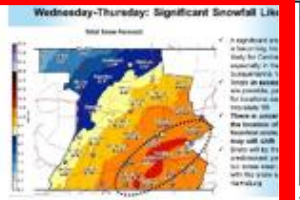
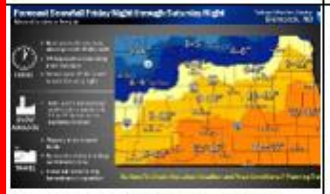
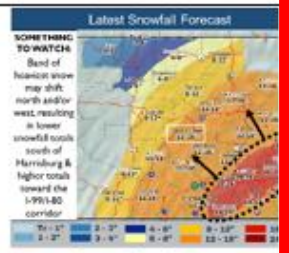


BISMARCK



GREEN BAY



	Scenario #1 – NWS Omaha	Scenario #2 – NWS State College	Scenario #3 – NWS Bismarck	Scenario #4 – NWS Green Bay
First Graphic Presen-ted	 Posted 1/22/21 – three days before storm	 Posted 12/11/20 – five days before storm	 Posted 11/24/19 – five days before storm	 Posted 11/23/19 – three days before storm
Second Graphic Presen-ted	 Posted 1/23/21 – two days before storm	 Posted 12/13/20 – three days before storm	 Posted 11/27/19 – two days before storm	 Posted 11/24/19 – two days before storm
Third Graphic Presen-ted	 Posted 1/23/21 – two days before storm	 Posted 12/14/20 – two days before storm	 Posted 11/28/19 – one day before storm	 Posted 11/24/19 – two days before
Fouth Graphic Presen-ted	 Posted 1/24/21 – one day before storm	 Posted 12/15/20 – one day before storm		 Posted 11/25/19 – one day before storm

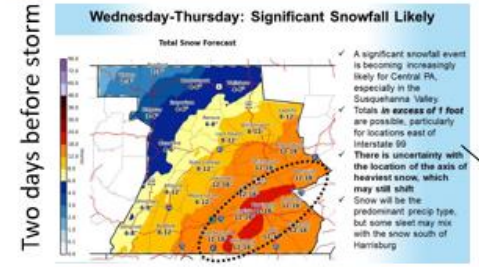
Finally, focusing on these snow maps with "circled areas of uncertainty"

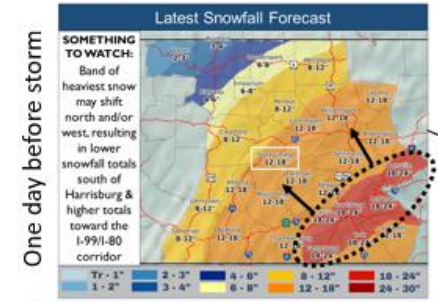
(slides 22-24 highlight the questions asked about them)

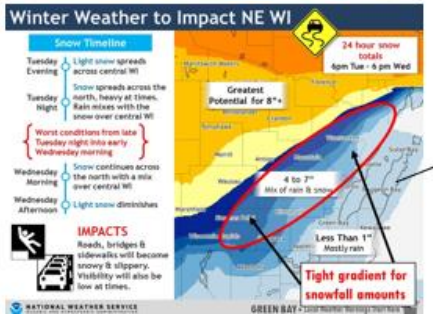
Question asked for all four of the graphics shown below:

(respondents selected a number from 1 through 10)

See Appendix C of thesis for full-size graphics



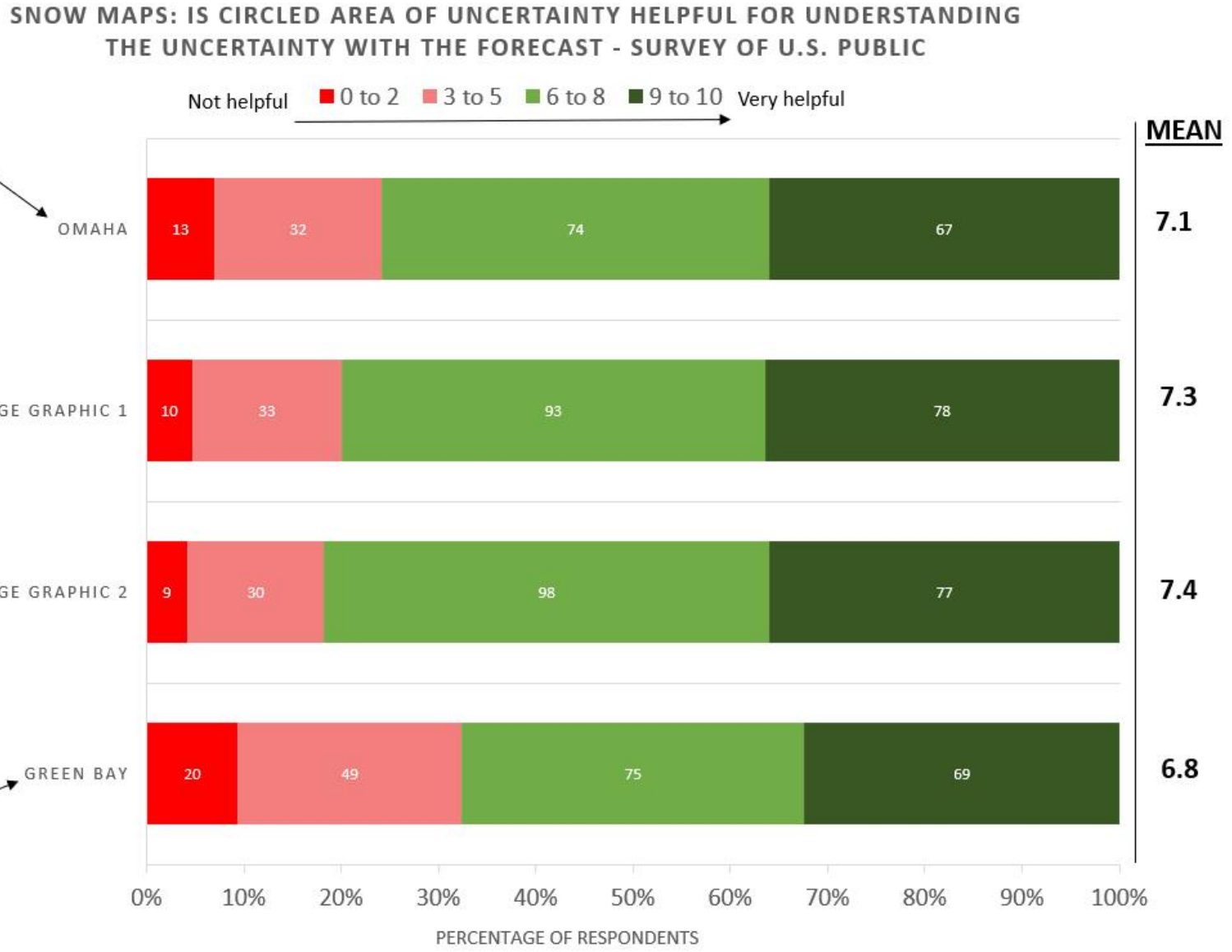




Is the circled area of uncertainty helpful for you to understand the uncertainty with the forecast?

Not helpful at all — Very helpful

0 1 2 3 4 5 6 7 8 9 10

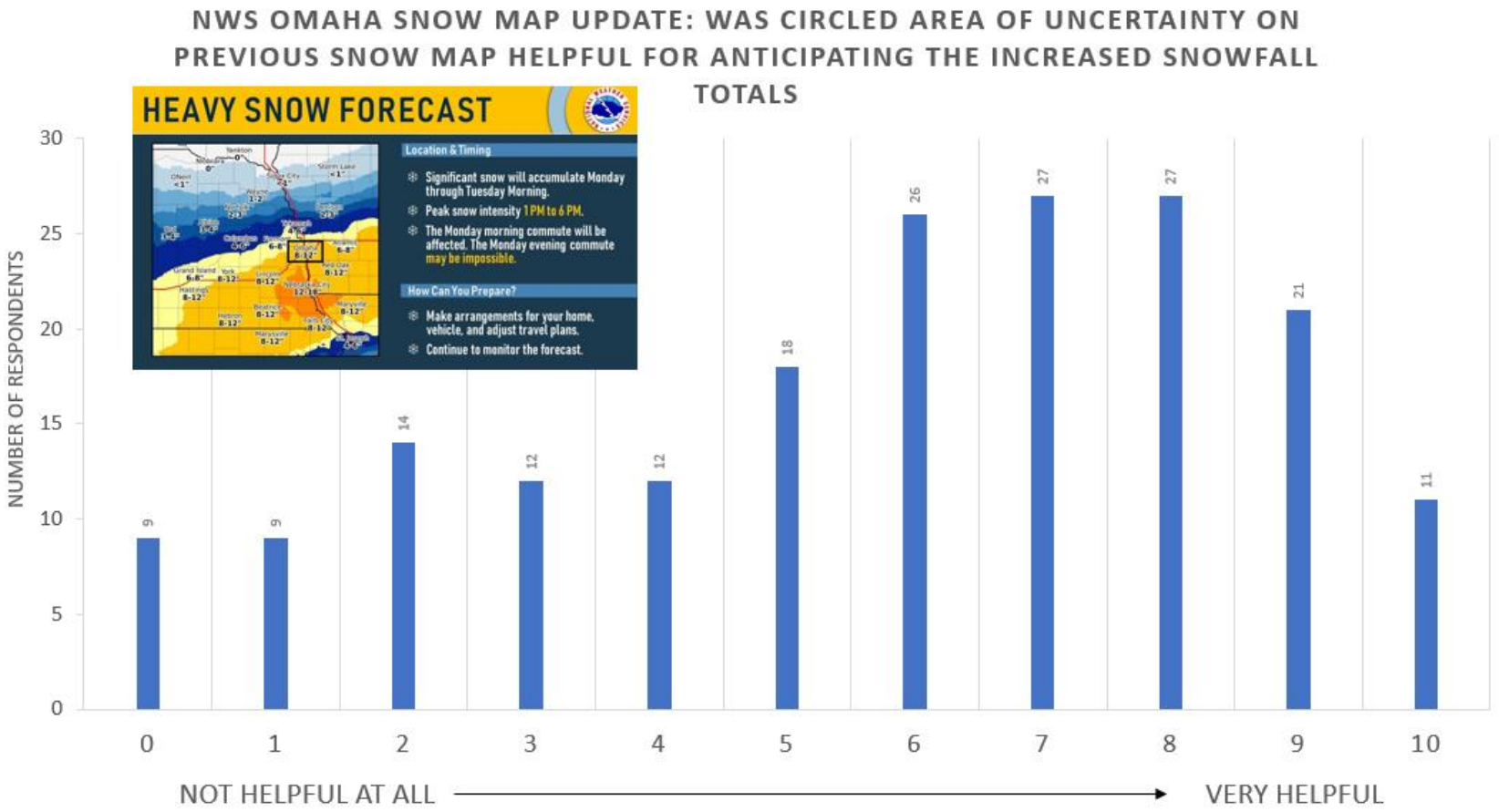


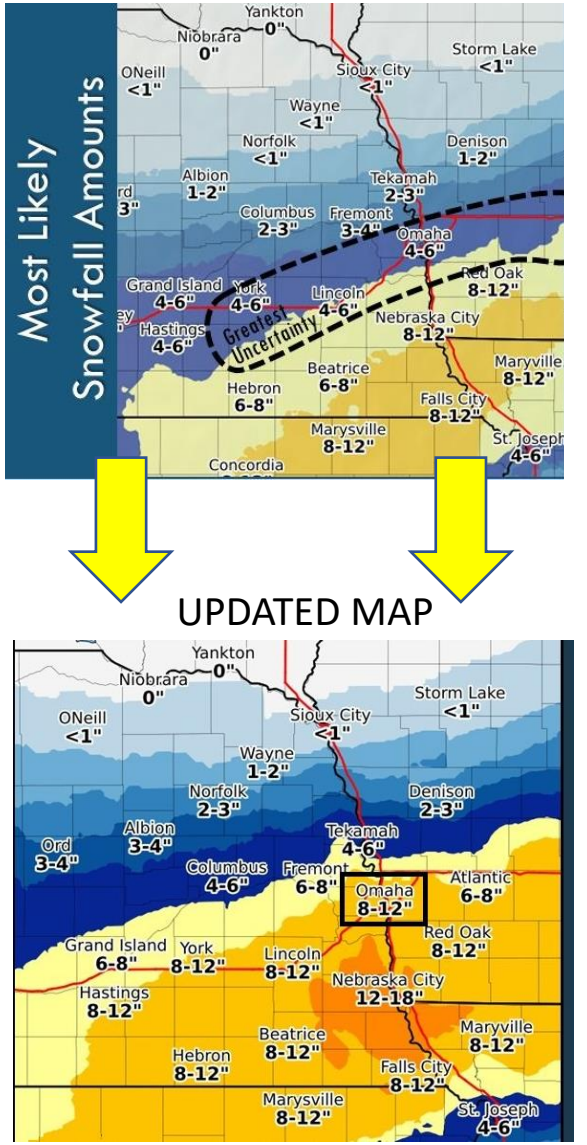
With just the NWS Omaha Scenario, a snow map update was given, and respondents were asked:

Suppose you live in Omaha (in the black box on the graphic above). Did the circled area of uncertainty on the previous graphic help you anticipate the increased snow totals predicted for Omaha on this updated map?

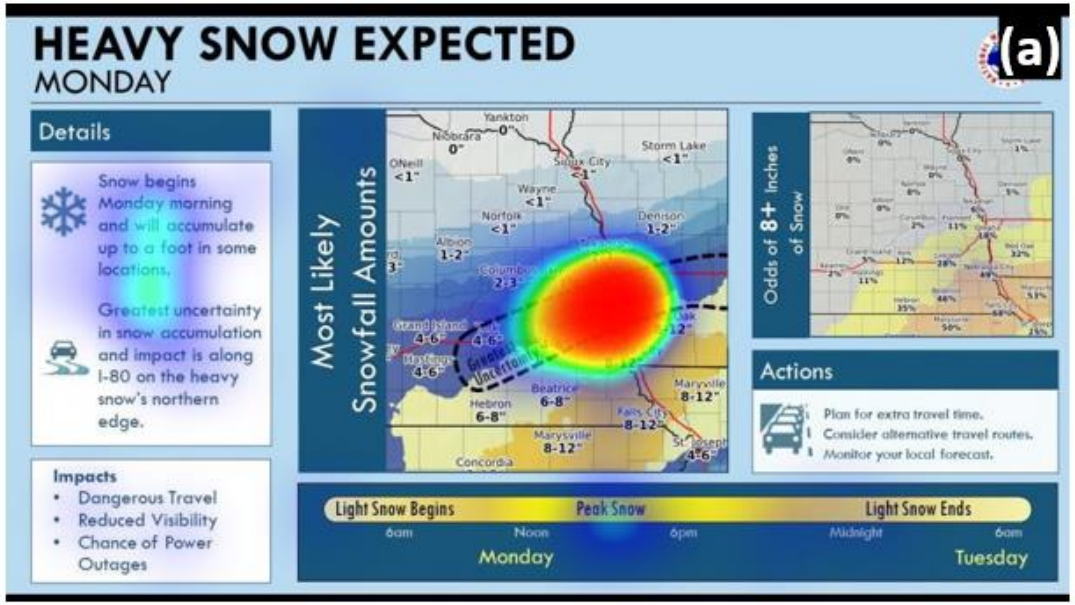
Not helpful at all — It was very helpful

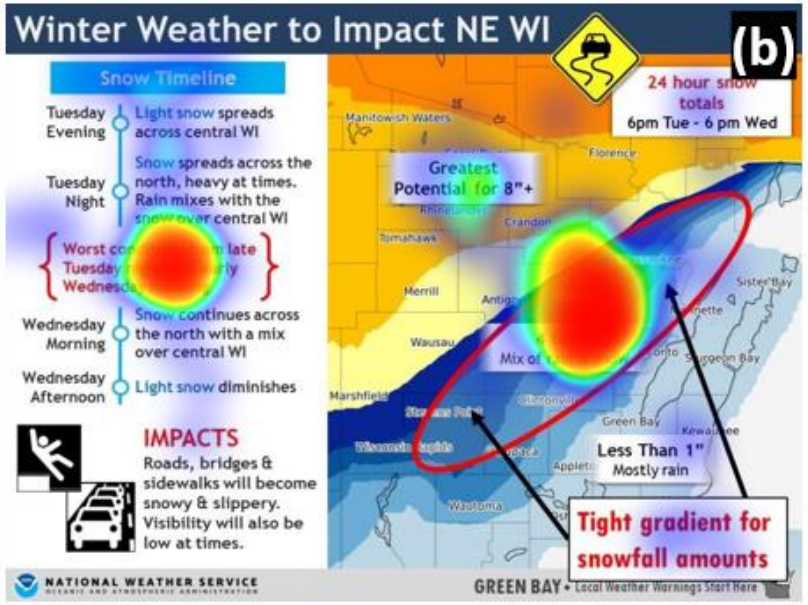
0 1 2 3 4 5 6 7 8 9 10

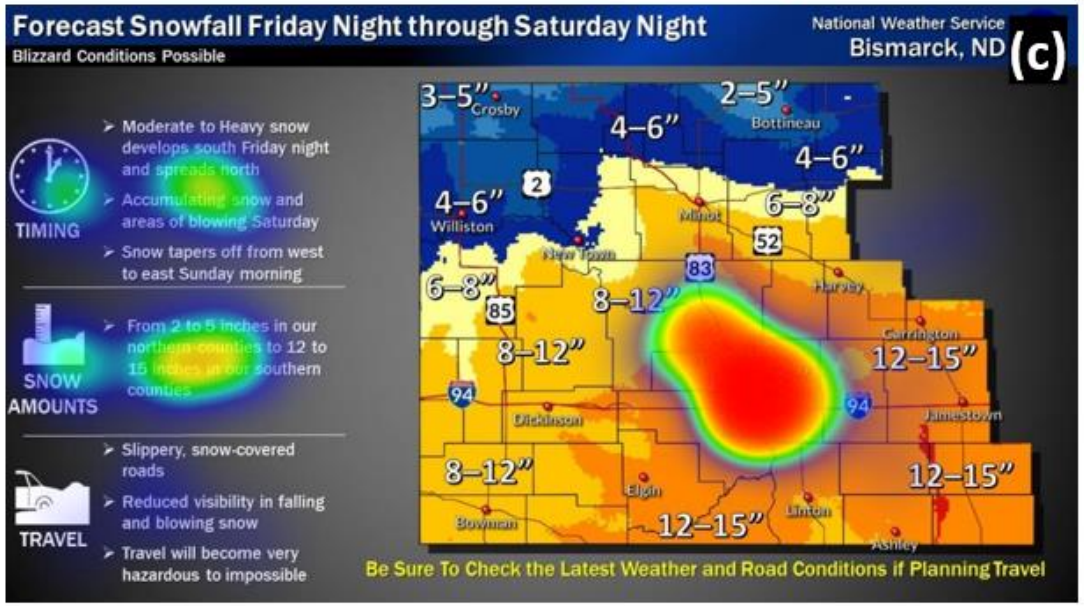




Heat Map Question Results: Respondents chose what part of each graphic they thought provided them with the *most important and helpful information*, and results are displayed as a heat map with blue and green shadings indicating that not many people selected that part of the graphic while red, orange, and yellow shadings indicate that many people selected that part of the graphic. (a) NWS Omaha graphic, (b) NWS Green Bay graphic, (c) NWS Bismarck graphic.

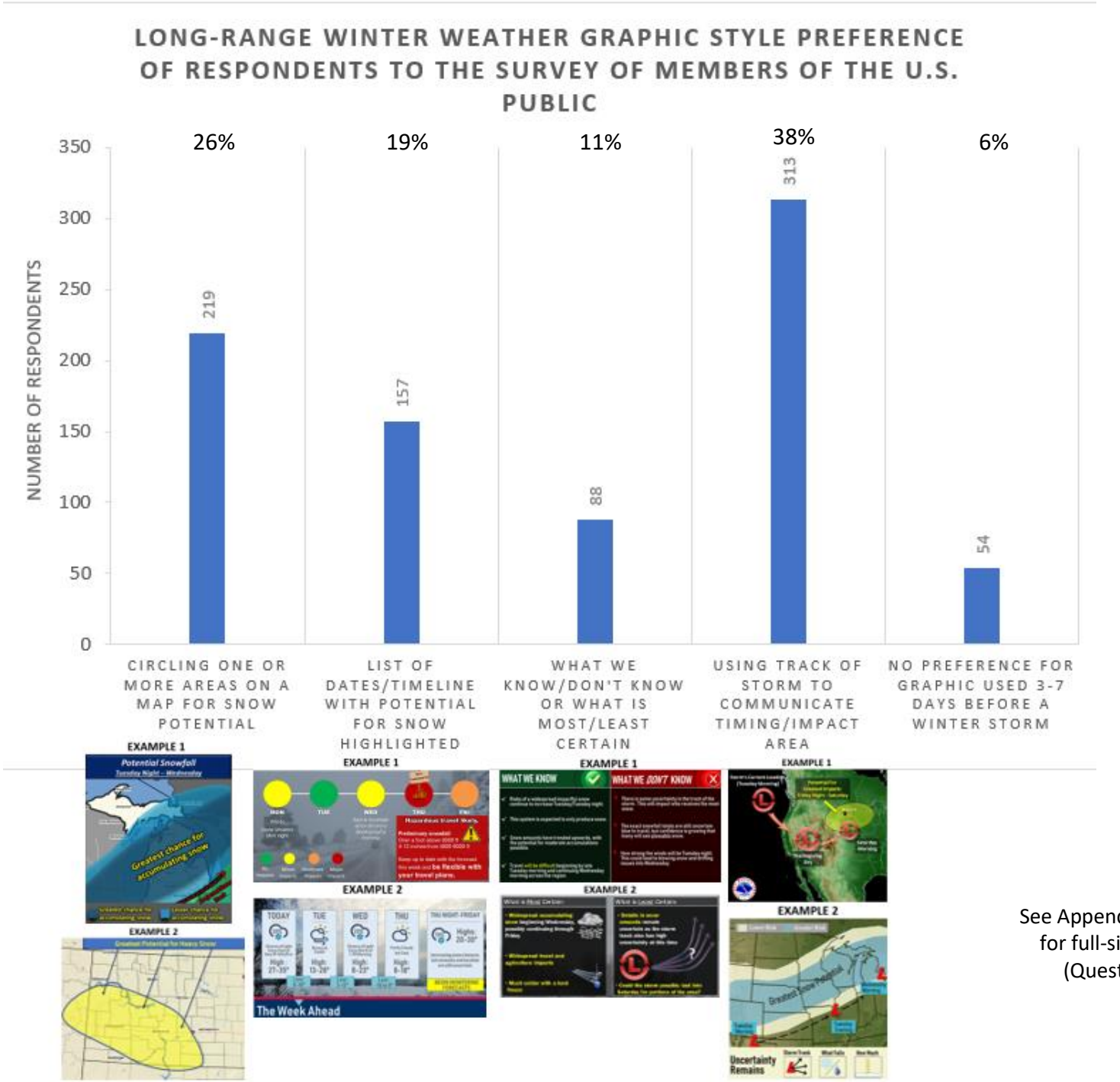






Question: *(N = 831)*
Several days (about 3-7 days) before a winter storm, National Weather Service offices will communicate the threat of an upcoming winter storm in a variety of ways. Please select the style of graphic that you think is **MOST** effective at communicating an upcoming winter storm.

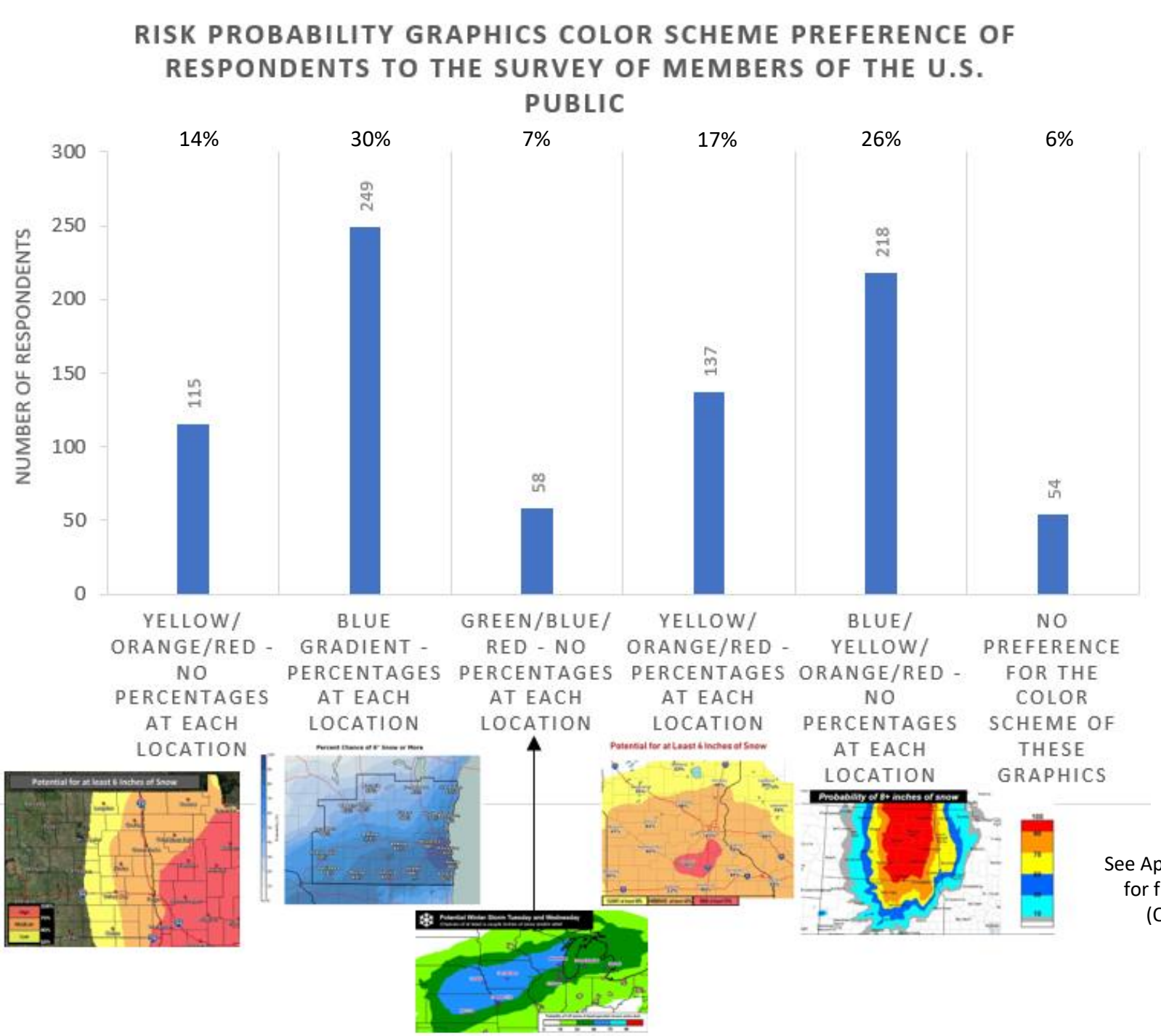
(Answer choices were randomized)



See Appendix C of thesis for full-size graphics (Question #50)

Question: *(N = 831)*
There are many different color schemes used in graphics to communicate the **probability of snowfall from a winter storm exceeding a specified amount** (in other words, the probability of at least a certain amount of snow).
Which **color scheme** do you think is the BEST? (Note: each graphic is from a different snow event - do not judge based on the situation or the extent of the map)

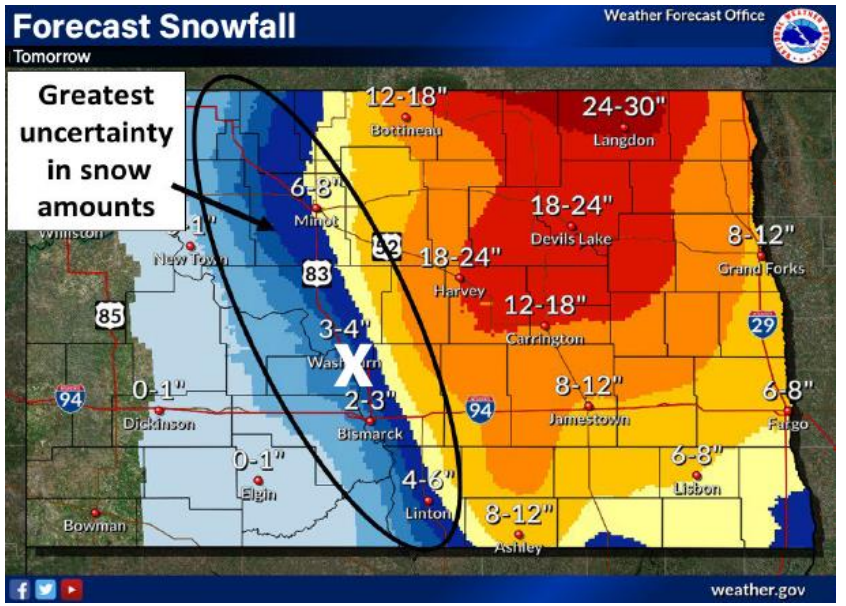
(Answer choices were randomized)

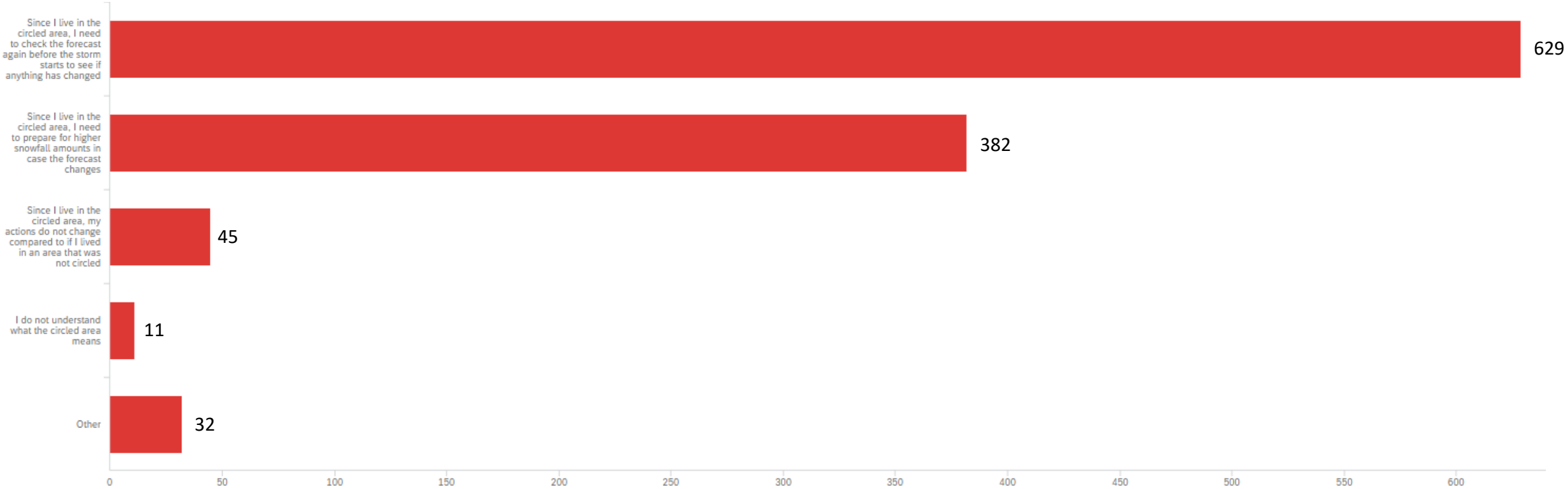


See Appendix C of thesis for full-size graphics (Question #51)

<u>Question:</u> (N = 831)

If you live at the white X on the above snowfall forecast map for an incoming storm that will impact your area tomorrow, <u>how do you interpret the circled area that you are located within?</u> ***Select all that apply*** **or type your own answer.**





Probabilistic Snowfall Map Questions

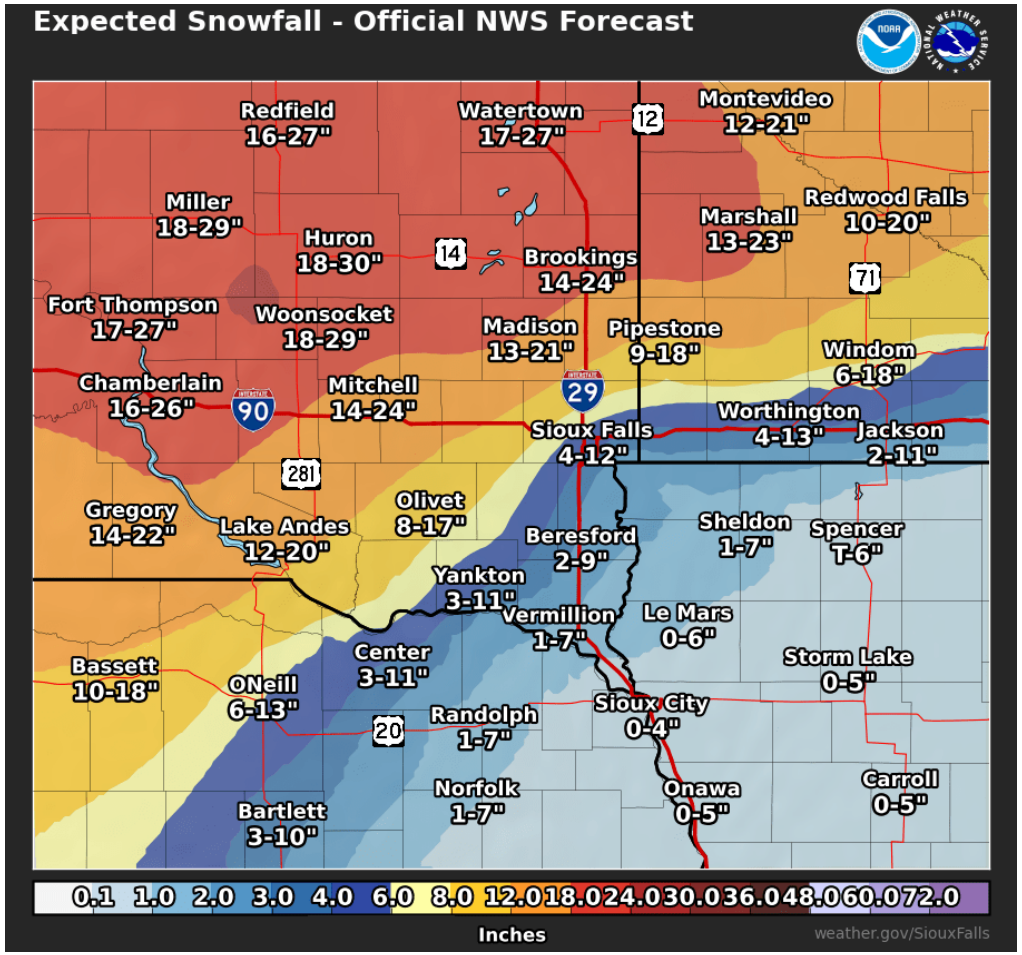
For both question 1 and 2 stated below, respondents were given the option of each of the snowfall forecast maps shown below

Section 3: Specific Questions About Graphics

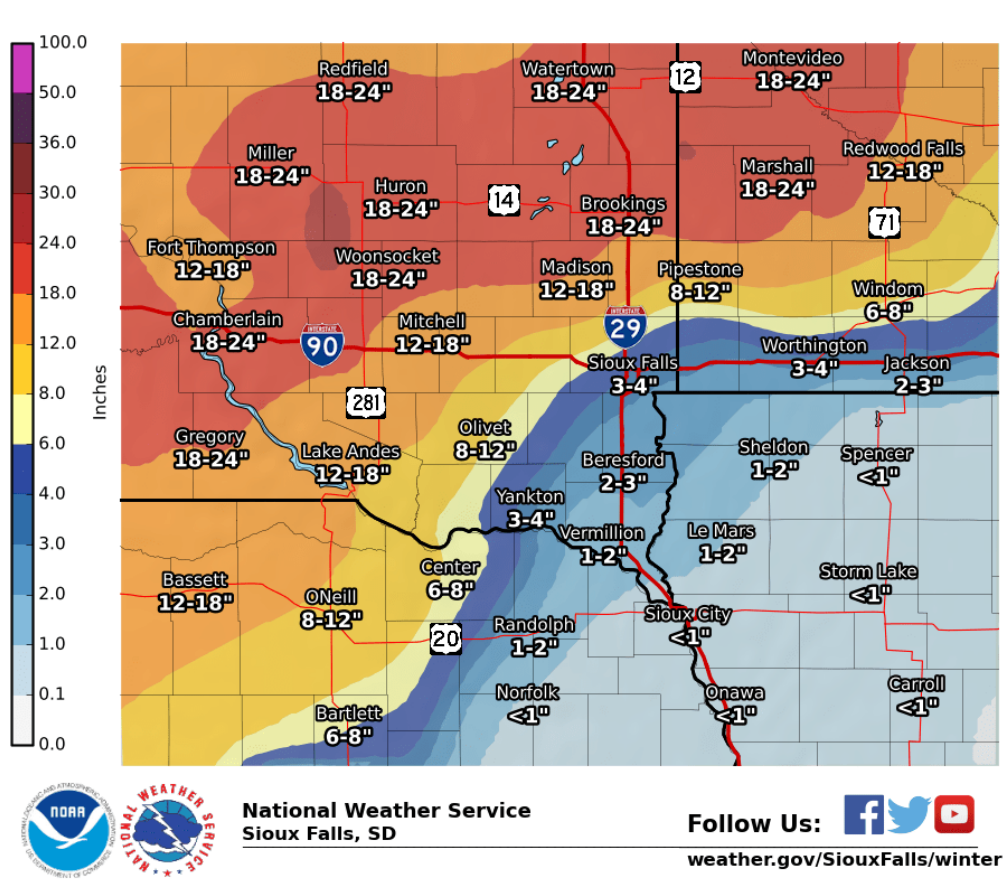
Q1 Suppose you live in the Sioux Falls, SD area and a winter storm will impact your area tomorrow. The National Weather Service could release one of the two snowfall forecast maps shown below. Both display virtually the same forecast, however, **the way that the snowfall forecast ranges are shown is different between the two.** Which snowfall forecast map do you prefer **based on this difference**?

Q2 Studies have shown that using the **larger snowfall ranges** results in the actual snowfall amount verifying within that range **50% of the time** (for example, if the forecasted range for Yankton is 3-11" and the actual amount of snow that falls in Yankton is 7", this forecast verifies). The **smaller snowfall ranges** result in the actual snowfall amount verifying within that range **30% of the time**. Given this information, which snowfall forecast map do you prefer? Note: snowfall forecast map graphics are the same as those from the previous question

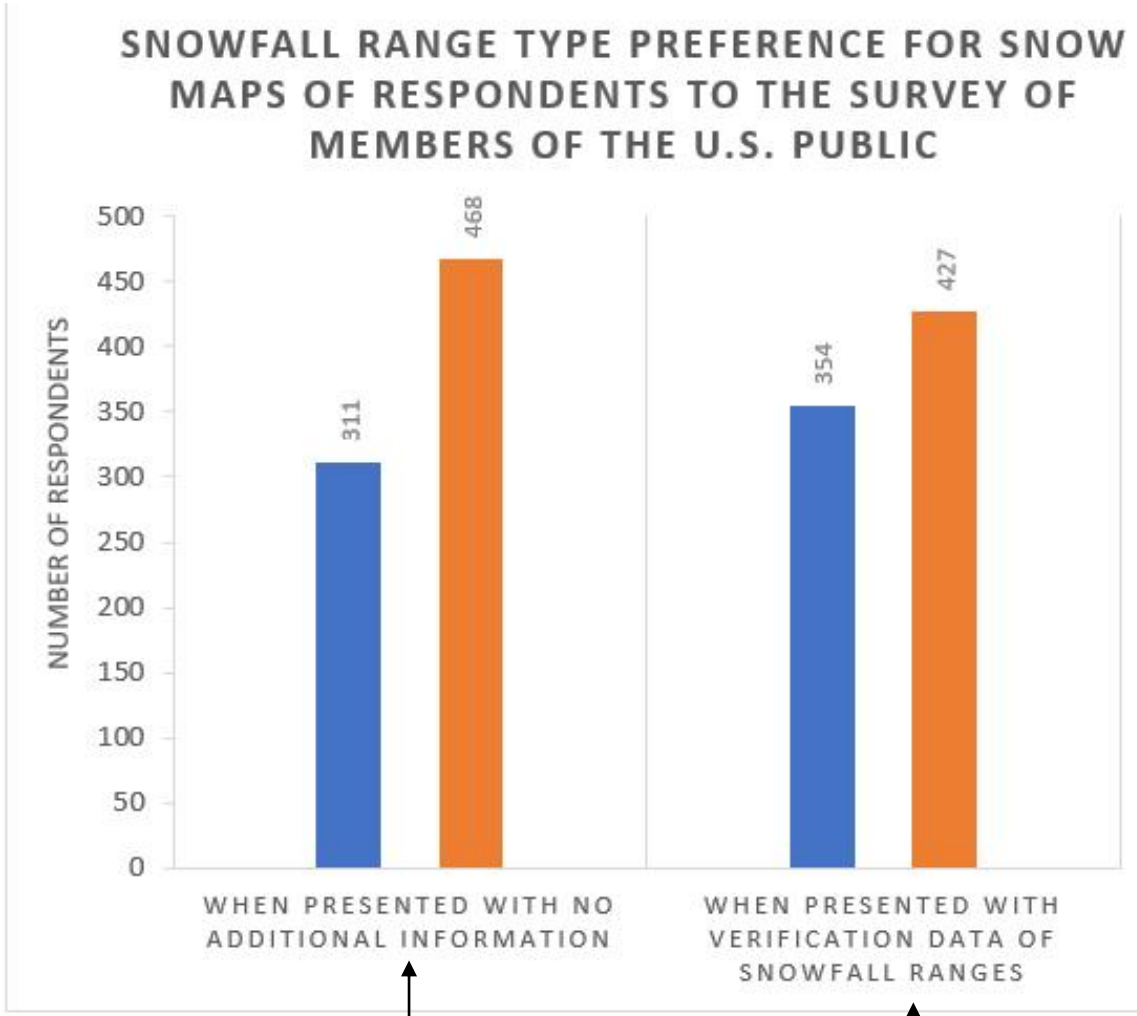
"Larger" snowfall ranges



"Smaller" snowfall ranges



Probabilistic Snowfall Map Results



Question 1 (Q1) from previous slide

Question 2 (Q2) from previous slide

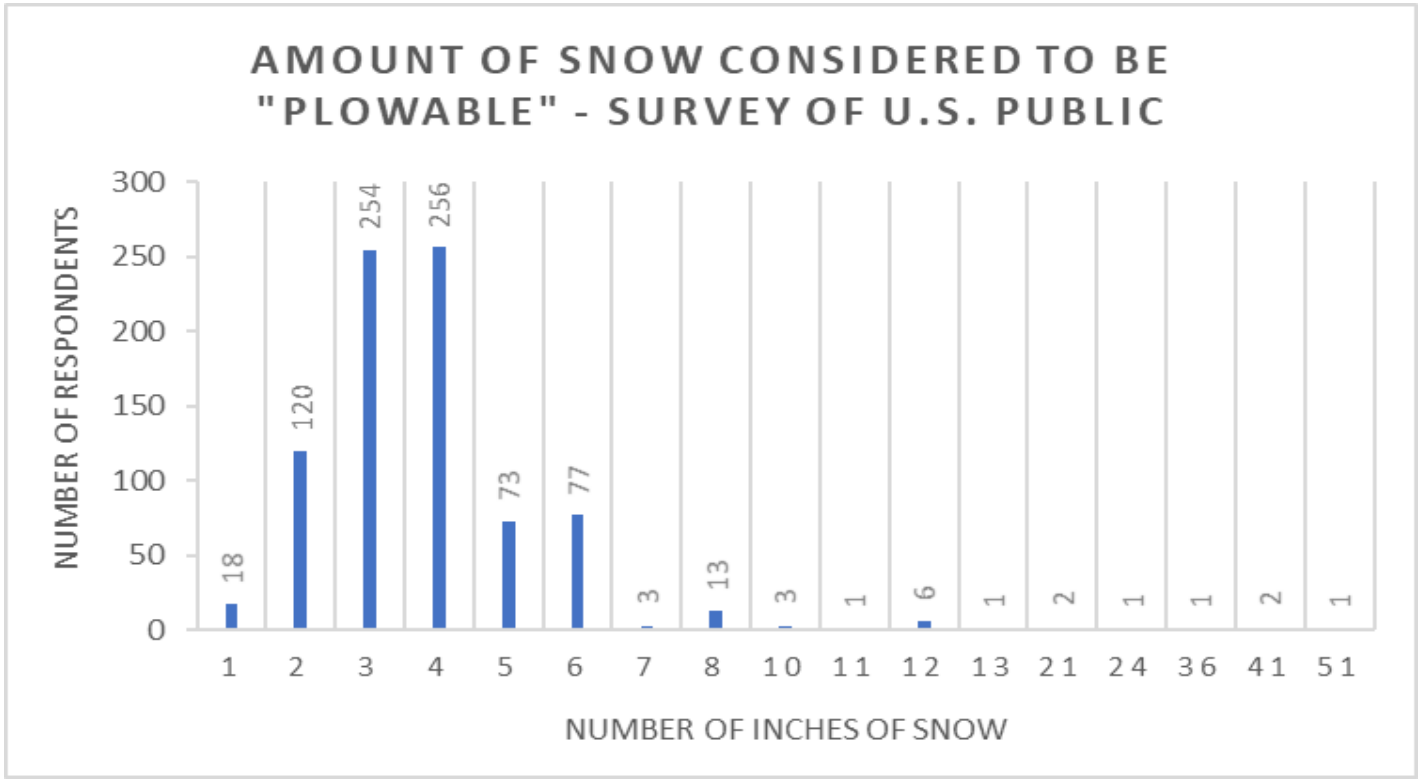
25th-75th percentile probabilistic snowfall ranges map (larger ranges) ▲

NWS color table snowfall ranges map (smaller ranges) ▼

See thesis pages 44-46 & 48-49 for full explanation of these snowfall forecast maps and what the results mean

See Appendix C of thesis for full-size graphics (Questions #53 & #54)

Question: In your opinion, at least how many inches of snow would need to fall for it to be considered "plowable"?



Question asked due to NWS State College's experimental "Probability of Plowable Snowfall" graphic used 4-7 before an upcoming winter storm

It uses the WPC's probability of exceeding 0.25 inches of liquid equivalent of snow/sleet map and puts those probabilities into a three-tiered, red/orange/yellow color scheme. Using a 10 to 1 snow to liquid ratio, this graphic would display the probability of exceeding 2.5 inches of snow, which NWS State College used the term "plowable" to define. Snow to liquid ratios can vary for each winter storm, which is one of the reasons why NWS State College chose to use a more generalized term instead of explicitly stating that this graphic provides the probability of exceeding 2.5 inches of snow throughout the forecast area.