Final Report Instructions for Partners and Cooperative Projects

Listed below are the content elements that should be included in your final report. While the report does not need to be lengthy, it should provide a summary of the **entire** project (not just the accomplishments since the last 6-month report). **Both** the academic and the operational forecasting partners should complete the report. It is **particularly important** that the operational partner provide as much information as possible in the Benefits section (section 3) in order to demonstrate the value of the Outreach Program to the NWS and other funding agencies.

Please send the final report in electronic form to the Outreach Program so that we can post it on the COMET Outreach Program's Website. We also appreciate receiving copies of journal publications and student theses that have resulted from the project.

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Type of Project (Partners or Cooperative): Partners

Project Title: Social Verification of Warnings: How can we improve the response to warnings?

UCAR Award No.: Partners Outreach Project S07-66862

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Section 1: Summary of Project Objectives

The study was designed to seek feedback from emergency managers (EMs) and other primary respondents, who depend on watches and warnings from the NWS, to mitigate the adverse impacts of tornados. The feedback would enable the NWS to revise the form and content of the warnings its offices issue to get prompt and proper response. This improved response we expect will qualitatively enhance the efficacy of improved lead-time.

This study would help us understand the factors that contribute to the gap or dissonance between what the NWS wants to communicate and how the EMs understand that message. Another objective was to ask the EMs to respond to scenarios describing the severe weather events after they have occurred. These post-event scenarios would allow the NWS to understand what elements EMs see as important when they consider the warnings issued by NWS. This will allow NWS to improve the acceptance of its warnings by the EMs and thereby actuate prompt response. The aim is to improve the value of these warnings to its users by incorporating the elements important to them.

Section 2: Project Accomplishments and Findings

Describe the research/development activities and accomplishments carried out to date. These accomplishments may relate specifically to the original project objectives, or they may be ones that arose during the course of the project (e.g., development of an innovative method for accomplishing the objective or insight into a related problem). Highlight any major changes to the scope of work. If the project involved separate research topics, please list each separately.

We have completed the scenario-based survey of the EMs in service area of three field offices. The responses have been analyzed in the attached report. The responses indicate that the EMs prefer to see varied evidence of the potential for a tornado to accept the reasons for issuing the warning. They would not like to depend on radar images alone for issuing a warning.

Section 3: Benefits and Lessons Learned: Operational Partner Perspective

List the benefits to the NWS office from the collaboration and any significant lessons learned during the study. Please be as specific as possible, particularly in regard to any improvements in forecasting resulting from the COMET project (see examples). Identify any major problems encountered and describe their resolution.

The opportunity to conduct the survey with our EM partners in and of itself was a positive experience. The EMs appreciated being part of the study and are looking forward to the results.

In a more tangible sense, the templates used by WARNGEN (at DVN) have been changed to reflect the results of the study. For example, instead of using call to action statements (CTAs) that just mention a wind speed (science speak), we now mention impacts caused by the wind, for example, "This storm is likely to produce 80 mph winds which will blow down trees and power poles". Trees blown down by severe thunderstorm winds have caused 4 fatalities in our CWA since 1994 while tornadoes have only caused one.

Typically the basis statement in a warning is "radar indicated" OR "trained spotter reported". Usually the trained spotter report trumps the use of "radar indicated". However, given that EMs are more convinced about a threat when multiple sources indicate a threat, we will reword our basis statement to include both sources, spotter and radar, when appropriate. Currently we already add a statement regarding a storm's history when we know what severe weather has already occurred. Also, local training for EMs has stressed that while the wording in a warning is "radar indicated", it truly reflects the forecaster's assessment of both radar and other environmental data (e.g., MESONET observations, LAPS analyses, etc.). Thus, the term radar infers a much broader environmental assessment, something not previously understood by EMs (and the local media).

An offshoot of this study relates to policies for communities which use outdoor sirens. We are currently working with municipalities in the Quad Cities metro area to develop a uniform siren policy. This policy would involve sirens being sounded *based on the wording of our warnings*, not just whether they are a severe storm or tornado warning.

Section 4: Benefits and Lessons Learned: University Partner Perspective

Describe the benefits to the University resulting from the collaboration and any significant lessons learned during the study. Identify any major problems encountered and describe their resolution.

From the university partner's perspective, the project afforded a unique opportunity to examine the way EMs respond to warnings issued by NWS offices. By developing the scenarios in collaboration with the NWS partners, it was possible to describe potential situations to elicit responses from the consumers of tornado warnings. The decision to use a scenario-based approach was the first time such a method was used in research related to meteorological issues. Such scenarios are often used in medical research. The advantage of scenario-based questions is that it allows us to focus on specific aspects of the problem we want to study. However, given the relatively small number of respondents, we did not use elaborate statistical methods to draw correlations or causations.

There were no major problems encountered during the project. Some offices had to change their planned schedule for conducting the surveys because of severe weather in their areas. However, the surveys were completed in time.

Section 5: Publications and Presentations

Provide complete citations using the AMS bibliographic format for each thesis, dissertation, publication or presentation prepared as part of this project.

We have not yet published any papers based on this research. We plan to publish in a journal with aim of reaching the appropriate audiences.

Section 6: Summary of University/Operational Partner Interactions and Roles

Describe the responsibilities of the various project participants over the course of the entire project.

The content of warning messages based on currently accepted practices was provided by the NWS researcher. This formed the basis for one set of scenarios. An alternative set of scenarios in plain English was developed by the university partner. The content of these scenarios were discussed and edited to ensure equivalence. The participating offices were given sets of questionnaires with these alternative scenarios. They were entrusted with the task of actual administration to suit their operational schedule given severe weather workload. The questionnaires were analyzed by the university partner. The initial draft of the final report was also prepared him. The NWS partner reviewed and edited the draft and enacted local changes to WARNGEN templates and conducted staff training to review the background on which these changes were based. This was discussed by both to clarify the changes. Participating offices were given the report for comment.

Social Verification of Warnings:

HOW CAN WE IMPROVE THE RESPONSE TO WARNINGS?

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Introduction

This project was initiated to address a problem occasionally encountered by the National Weather Service (NWS) field offices. The problem, as they see it, is why emergency managers (EMs) do not always respond promptly to the tornado warnings issued by them. It is expected by the warning offices that EMs will activate warning systems and sirens when a tornado warning is issued. The responses from the public and EMs are not always congruent with the urgency implied in these warning messages. The EMs tend to delay activation of warning systems for different reasons. As a result, the advantages gained from increased or improved lead-time through newer technology may be partially or wholly nullified. This could prove to be a weakness with potentially serious consequences.

Public Understanding of Science

It is commonly assumed that the general public, of whom the EMs are a subset, do not understand science or science-based information because they lack of training in science. In the 1980s and 1990s, it was argued that if people are provided appropriate training or information, then they will accept science and science-based information. This is called the 'deficit model' of the public understanding of science in the literature. This model has been widely accepted by the scientists and policy-makers and by some social scientists. The solution commonly suggested is education and outreach where information is passed down by the 'experts'. This model and its solutions to remedy the situation have been criticized in many studies; however, the model keeps reappearing in different forms. The critics have called for public engagement and dialogue between scientists and 'citizen scientists' or 'lay experts'. The kind of engagement they seek to nurture includes reflection on social and ethical dimensions, values and norms that govern scientific practice.

The critique of the deficit model has demonstrated that the deficit is not of the public but of the scientific community (Jasanoff and Wynne 1998, Irwin 2001, Sturgis and Allum 2004). More recently, the term "public understanding of science" has been inverted to examine "the understanding of the public by scientists" (Levy-Leblond 2007, Davies 2008). From the body of literature critical of the "deficit model", we can build a picture of a homogeneous scientific body composed of individuals who, in all circumstances, subscribe to the deficit model and hold simplistically to their "naïve sociology".

However, recent study of scientists' discourse about their public paints a more complex picture. This complexity does not negate the dominant deficit discourse, but serves to "problematize the public and protect science". The public are constructed, in the scientists' discourse, as deficient not simply in knowledge, but in a whole raft of other factors as well—agency, capability, and understanding, amongst other features such as fear of uncertainty (Davies 2008:17).

We live in a knowledge society in which we regularly defer to and trust in experts. However, various groups (social and physical scientists, democracy advocates, environmental activists, etc.) have challenged the idea that we should trust scientific experts because they have special access to truth. The trust can be defined as the "willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party" (Mayer et al 2006: 85). It is important to note that being vulnerable implies that there is something of importance to be lost. Making oneself vulnerable is taking risk. Trust, the authors argue, is not taking risk *per se*, but rather it is a *willingness* to take risk" (Mayer et al 2006: 85, original emphasis).

It is this willingness to take risk on the part of the public (e.g., EMs) and their inability to monitor or control the actions of the risk communicator (e.g., NWS) that enables us to appreciate why the emergency managers want to see more evidence before taking any action. It is this reason why it is prudent to be transparent about the forecast and warning process with those who are willing to take risk based on the warning. That is why false alarm rate can erode the trust. Expertise is "a relation between those who 'have' the expertise (the forecasters) and those who 'consume' it", that is, the rest of the society (Selinger and Crease 2006:5). What is in question is the value of particular specialized knowledges in the face of real-world problems that rarely fit the confines of any single disciplinary box. In short, weather forecasters are being asked to demonstrate their accountability and relevance to society.

Communication of Science-based Information

For a long time, weather information providers have supplied weather information to customers without explicit understanding of their information needs or how that information is used in their decision processes. This has left a gap between producers and consumers of information (WMO 2007). To bridge the gap between information providers and consumers, it is necessary to establish credibility and trust. This is difficult because providers rarely interact directly with the users. The providers tend to fabricate an artificial conception of the kind of lay person or user they claim to serve. The imagined lay persons do not have to resemble their "real" customers, but are functional constructs or "models" created by "experts" to legitimize their work. This prevents them from understanding the information needs of the real-life users.

Historically, the criteria for what constitutes a "good forecast" were not primarily based on values relevant to society. The criteria were developed with what would be acceptable to other meteorologists. This was fostered because of insufficient understanding of relationship between science and society. It is true that forecasting is based on and depends on, science and technology. However, that is only partially true. We recognize that science is transforming modern society. However, it is less often appreciated that society, in speaking back, is transforming science (Nowotny et al 2007). **It is this reverse communication that is important to understanding the changed relationship between science and society.**

What has changed? Under the prevailing contract between science and society reached after the Second World War, science has been expected to produce reliable knowledge. This contract was based on trust. It set out the expectations of science held by the society, and includes appropriate sanctions if these expectations are not met. Under the prevailing contract, science has been expected to produce reliable knowledge, provided it communicates its discoveries to society. Reliable knowledge is defined as such because it "works". Many times this knowledge worked in laboratories, under controlled conditions, but created many unanticipated problems when exported in the real world.

From the second half of the twentieth century, the shifts and changes in the economy, increased global competition, and expansion of higher education have been accompanied by a culture of accountability. As a result, the boundaries demarcating university science, industrial R&D, and government research have gradually become porous. Cumulatively, they signal the end of the social contract through which science flourished during and after the Second World War, and thus mark the expiry of that social arrangement (Nowotny et al 2007).

A new social contract has become necessary. It must now ensure that scientific knowledge and science-based information are socially robust, and their production is seen by society to be transparent and participative. This cannot be achieved by merely patching up the existing framework. Contextualized knowledge or increased socio-economic demands on sciences have also contributed to the multiplication of user-producer interfaces. The word *interface* supposes that the junction between two sciences or two concepts is perfectly under control. On the contrary, spaces *between* them are more complicated than one thinks. The passage between the hard sciences and the so-called human sciences resembles the Northwest Passage, more fractal than simple, and full of jagged shores, islands, and fractal ice floes (Serres and Latour 2005, Nowotny et al 2007).

Here is a conversation taking place among professionals in a multi-disciplinary team.

> Engineer: . . . we use PDA in water.
> Somebody: What is PDA?
> Engineer: Polydiacetyleen, one of the simplest substances to draw in a zigzag line.
> Chemist: Sure, they are simple to draw, but by no means simple to synthesize (Duncker 2001:349).

An abbreviation, PDA (personal digital assistant in common usage), is used to simplify the conversation, but it means different things to different participants. Not only is there confusion about the exact or appropriate meaning of PDA, but whose meaning will prevail. If the participants continue to insist that their particular meaning is correct, then interaction and sense-making will be difficult. The communication will add to the confusion. **For effective communication, you will need to use language that different groups can understand.** If you conceptualize the process of communication, as indicated below, the complexity of sharing information becomes clear.

Adapted from P. R. Timm and James A. Stead, *Communication Skills for Business and Professions*, 1996: 83.

That is why the interface, between two sciences or professions, is not as secure as popular opinion leads us to believe. It is not as easy as simply opening a door and crossing from one place to another. It is more like a labyrinth. It is in these places that confluences form as messages intersect with one another. The science can flourish in these confluences through its inventive power, where heterogeneous projects, social practices, and ideas become mixed together (Serres and Latour 2005).

At these confluences translation becomes necessary. Think of translation as a form of communication, a message passing between points. Contemporary rhetoric on communication holds the term as an unalloyed good – communication is good, whilst miscommunication is at best an error, or at worst a disaster. Think of communication as equal mixtures of signal and noise or interference produced in the course of transmission. As such, noise is really part of the relationship between sender and receiver. It is an accompaniment to the signal. For the sender, noise will always be an obstruction – it gets in the way and must be overcome. But for the receiver, noise need not play this role. It may have its own informational value when interposed with the signal (Serres and Latour 2005, Callon 1986).

> For example, a forecaster issues a forecast with 30% chance of a "major" flood. S/he does not provide any other information that may be useful to the receiver reading this forecast. A customer calls the forecaster.
> Customer: "How certain are you about this flood?"
> Forecaster: (pause) "Err, I mean, fairly certain."

The pause and the hesitation could be construed as disturbance, but to the customer it tells a lot about the uncertainty in the mind of the forecaster. That hesitation was not part of the message; however, the noise of hesitation made the message stand out.

Translation appears as the process of making connections, of forging a passage between two domains, or simply as establishing communication. Translation is, then, an act of invention brought about through combining and mixing varied elements. Callon (1980:211) has argued that "Translation involves creating convergences and homologies by relating things that were previously different". The way in which translation takes place on a common site is where varied 'significations, concerns and interests' commingle.

What do the Survey Responses Mean?

With the advent of strategic science, and what Gibbons et al. (1994) called "discovery in the context of application," cooperation across groups and across institutions is becoming the rule. This is not to say that such co-operations operate smoothly: differences in work content and work style, patterns of explanations, frames of reference, and institutional context can be large and have to be bridged (Duncker 2001: 349-50). Also different disciplines and professions have their own paradigms, organization, cognitive development, and cultural practices. To assume that somehow the message sent from one entity to another will be received and understood as intended by the sender is not necessarily correct.

It is important to recognize the use of the terms "information" and "knowledge" in contemporary society. Currently, these terms are used interchangeably. However, Hansson (2005) draws attention to the need to understand the difference. He argues that knowledge is a type of belief. If one has access to correct information, but do not believe in it, then one's access to it does not constitute knowledge. Incorrect beliefs cannot count as knowledge either. For something to count as knowledge, it has to be assimilated into the person's belief system. One can have access to information, but if that information is not understood in the right way, that is, assimilated into the belief system; it is not transformed into knowledge and therefore action.

NOAA|NWS has taken on challenges of providing weather, water, and climate information (NOAA Strategic Plan 2006-11). Many non-expert user groups will need to domesticate that information and integrate it with their knowledges and into their activities. Most people do not appropriate scientific concepts or information in order to emulate the scientist. They seek information about relevant natural phenomena to make sense of their own lives and livelihoods from within their own cultural framework.

It is, therefore, necessary to ensure that the target groups understand and interpret information properly. Another way to express this point is to refer back to the contextualized knowledge, mentioned above. People make better sense of information when there is context to which they can relate. This ability to relate enables them to domesticate information and add it to their existing knowledge base. Decontextualized information distorts this process and can create confusion, misinterpretation, or misunderstanding.

The analysis of survey responses to post-event scenarios shows that the respondents want to see more sources of evidence to validate the reason for issuing tornado warning. They are not always ready to accept that radar observation showed signs of tornadic activity as a valid reason for issuing a warning even when there was no damage. It will be constructive to ask why the respondents, the emergency managers, want more evidence.

First, many emergency managers told me in a different context that they do not know how to interpret the radar colors. They generally follow the "traffic light" code; green means safe, yellow means caution and red means danger. This indicates that radar as a tool for detection has limited value from their perspective. Recall that most people do not appropriate scientific information in order to imitate the scientist.

Second, the respondents ask for visual confirmation on the ground, through trained spotter, general public, and the media. This suggests that they are willing to trust other members of society for signs of tornado-related activities. This raises the question, how much trust do people put in technology (namely, radar) and how much on visual confirmation from other humans.

Third, the respondents have to trust the warnings issued. The false alarm rate (FAR) measures the fraction of forecasted events that did not occur. It is a principal measure by which the performance of the NWS in issuing warnings of natural hazards is measured. The fraction of all tornado warnings issued by the NWS across the US in 2007 that did not verify was 0.76 (John Ferree, Severe Storms Service leader, **NWS** 2008). In plain words, given four tornado warnings, only one was associated with a reported tornado. An ideal forecast would have an FAR of 0.00, but the uncertainties in forecasting technology, forecasting science, and verification make this an unattainable goal. Repeated warnings that do not result in tornadoes or other severe weather as forecast are often viewed as problematic. NWS policy actively seeks to reduce the rate of false alarms. The model suggested by Barnes et al (2007) shuffles the numbers in different boxes but does not change the reality, namely, EMs and general public are weary of false alarms and the consequent disruptions.

The approach we have taken is to ask the EMs what they would consider a valid basis for issuing tornado warning. The scenarios provided different situations under which offices issue tornado warnings. We asked them to choose what more evidence they would like to see to consider a warning *justifiable*. The respondents wanted to see human eyewitness accounts to substantiate the technological (namely radar) signature. This has two possible explanations. One, the respondents are not as ready to rely on radar as meteorologists may be. That is there is a difference between science workers putting faith in instruments because they are trained to do so and the public who see the situation differently (do not have the understanding and trust in technology). From the responses it is clear that the composite picture that the respondents were looking at had radar as one, but not the only evidence of tornadic possibility. Second, the information in the form of warning has no context for the respondents to make sense. Recall the argument from Hansson mentioned above. If one has access to correct information, but do not believe in it, then one's access to it does not constitute knowledge. One can have access to information but if that information is not understood in the right way, that is, assimilated into the belief system; it is not transformed into knowledge. It is not likely that they will act based on that information.

The way a forecaster thinks about severe storms and the public's reaction to it are not the same. It is akin to multi-disciplinary teams working with different knowledge, language, and perspectives. Research has shown that such teams do not present a reductionist picture of either complete homogeneity or mere patchwork sutured for a purpose. The operative word here is "team". Research on communication and interaction in multi-disciplinary teams can provide some helpful insights. Similar to different neighboring tribes encountering one another through trade, cooperating disciplines meet in such trading zones and, by way of trade and exchange, develop more or less elaborate, mutually comprehensible languages (Galison 1997, Duncker 2001). A translation between them is not a simple matter. It needs extra efforts to translate cultural particularities. Duncker argues that "Insofar as actors normally understand each other only in terms of their own symbolic repertoires, they tend to normalize strange expressions; that is, they perceive 'the other' through their own semantic frame and fit the other's statements into their own repertoires" (2001:356). It is possible for forecasters and the public to overcome the cultural particularities of trading zones and develop mutually comprehensible language.

For that to happen, it is necessary to develop a sense of trust in each other's abilities. Can the general public send pictures of storms with their physical location on their cell phones using GPS? Is that acceptable evidence? Does the reporting person have to be part of the federal, state or local government? Can the general public be given the list of signs to observe when reporting storm-related information? Can the public trust a warning issued by the NWS given the high rate of false alarms? Can the public rely on the advice given by the NWS in the event of a tornado? Is it based on scientific evidence?

A recent paper has expressed doubts about it (Farley 2007). The author argues that the call-to-action statements do not directly contradict official guidelines and advice, although there is significant variation among NWS offices regarding what advice is given and what guidelines are emphasized in call-to-action statements in tornado warnings. A call-to-action statement is included with the warning to tell the public what to do to protect from impending hazard. The research shows that the safest action to take is highly conditional upon the specifics of the situation. However, **the research on risk communication indicates that repeated provision of clear and understandable messages about the nature of risk and protective action is likely to lead to adoption of appropriate preparedness and response.** Farley argues, based on research in risk communication, that the warning message is most effective when it is clear, consistent, and repeated. When the same information is received multiple times from different sources, its impact on risk perception and on people's efforts to obtain further information is maximized (Farley 2007:2).

For the purpose of this project, **it is crucial to develop and maintain trust in the message and the sender.** This brings us to the phenomenon referred to as "cry wolf" or false alarm effect (Atwood and Major 1998). Officials responsible for issuing warning about threats to public safety face a dilemma. If the warning results in a false alarm, the public is likely to pay less attention to future warnings. Such a decline in attention to warnings can be problematic. False alarms can result in a loss of credibility for the hazard warning entity. The effect can be further compounded if there are alternative sources of similar information (new media, private weather websites, etc.) available to the public. And it is further complicated by the fact that, while many tornado warnings do not result in tornadoes, they do result in some form of severe weather (large hail and/or damaging winds). Moreover, the public's definition of the severe thunderstorms is not necessarily congruent with the NWS definition. A tornado warning which produces torrential rain and copious lightning may be thought to be severe by some in the general public, even though it does not meet NWS criteria. Of course this lack of congruency between the public perception and NWS definition can also result in a perceived "missed event".

WHAT CAN BE DONE?

Looking at the responses (a) as demand signals from the contemporary information market, (b) trust as willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, and (c) given that expertise is a relation between those who have it and those who consume it; **it is possible to refine the way to issue a tornado warning.** That **new way is not to rely solely on what the forecaster says is a tornado or possible tornado, but what the public considers as legitimate reason to issue warning.** Such a process has a better chance of producing desirable effect, namely, to take protective shelter or plan for other actions, because the 'consumers' have subscribed to it as partners.

We suggest that the warning should have the following elements. **They should be written in a clear and concise manner to be understandable to the average citizen who has limited 'technical' resources.** The questions for every element are those in the minds of people reading the warning:

1. **Nature of threat**: What is the threat? Is there an actual tornado or a potential for a tornado?

2. **Area/s likely to be affected by the threat**: Where is the storm coming from? In which direction is it moving? The direction of movement should be given in the form of geographic direction, with city, county and state names of places that will be impacted. For people traveling from out of the area, it is helpful to provide ample signs (e.g. Interstate mile markers, well-known landmarks) to facilitate their decisions.

3. **History of damage**: Is there history of damage from this storm? What is the nature of damage? These storms move quickly and hence, getting the necessary information will require a socio-technical network that the offices can tap into. People with cell phones, with camera or GPS devices, can be a good resource to build such a network with some training or information about what is helpful to the forecasters, such as is done in spotter training.

4. **Available evidence**: What is current evidence available that led to the warning? Is there supplementary evidence that has given forecasters confidence to issue the warning, e.g. spotter reports, phone calls from the public, observation cameras or webcams, local media, etc.

5. **How imminent is the threat**: Typically tornado watches precede the warnings. It is important to provide a time-frame for people to recognize the intensity of the situation and when the chances are high. In short, it is a strategy to build the anticipation over time by gradually increasing the sense of urgency in language people can understand.

6. **Actions that need to be taken**: What action should the public take when the tornado warning is issued? It needs to be clearly stated, such as,

> If indoors, go the innermost or window-less room
> If in mobile home, go to the nearest stronger structure
> If in car, move away from the path of tornado, etc.

This format provides immediate guidance, as a reminder for what the message recipient should ideally already know.

This is essentially similar to the current warning format employed by the NWS, except for two items. It is recommended that a warning **always** refers to a storm's history of severe weather production when known. Second, traditionally the basis for the warning is either radar or spotter report. This research has shown that mentioning both is more likely to confirm the threat in the receivers mind and prompt them to action.

Finally, while not directly part of the tornado warning text, it is implicit in these findings that relationships, hence trust, developed between a local NWS office and EMs are a critical part of the warning process and warning effectiveness. The importance of county visits, EM workshops, attendance at state EM meetings, etc. is clear.

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ANALYSIS OF SURVEY RESPONSES

All respondents:

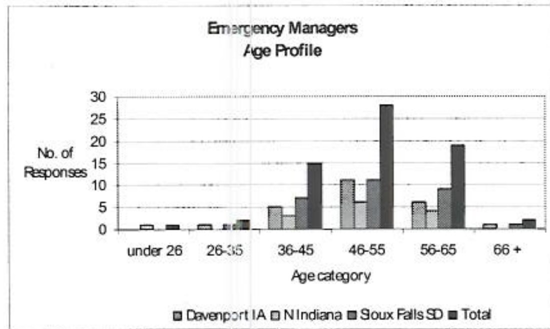
Age
41.8% were between 46-55 years
28.3% were between 56-65 years
22.4% were between 36-45 years

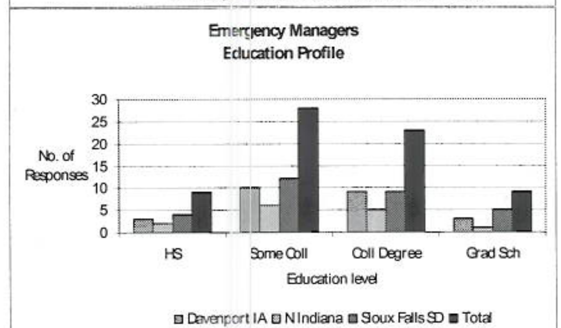
Education
40.7% had some college education
33.3% had college degree
13% had high school level education
13% had graduate school education

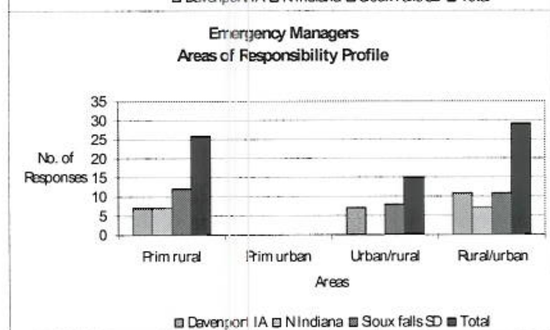
Area of responsibility
41.4% were primarily responsible for rural areas with some urban areas
37.2% were principally responsible for rural areas
21.4% were primarily responsible for urban areas with some rural areas

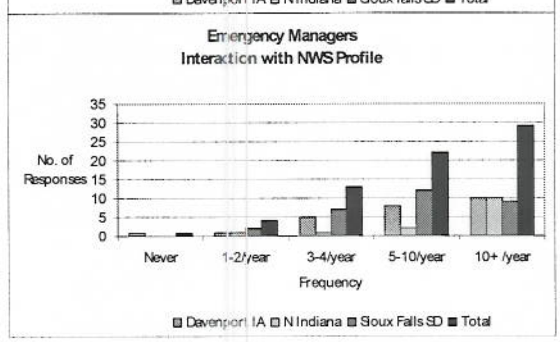
Interaction with NWS office
42.1% interacted more than 10 occasions during a year
31.9% interacted between 5-10 occasions during a year
18.8% interacted between 3-4 occasions during a year

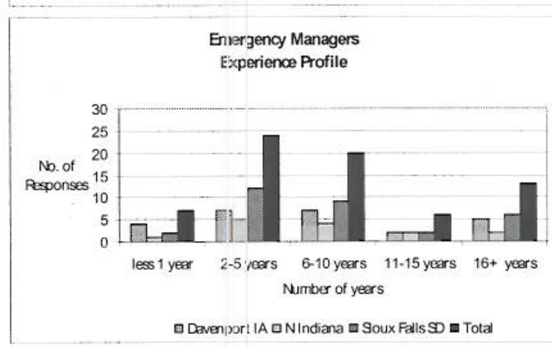
Experience
34.2% had between 2-5 years experience
28.6% had between 6-10 years experience
18.6% had more than 16 years experience
10% had less than one year experience



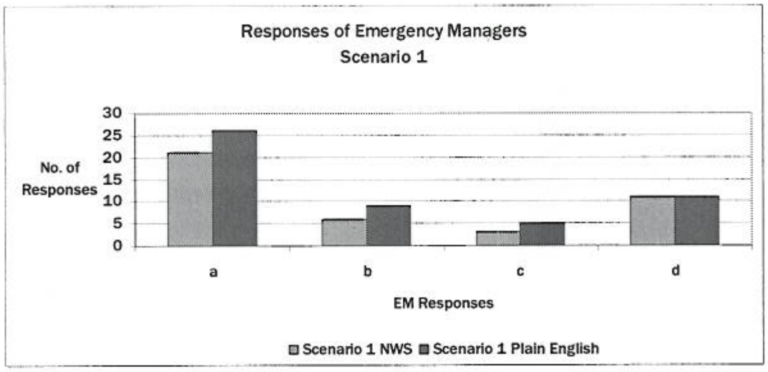








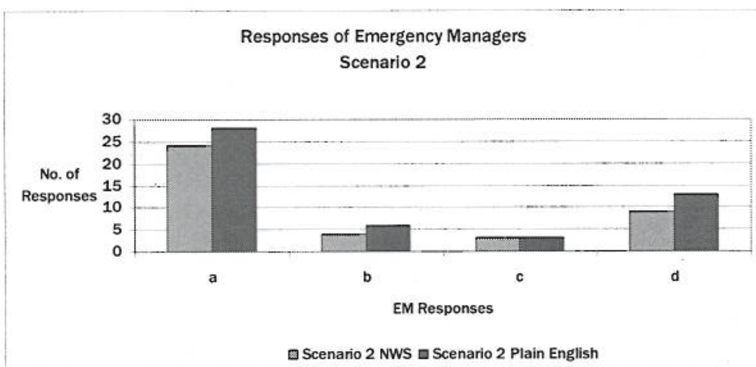
PRE-EVENT OR WARNING PHASE SCENARIOS



	a	b	c	d
Scenario 1 NWS	21	6	3	11
Scenario 1 Plain English	26	9	5	11

The first scenario describes that the NWS has observed a supercell moving into your county and therefore has issued a tornado warning. The emergency managers were asked to choose one of the four options: (a) Activate warning system including sirens, (b) Will not activate emergency system unless a funnel cloud is confirmed, (c) Will wait for further information, and (d) Will seek additional information.

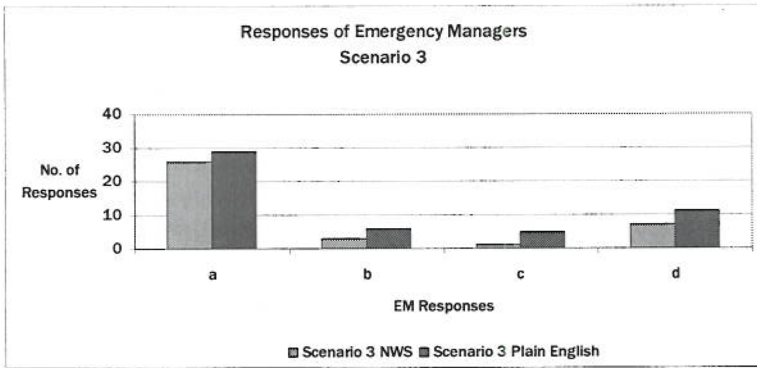
The response to warning is better when it is in plain English. At the same time, some respondents seem to take a wait and see attitude as reflected in (b) and (c). They seem to take a pro-active approach to seeking more information in both NWS and plain English versions.



	a	b	c	d
Scenario 2 NWS	24	4	3	9
Scenario 2 Plain English	28	6	3	13

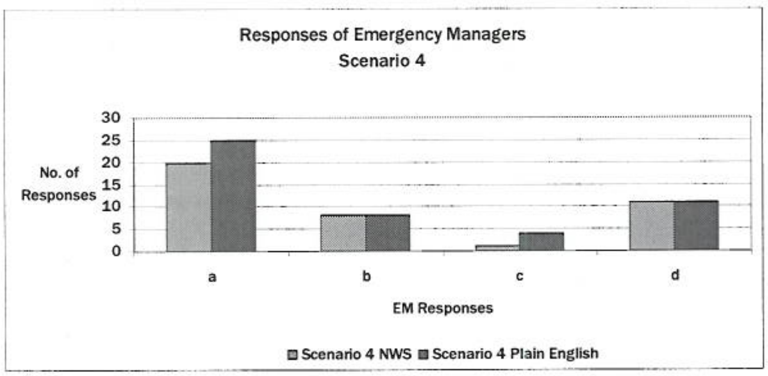
The second scenario describes that the NWS has observed a supercell moving into your county. The storm has a history of producing funnel clouds and therefore, has issued a tornado warning. The options were same as in the first scenario.

The response to warning is slightly better in plain English version. The respondents are more inclined to be pro-active in seeking more information. The number of respondents who preferred to wait for more information or chose to delay the activation is relatively small. It seems that respondents respond better to English version.



	a	b	c	d
Scenario 3 NWS	26	3	1	7
Scenario 3 Plain English	29	6	5	11

The third scenario describes that the NWS has observed a supercell with a rotating wall cloud moving into your county. The NWS, therefore, has issued a tornado warning. The options were same as in the first two scenarios.
The response to the warning is slightly better in the plain English version. The respondents are more inclined to be pro-active in activating warning system and seeking more information. The number of respondents who preferred to wait for more information or chose to delay the activation is relatively small as in scenario 2. It seems that respondents respond better to English version.



	a	b	c	d
Scenario 4 NWS	20	8	1	11
Scenario 4 Plain English	25	8	4	11

The fourth scenario describes that the NWS has observed a supercell with a history of producing straight line wind damage moving into your county. The NWS, therefore, has issued a tornado warning. The options were same as in the first three scenarios.
The response to the warning is slightly better in the plain English version. The respondents are more inclined to be pro-active in activating warning system and seeking more information. The number of respondents who preferred to wait for more information or chose to delay the activation is relatively small as in scenarios 2 and 3.

When we look at the responses to these four scenarios, there are some points that stand out. The respondents seem to react to warnings better by indicating that they would activate the warning system when the warnings are in plain English. They are also pro-active in seeking more information about the storm or the warning. This could be because they want to understand what is happening and what sort of evidence is available. We had included no specific evidence about the storms or tornadoes in the phrasing of the scenarios. There are some differences when we look at respondents from individual offices separately.

Sioux Falls	a	b	c	d
Scenario 1 NWS	15	4	1	6
Scenario 1 Plain English	9	5	4	9

Northern Indiana	a	b	c	d
Scenario 1 NWS	4	1	0	0
Scenario 1 Plain English	7	2	0	0

Quad Cities	a	b	c	d
Scenario 1 NWS	2	1	2	5
Scenario 1 Plain English	10	2	1	2

The responses from three offices vary markedly. For example, In Sioux Falls, the respondents react positively to the warning in NWS wording, while in Quad Cities and Northern Indiana they respond promptly to the plain English version.

The respondents seem to be more willing to ask for more information in responses to plain English version in Sioux Falls, but not so in the Quad Cities.

It should be noted that the responses were exactly the same to all four scenarios in Northern Indiana. It is not possible to know if it was because the respondents did not notice the differences in the scenarios or because of some other reasons.

Sioux Falls	a	b	c	d
Scenario 2 NWS	15	3	1	5
Scenario 2 Plain English	12	3	3	9

Northern Indiana	a	b	c	d
Scenario 2 NWS	4	1	0	0
Scenario 2 Plain English	7	2	0	0

Quad Cities	a	b	c	d
Scenario 2 NWS	5	0	2	4
Scenario 2 Plain English	9	1	0	4

The responses to scenario 2 from the three offices show a pattern similar to the first scenario. For example, in Sioux Falls, the respondents react positively to the warning in NWS wording, while in the Quad Cities and Northern Indiana, they respond promptly to the plain English version.

The respondents seem to be more willing to ask for more information in responses to the plain English version in Sioux Falls, but in Quad Cities the numbers even.

Sioux Falls	a	b	c	d
Scenario 3 NWS	16	1	1	5
Scenario 3 Plain English	11	3	5	9

Northern Indiana	a	b	c	d
Scenario 2 NWS	4	1	0	0
Scenario 2 Plain English	7	2	0	0

The responses to scenario 3 are similar to the first scenarios. Sioux Falls respondents respond promptly to NWS phrased warning, while Northern Indiana and Quad Cities respond more promptly to plain English warnings for activating emergency warning systems.

While there is no difference in responses to other three options in Northern Indiana and Quad Cities, Sioux Falls respondents seem to respond better to plain English warnings.

Quad Cities				
	a	b	c	d
Scenario 3 NWS	6	1	0	2
Scenario 3 Plain English	11	1	0	2

Sioux Falls				
	a	b	c	d
Scenario 4 NWS	12	5	1	7
Scenario 4 Plain English	10	3	4	8

Northern Indiana				
	a	b	c	d
Scenario 2 NWS	4	1	0	0
Scenario 2 Plain English	7	2	0	0

Quad Cities				
	a	b	c	d
Scenario 4 NWS	4	2	0	4
Scenario 4 Plain English	8	3	0	3

The pattern of responses to scenario 4 is similar to the other scenarios. Northern Indiana and Quad Cities respondents react better to plain English warnings, while those in Sioux Falls respond better to NWS warnings. It is possible that the instructions in Sioux Falls led the respondents to construe the intent of this survey as a vote of confidence in local office.

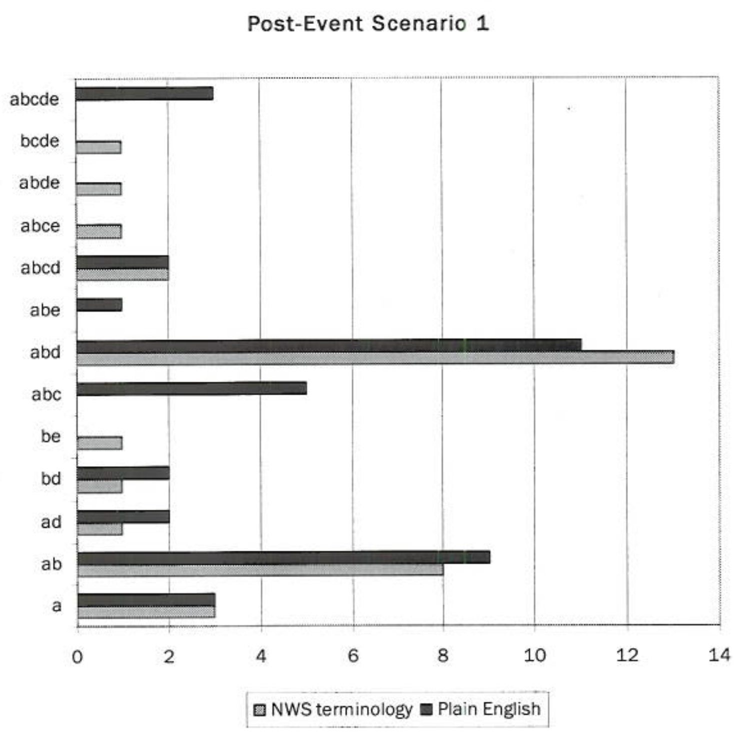
It is also worth noting that the respondents in Sioux Falls also indicate that they will not act promptly by activating warning system in response to NWS warning.

It is difficult to provide precise reasons for differences in responses between offices. There are several possible reasons. The respondents wished to maintain cordial relations with the local office they deal with regularly. The instructions given before the survey may have given the impression to the respondents that the survey was a vote of confidence in the service provided by the office. Or it could be simply that the respondents were accustomed to the way warnings were issued and their reliability.

POST-EVENT SCENARIOS

The first scenario described why the National Weather Service had issued a tornado warning. They had observed a supercell thunderstorm move across the county on their radar. A tornado occurred, but no damage was reported. The respondents were asked if the warning was justified for which of the following reason/s?

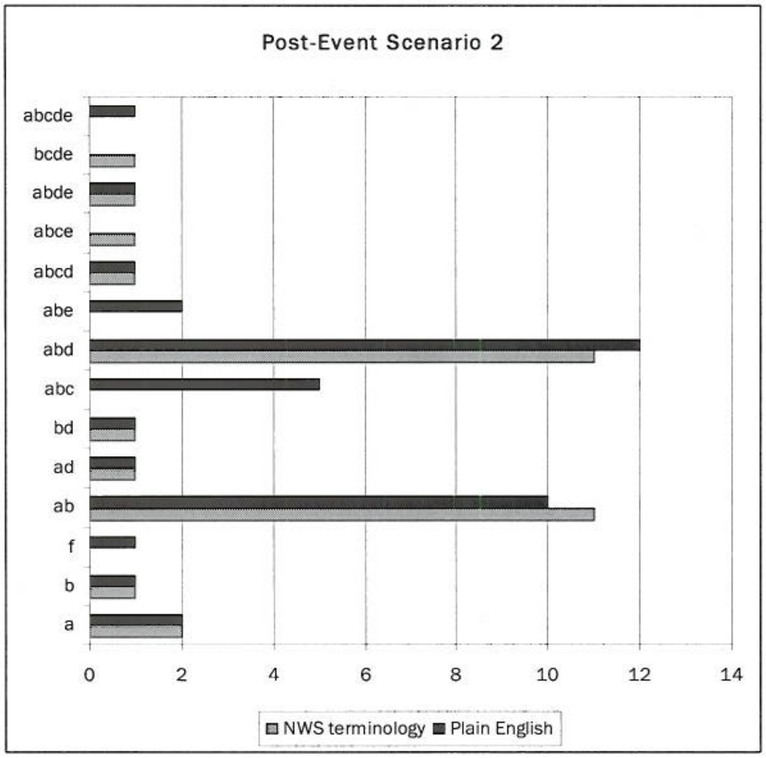
a. The National Weather Service's radar observation of a supercell thunderstorm that is likely to produce a tornado.
b. The report of tornado by a trained spotter.
c. The report of tornado by the public.
d. The supercell thunderstorm had a history of producing a tornado.
e. The media report of a tornado.
f. None of the above.



It can be seen from the bar chart that the respondents reading either version were not ready to accept radar observation (a) alone as evidence for issuing a tornado warning. They wanted it substantiated with spotter report (b) or report from the public (c) besides history of storm to produce a tornado (d) and media report. It is significant that the respondents were looking for multiple sources of evidence to justify a tornado warning. Also important is that the non-technical evidence is mostly from society (spotters, the public and the media) are part of the society. They are not experts in forecasting or meteorology. It should be noted that a very small proportion of respondents are willing to depend on radar observations alone (a).

The second scenario indicates that the National Weather Service had observed a supercell thunderstorm move across the county on their radar. A funnel cloud occurred, but no tornado was reported. Which of the following reason/s would justify their tornado warning? Their choices were

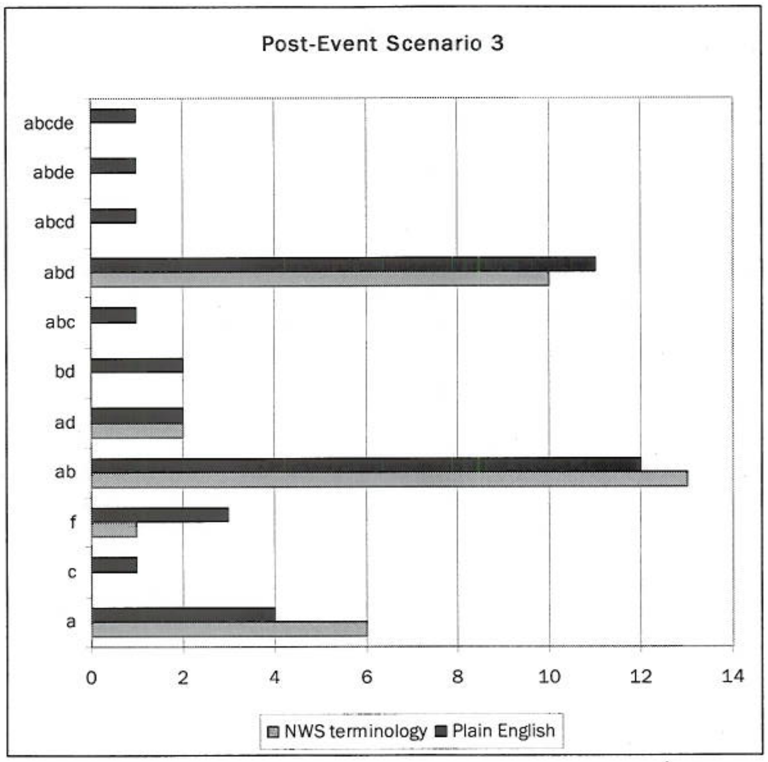
a. The National Weather Service's radar observation of a supercell thunderstorm that could produce a tornado.
b. The report of funnel cloud by a trained spotter.
c. The report of funnel cloud by the public.
d. The supercell thunderstorm had a history of producing a funnel cloud.
e. The media report of a funnel cloud.
f. None of the above.



The respondents did not consider radar observation (a) alone was sufficient to issue a tornado warning. They wanted to additional evidence, such as, spotter report (b), report from the cloud ((c), or history of the storm producing a funnel cloud (d). There were many respondents who wanted more evidence than radar observation to justify a tornado warning.

The third scenario describes that the NWS had observed a supercell thunderstorm move into the county, a rotating wall cloud occurred but there was no tornado. A tornado was issued by the office. Was it justified? If so, for which of these reasons the respondents would consider it appropriate?

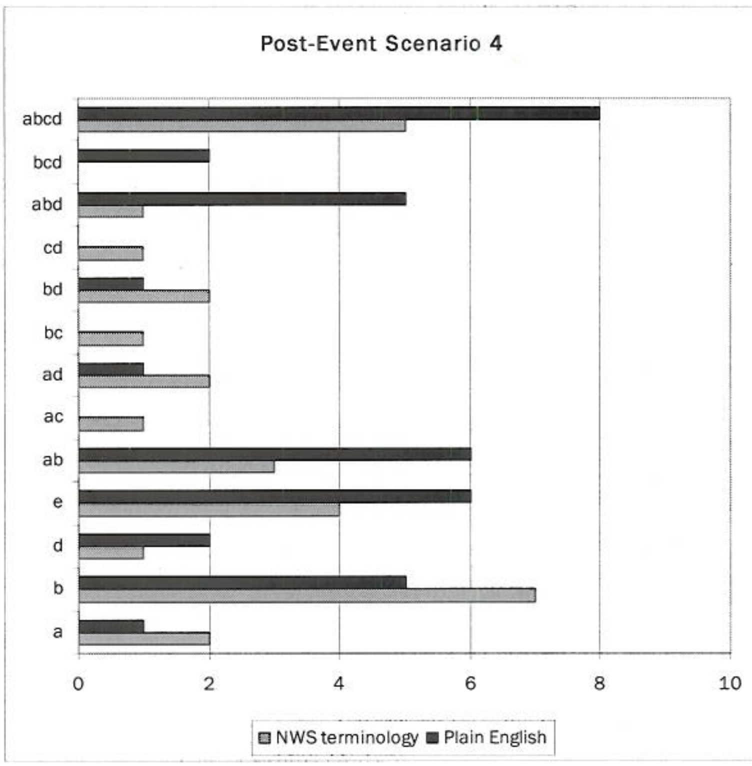
a. The National Weather Service's radar observation of a supercell thunderstorm that could produce a tornado.
b. The report of a rotating wall cloud by a trained spotter.
c. The report of a rotating wall cloud by the public.
d. The super cell thunderstorm had a history of producing a rotating wall cloud.
e. The media report of a rotating wall cloud.
f. None of the above.



It is clear from the responses that simply relying on radar observations (a) was not sufficient reason for issuing a warning. The respondents wanted to see the corroborating evidence, such as, report from a spotter (b) or history of the storm producing a rotating wall cloud (d). It is also noteworthy that respondents are asking for multiple pieces of evidence (ab, ad, bd, abc, abd, abcd, abde, abcde in the chart) before a warning can be justified.
The respondents with the plain English version were more inclined to ask for this additional evidence. Those reading the NWS version tended to ask for spotter report and history along with radar observation.

The fourth scenario described why National Weather Service had issued a tornado warning. They had observed a supercell thunderstorm move across the county on their radar. There were straight-line thunderstorm winds and damage, but no tornado was reported. The respondents were asked if the warning was justified.
Their choices were as follows:

a. The National Weather Service's radar observation of a large, severe thunderstorm that is likely to produce a tornado.
b. The report of tornado by a trained spotter.
c. The report of tornado by the public.
d. The large, severe thunderstorm had a history of producing a tornado.
e. The media report of a tornado.
f. None of the above.



Note that the respondents were not depending on radar observation (a) to decide on the justification of the warning. They were willing to accept a warning if there was radar observation (a) along with a spotter report (b), report of a tornado from the public and history of producing tornado (d). They also wanted to see if there was a report of tornado in the media. As can be seen from the bar chart, the respondents wanted to see more corroborating evidence to justify a warning when there was no tornado reported. Also note that the respondents are looking for multiple pieces for evidence (ab, ac, ad, bc bd, cd, abd, bcd, and abcd in the chart) before they consider a tornado warning is justified. Those reading the scenario in plain English were more inclined to ask for more corroborating evidence than those reading the scenario in NWS terminology.