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The National Weather Service's Polygon Method: Warning Dissemination of the Future

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By
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Abstract

The National Weather Service (NWS) is continuously improving its forecasting skills, but forecasters still cannot accurately predict the path of a tornado or a severe thunderstorm. The NWS has developed a new warning system in which the warned area is outlined by a polygon, not a county boundary. The polygon-warning approach is expected to significantly reduce the total square-mile area of warnings not followed by an event, called the False Alarm Area. There are three central issues concerning the failure of the polygon-warning method: 1) the size of the counties impacted by a storm, 2) the impact of the new warning system on visual and auditory warning methods, and 3) the communication between the NWS, media, and emergency management. If the polygon-warning method is going to be a practical alternative to the county-warning method, then warning disseminators will have to work together to provide the most consistent method of communicating severe-weather warnings to citizens who are in immediate danger.

Acknowledgements

I would like to thank all those who contributed to my thesis and my knowledge of the polygon-warning method: Mike Coyne, Nate Johnson, Patrick McCullough, Richard Okulski, Jerry Orchanian, Ken Waters, and Peter Wolf. I would especially like to thank Patrick McCullough for keeping in touch with me and sending me results from the studies conducted when they were available. I would also like to thank Nate Johnson for providing a tape using the polygon-warning method to help make more sense of all the written material on the subject. Thank you to Scott Dobler for being my helpful and patient thesis director. Finally, I want to thank my husband, Andrew, and my mother, Janie, for all their support throughout my endeavors with the WKU Honors Program.

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Introduction

The National Weather Service (NWS) is continuously improving its forecasting skills, but forecasters still cannot accurately predict the exact path of a tornado or a severe thunderstorm. Because of this problem, the NWS, the media, and emergency management lose their credibility with the public. After being interrupted during a favorite television show and after running for cover to the bathroom or hallway – just to find out that no storm was in the immediate area – people may begin to ignore warnings altogether. Of course, this practice may prove fatal when one ignores a valid warning and is in imminent danger. Thus, the cycle continues.

A total of 31,293 severe thunderstorm and tornado warnings were issued in the U.S. in 2004. The False-Alarm Rate was .467, which means about 46.7%, or almost half, of the warnings issued were false (National Weather Service 2004, quoted by Melody Magnus). This means that American citizens found themselves unnecessarily alarmed almost as often as they were necessarily alarmed. On the other hand, many people are surprised by a tornado or a severe thunderstorm in which no warning was issued. How efficient is the NWS with respect to accurately predicting the path of a severe storm? The Critical Success Index (CSI) measures the accuracy of warnings, including both surprises and false alarms (Smith 2003, 1). The measurement ranges from zero to one; zero is perfectly inaccurate, one is perfectly accurate. Figure 1 depicts the CSI for tornado warnings for the years 1986 to 2001.

This figure illustrates a two-fold picture. The most obvious pattern is that the measurements are often inaccurate. This figure shows that our surprise and false-alarm rates are grossly high while our storm-path predictions are extremely poor. The other observation is that reduction in surprises and false alarms is not steadily improving the way it should be.

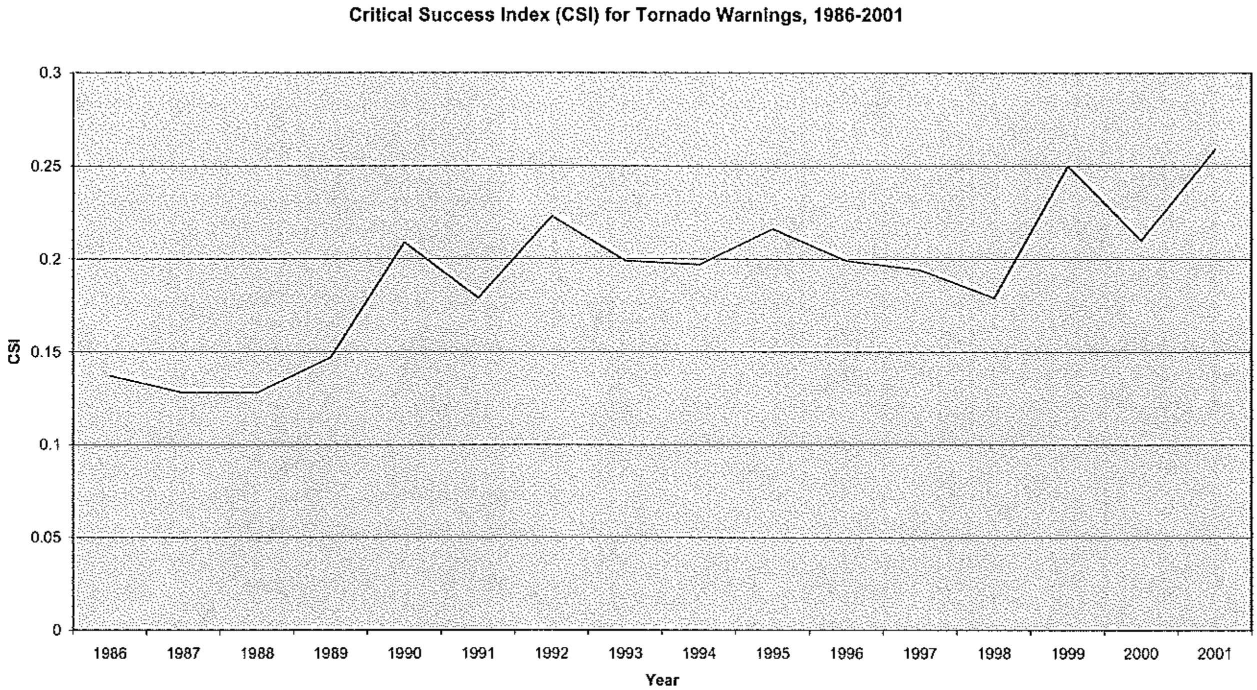

Figure 1. (Smith 2003, modified by Crystal Bergman 2005)

In addition to loss of credibility, economic loss is also a pertinent issue. At a small scale, a warning may cause customers to empty out a restaurant due to safety concerns. If this warning is proven to be false or unnecessary, the restaurant has lost revenue that day. At a larger scale, unnecessary hurricane evacuations lead to an overwhelming economic loss. Hurricane Floyd prompted millions of people to evacuate the coast. Then, the storm weakened considerably before making landfall. The cost of evacuation procedures nearly outweighed the economic loss due to the storm itself (Smith 2003, 3).

Traditionally, warnings have always been disseminated in terms of county boundaries (Figure 2a). Although county lines are simple for the public to understand, they are not very effective with regard to false alarms. It is seldom that a storm covers an entire county. Stated differently, it is usually not necessary to warn an entire county. How can the false-alarm rate be reduced? The NWS has developed a new warning system in which the warned area is outlined by a polygon, not a county boundary (Figure 2b). The NWS defines a *polygon* as the "area of maximum impact within a warned county" (Okulski 2005). A team of ten people, comprised mostly of NWS employees, was created in 2004 (Coyne 2005) to investigate the new warning system and implement it by the fall of 2006 (Okulski 2005). According to Patrick McCullough, Lead Forecaster for the NWS office in San Angelo, Texas, "The NWS needs to provide more precise warnings than we have done in the past, warnings that eliminate much of the margin of error relied on in the county-based warning system" (2005). This is what the implementation of the polygon-warning method hopes to accomplish.

Warning by County   Warning by Polygon

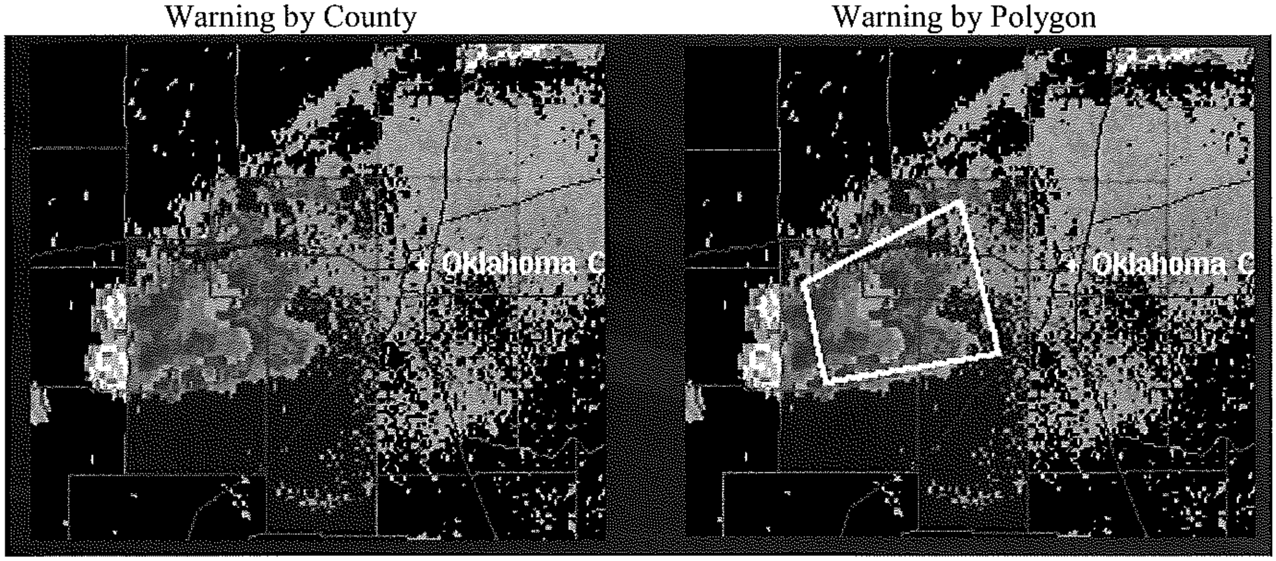

Figure 2. (a) A warning is issued for every county the storm is expected to affect. (b) A warning is issued only for the immediate area the storm is expected to affect, neglecting county boundaries. The warned area is contained in the white polygon. (Coyne 2005)

The polygon-warning method is expected to significantly reduce the total square-mile area of warnings not followed by an event, called the False-Alarm Area (Wolf 2005). As a result, the new public warning system is expected to reduce economic loss and increase the credibility of severe-weather warning systems. Instead of wasting valuable dollars by causing businesses to empty out or activating warning systems when unnecessary, the system would allow citizens to know that when they are warned, there is really imminent danger. Instead of people ignoring a warning because it is most likely another "false alarm," citizens would heed the warning and follow proper procedures to protect themselves and their property.

The following questions must be addressed concerning the polygon-warning method. First, would county size play an important factor in the effectiveness of the polygons? Some states, especially in the eastern U.S., have numerous, small counties, while many states in the western U.S. have counties larger than some northeast states. How would the role of polygon warnings be different in these states, and should it be different?

Second, how would the polygon warnings affect warning dissemination, especially radio communication? A polygon warning can be easily displayed graphically. This would work for those who receive their warnings by television or the Internet, but how would those receiving their warnings through radio be able to comprehend a polygon warning?

Third, how can the NWS, the media, and emergency management work together to ease the transition from warning-by-county to warning-by-polygon for the public? If polygon warnings make sense to those who create them, but the public does not understand how they work, then the entire idea is pointless and the desired results would not be achieved. After all, it is the public who must be warned of impending severe weather. If these issues are solved, the polygon-warning method would become an effective warning dissemination system.

Methodology

Because the polygon-warning method is innovative, a limited number of research materials are available at this time. Very few papers have been written on the subject thus far. The best methods of retrieving information on the polygon-warning project are through presentations given by NWS employees and e-mails that contain thoughts and opinions about polygon warnings. After significant results of the performance of the polygon-warning method have been compiled, many more papers will most likely be written about the new warning method.

The most effective way to organize the literature is to discuss it from the perspectives of each NWS employee that contributed to the literature review. The literature provides an overall evaluation of the polygon-warning method. From this analysis, conclusions may be drawn regarding the effectiveness of the polygon-warning method.

Literature Review

Peter Browning and Mark Mitchell, in their study "The Advantages of Using Polygons for the Verification of National Weather Service Warnings," discussed the method for generating a polygon. By feeding the location, direction, and speed of a storm into a warning generation tool, referred to by the acronym WARNGEN, the NWS can create a default polygon. A four-sided polygon is generated for an individual storm cell by placing it two miles upwind from the storm and making it six miles wide on both sides. In other words, the polygon reflects a width of twelve miles. The polygon is then widened by a factor of 0.12 miles for each mile along the storm path. The length of the polygon is mostly based on the time of expiration for the warning (Browning and Mitchell 2002). The penultimate line of text in the block quote beginning page 7 is a set of four latitude and longitude points that define the four corners of the polygon (Okulski 2005).

In 2003, Peter Wolf began initial testing of the polygon-warning method at the Wichita, Kansas, Weather Forecast Office (WFO). Wolf evaluated the research in his study entitled "An Effective 'Risk Management' Strategy for Reducing Tornado Warning False Alarms: The Polygon Warning Approach." In 2004, he evaluated the effectiveness of the warning method between the months of March and June. Twenty-five tornado warnings and 180 severe thunderstorm warnings were issued from the Wichita WFO during that time. Wolf's research showed that using the polygon-warning method would have reduced the false-alarm area (FAA) by 65-75% (2005). This means that by the county-warning method, many people residing within the warned area were in no imminent danger, a situation that could have been avoided with the polygon approach.

In April 2002, a tornado warning was issued for two counties in Kansas – Sedgwick and Kingman. The city of Wichita is in Sedgwick County. The following text statement was issued by the Wichita WFO on its website:

```
WFUS53 KICT 112312
TORICT
KSC095-173-120015-

BULLETIN - EAS ACTIVATION REQUESTED
TORNADO WARNING
NATIONAL WEATHER SERVICE WICHITA KS
612 PM CDT THU APR 11 2002

THE NATIONAL WEATHER SERVICE IN WICHITA HAS ISSUED A

* TORNADO WARNING FOR...
SEDGWICK COUNTY IN SOUTH CENTRAL KANSAS
KINGMAN COUNTY IN SOUTH CENTRAL KANSAS

* UNTIL 715 PM CDT

* AT 612 PM CDT...NATIONAL WEATHER SERVICE DOPPLER RADAR INDICATED A
SEVERE THUNDERSTORM WITH STRONG ROTATION 26 MILES WEST OF DOWNTOWN
WICHITA...OR 5 MILES NORTHWEST OF CHENEY...MOVING SOUTHEAST AT 10
MPH. THIS STORM COULD PRODUCE A TORNADO AT ANY TIME.

* THE SEVERE THUNDERSTORM WILL BE
NEAR CHENEY AROUND 635 PM CDT...

IF NO UNDERGROUND SHELTER IS AVAILABLE...MOVE INTO AN INTERIOR ROOM
ON THE LOWEST FLOOR OF A STURDY STRUCTURE.

REPEATING...A TORNADO WARNING HAS BEEN ISSUED FOR UNTIL 715 PM CDT.

LAT...LON 3772 9779 3768 9791 3757 9782 3762 9767

/CARUSO
```

The warning was not confined to a smaller area within either Sedgwick or Kingman counties. Just after stating the counties that the threat existed in, the WFO then reduced the tornado threat area by giving the direction and the speed at which the tornado was expected to travel.

Figure 3 displays a map of the plotted latitude and longitude points that were given at the end of the previous text statement. The actual threat area is outlined by a polygon. The arrow indicates the movement of the tornado. Nearly cutting the polygon down the middle is the boundary between Sedgwick and Kingman counties. It appears that the tornado would only impact extreme northeast Kingman County and southwest Sedgwick County. The threat area was just a small portion of each county. Because of the county-warning system, hundreds of thousands of people living in the greater Wichita area were warned for a storm that did not threaten the area. Had the polygon-warning approach been in place at the time of this warning, the FAA would have been reduced and only the citizens in the path of the tornado would have been warned.

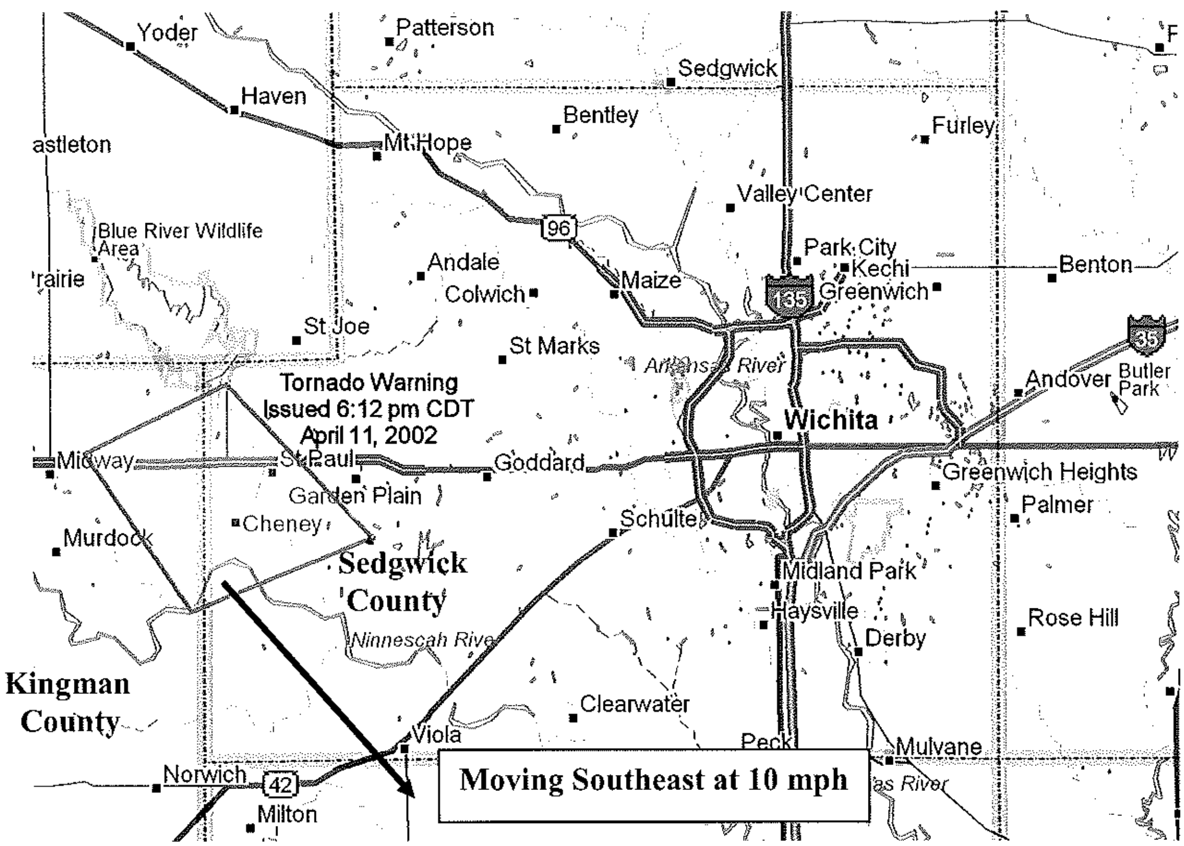

Figure 3. (Smith 2003, revised by Bergman 2005)

Ken Waters from the Honolulu, Hawaii, WFO discussed the National Weather Service's methodology for warning dissemination in his study "Polygon Weather Warnings – A New

Approach for the National Weather Service." According to Waters, warnings are issued in a number of ways: through NOAA weather radio (NWR) using Specific Area Message Encoding (SAME), through the Emergency Alert System (EAS), and through the media (2005). Currently, these warning methods are county-based.

Waters emphasized the importance of software that makes warning dissemination easier using the polygon method. Since 1998, the NWS has been using WARNGEN to produce short-term warnings (Waters 2005). The latest method to display warnings involves integrating Geographic Information Systems (GIS) with polygon warnings. GIS software is useful because various types of information can be overlain, such as county borders, roads, and radar reflectivity. Figure 4 shows an example of the polygon warnings integrated into a GIS product. Another advantage of using GIS comes with the plotting of geographic coordinates. Using latitude and longitude points makes a storm easier to plot, and in turn makes warning verification easier. Because storm reports can be plotted much more quickly, a faster analysis of the WFO's performance is possible (ESRI 2005).

Mike Coyne of the NWS Southern Region Headquarters provided some data from the research conducted in Wichita, led by Pete Wolf, in his presentation entitled "Polygon Warnings," given at the 2005 National Severe Weather Workshop. During the time period of the study, the tornado warnings issued by county covered 31,990 square miles and 494 individual towns. If the polygon-warning approach had been in place, the area warned would have only covered 9,500 square miles and 152 individual towns (Figure 5). This approach would have reduced the FAA by approximately 70 percent. (Coyne 2005)

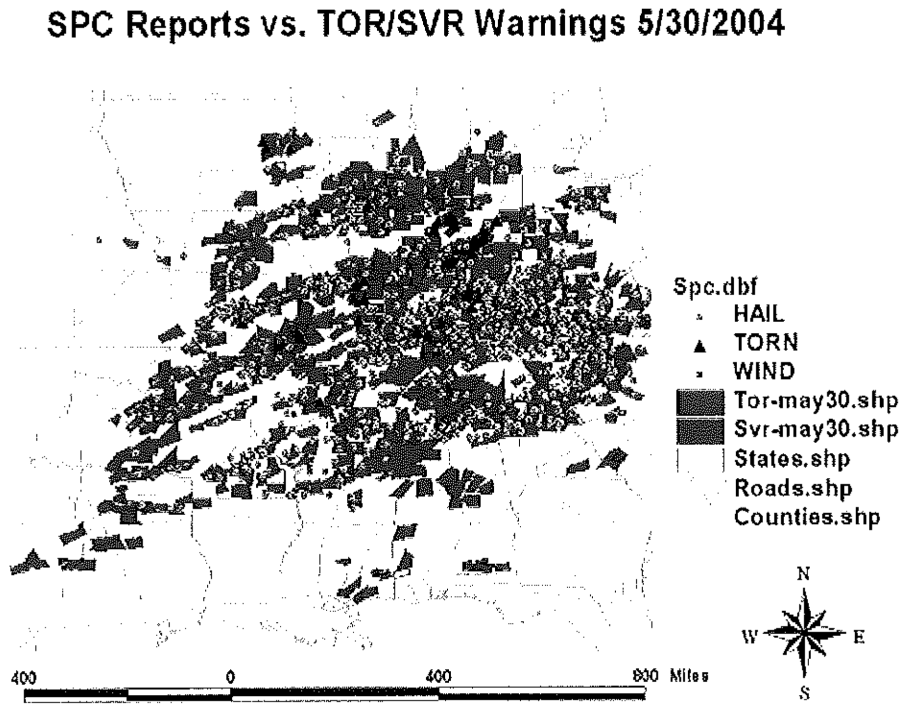

Figure 4. (Waters 2005)

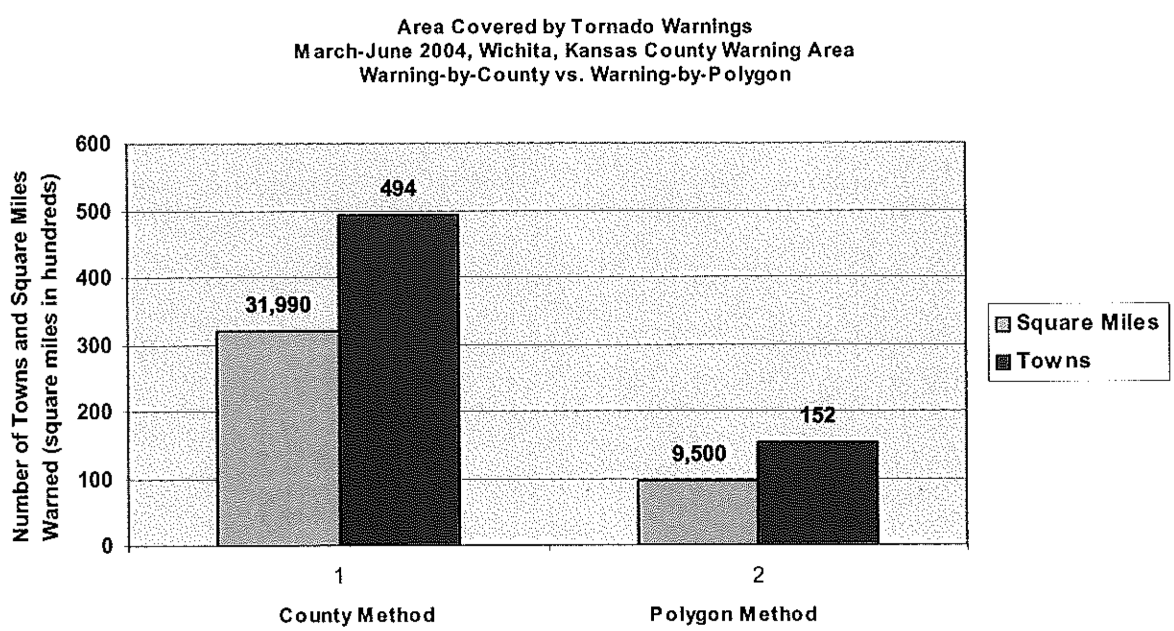

Figure 5. Data from Coyne, 2005

Coyne also addressed issues such as training, dissemination, verification, and operations. Before adopting the polygon-warning approach, NWS employees would have to be trained to use the software (such as WARNGEN) needed to generate the polygons. The software would also have to be up-to-date and readily available to all NWS offices so that everyone would be using the same version. In addition to the software, NWS employees would need a thorough understanding of how to use the polygon-warning approach. If the NWS employees were not properly trained, the general public would not understand polygon warnings.

If a polygon-warning system were adopted, the public would also have to be educated regarding the differences between warning-by-county and warning-by-polygon. This would not be a simple task because citizens are used to being warned by county. All dissemination systems would have to be adapted to the new warning system, and they would have to work together to disseminate warnings to the public in an effective way. The issue of a polygon crossing a County-Warning Area (CWA) would also have to be handled. The polygon-warning method would most likely increase the number of warnings issued because the polygons would be more concentrated. For example, if two storms entered a county in different locations and at the same time, two warnings would be issued via the polygon-warning method, but only one warning would be issued via the county-warning method. The polygon-warning method would require two broadcasts, while the county-warning method would only require one. Therefore, the polygon-warning method would take away valuable broadcast time. (Coyne 2005)

A method must be adopted to verify the effectiveness of the polygon-warning approach. It would be difficult to know whether or not the polygon-warning approach would work before implementing it. Therefore, an analysis would have to be conducted when enough information was gathered after the method was implemented. (Coyne 2005)

The sizes of the polygons would have to be determined based on their effectiveness with the general public. For example, either several small polygons would be generated for warnings, or a few large polygons would be generated. Perhaps this issue would depend on the situation and the size of the counties in the threat area. Operations would go more smoothly if a decision were made and each NWS office remained consistent with that decision (Coyne 2005). To put these issues into perspective, there are many problems to consider when transitioning to warning-by-polygon. Solving these problems would make the transition much easier for the general public.

Richard Okulski addressed the issue of sub-county warnings in his presentation entitled "Polygons: A Practical Approach to Sub-County Warnings," also given at the 2005 National Severe Weather Workshop. A sub-county warning is a warning within a county. Okulski discussed the issue of county size with respect to warning-by-county. There are several counties in the western United States that are larger than some of the smaller northeastern states. Warning an entire county that large is ineffective. (Okulski 2005)

The NWS developed the Valid Time Event Code (VTEC) to distinguish storms from one another. The VTEC includes the event type and significance, the start and end times of the warning, the status of the event, and the Event Tracking Number (ETN). VTEC would eliminate confusion between different storms and the warnings associated with them. (Okulski 2005) The VTEC is only utilized by the NWS at this time, not by the media or emergency management personnel.

Okulski also discussed the importance of preliminary Local Storm Reports (LSR). These storm reports include the event type, the time of the event, the reporter of the event, and the latitude and longitude points of where the event occurred. The following text displays an example of a local storm report:

```
PRELIMINARY LOCAL STORM REPORT
NATIONAL WEATHER SERVICE HOUSTON/GALVESTON TX
351 PM CST TUE NOV 23 2004

...TIME...    ...EVENT...      ...CITY LOCATION...          ...LAT.LON...
...DATE..     ...MAG......     ...COUNTY LOCATION...ST.. ...SOURCE....
              ...REMARKS..

0115 PM        HAIL            MIDWAY                       31.03N 95.75W
11/23/2004     1.75 INCH       MADISON                  TX  AMATEUR RADIO

              FM1119 1.5 MILES NORTH OF OSR

0220 PM       TORNADO          BRENHAM                  30.16N 96.40W
11/23/2004                     WASHINGTON            TX  LAW ENFORCEMENT

             MARBLE SIZED HAIL ALSO REPORTED.

0220 PM      TSTM WND DMG  BRENHAM                    30.16N 96.40W
11/23/2004                     WASHINGTON            TX  LAW ENFORCEMENT

             TREES DOWN.

0240 PM      HAIL              BRENHAM                  30.16N 96.40W
11/23/2004  1.75 INCH          WASHINGTON            TX  LAW ENFORCEMENT

             SOUTH SIDE OF TOWN.

0325 PM      TORNADO          TODD MISSION             30.26N 95.83W
11/23/2004                    GRIMES                 TX  LAW ENFORCEMENT

             POSSIBLE TORNADO IN TOWN.
```

These storm reports are significant because the polygon-warning approach would allow a quick analysis of the effectiveness of the polygon, e.g., whether or not the storm occurred within the polygon. (Okulski 2005)

In a series of e-mails, Patrick McCullough shared his opinions on the polygon-warning method. Overall, his office has had favorable experiences, but there are a few issues to address: the lack of visual representation of a warning when receiving it via a non-visual method, the difficulty of describing a visual representation when it is unavailable, and an increase in the number of warnings issued.

A polygon warning can be depicted using a map or radar, but not everyone receives his or her warnings through television or Internet. Many people receive warnings through radio. In this case, warning by county is advantageous because a person would most likely have an image of the county shape in his or her head, but it would be difficult to develop the outline of a polygon in one's head based on the information given over the radio.

In addition, it is equally as difficult for the conveyor of a warning to describe the dimensions of a polygon to a listener as it is for a listener to interpret the dimensions of a polygon. At most, the conveyor of a warning can state the latitude and longitude points of a polygon and can list communities that would be affected by the warning. It would be up to the listener to interpret the warning correctly.

According to McCullough, increasing warning precision means decreasing warning duration (2005). The goal is to decrease the size of a polygon by confining it to the expected threat area. However, the number of warnings would increase since the duration of the warnings would be much shorter. This would interrupt valuable broadcast time, as Coyne mentioned in his presentation (2005).

The San Angelo WFO tested the polygon-warning method from March – August 2005 and published the results (Table 1). Without Crockett County, which is much larger than the other counties in the CWA, the counties average 1,116 square miles in area. During this study, a polygon for either a severe thunderstorm warning or a tornado warning averaged an area of 477.4 square miles, which is about half the size of one of the CWA's counties. This is a significant reduction in the total area warned for both severe thunderstorm warnings and tornado warnings. (McCullough 2005)

With regard to county size, McCullough thinks that there are more issues with using the polygon-warning method in larger counties than in smaller counties. For example, Crockett County in west Texas is larger than the state of Rhode Island. Several storms could fit into that county, producing multiple, simultaneous polygon warnings within Crockett County. This could cause ample confusion to the citizens in the warned area. (McCullough 2005)

	Severe Thunderstorm Warnings	**Tornado Warnings**	**Combined**
Polygon Average (sq. mi.)	494.0	353.9	477.4
Total County-Based Area (%)	24.6	20.4	24.2
Total Reduction in Area (%)	75.4	79.6	75.8

Table 1. (Data from McCullough 2005)

Jerry Orchanian, warning coordination meteorologist for the NWS WFO in Nashville, Tennessee, has a different opinion regarding the effect of county size on polygon warnings. In an e-mail sent on July 28, 2005, Orchanian stated that the polygon-warning method would be less effective in the eastern United States, where the counties are generally much smaller, than in the western United States, where the counties are generally larger. (Orchanian 2005)

Although he believes the polygon-warning method might be effective for warning against tornadoes, which seem to have a more definite path, Orchanian does not think that using polygon warnings to warn of severe thunderstorms in small counties would work. Orchanian also mentioned in his e-mail the issue of multiple warnings in one county. This would become particularly chaotic in a small county. Additionally, he discussed the issue of thunderstorm cells merging and dividing, a situation that would make the generation of polygon warnings more problematic.

Analysis

County Size

The size of the counties impacted by a storm is of great concern under the polygon-warning method. Counties vary greatly in size; as mentioned earlier, they tend to be larger in the western United States than in the eastern United States. For example, the initial test conducted on the polygon-warning method occurred in Kansas, where most of the counties are large. One of the goals of the polygon-warning method is to implement it nationally. Many NWS employees are debating whether or not the polygon-warning method would be effective for all counties, regardless of their sizes. There are three important items to address that would help resolve the county-size issue: consistency in using the polygon-warning method, distinction of each polygon warning, and methodology of handling a storm's behavior.

If the polygon-warning method is going to be implemented, it should be implemented everywhere. The NWS must be consistent to avoid confusing the general public. For example, if a storm were to wander from one CWA to another, it would be confusing to change from using a polygon warning to using a county warning, or vice-versa. This is mostly because television stations' viewing areas do not conform to CWA boundaries. A viewer who is watching a particular storm should understand the location of the warned area, as well as the storm's path.

Each polygon must be distinct to avoid confusion. The county-warning method allows for only one warning to be issued within a county, but the polygon-warning method may call for more than one warning to be issued within a county. If multiple warnings confuse the public, then using polygon warnings defeats the purpose of shaving down the warned area. Multiple polygon warnings would still be effective if each polygon were distinct from another.

A polygon should be numbered according to its order of occurrence. According to Patrick McCullough, the NWS already numbers polygons (2005). However, this number system would be more effective if it were implemented by media and emergency management. Polygons should be assigned numbers chronologically, e.g., Polygon Warning 1 occurred first in the CWA, Polygon Warning 2 occurred second in the CWA, etc. If this method were adopted, the NWS would need to decide when to start the numbering system over. The numbering system could start over at midnight, or it could start over each year as tornado and severe thunderstorm watch boxes do. If a storm were to move out of the CWA it originated in, the NWS office in the CWA it moved into could renumber the polygon.

In his e-mail, Jerry Orchanian discussed the problem of a storm cell splitting into two cells, as well as two storm cells merging to form one cell. He is correct in thinking that a storm's behavior would make polygon warnings extremely confusing. If a storm were to split into two cells, the old polygon warning should expire and the NWS office should issue new polygon warnings for the new storm cells. For example, if Polygon Warning 5 split into two cells, the new storms should be assigned Polygon Warnings 6 and 7. Assigning new polygon-warning numbers would be much easier than retaining the old polygon-warning number because the storm would no longer be the same; it would have split and become two cells.

Likewise, two storms that merge together to form one storm should have a new polygon-warning number assigned. For example, if Polygon Warnings 12 and 13 merged together, they should be called Polygon Warning 14. Again, if the storms changed their behavior, creating a new polygon-warning number would be a better alternative to trying to retain the old polygon-warning numbers.

Warning Dissemination

Timely warning dissemination is the key to saving lives and protecting property when severe weather threatens an area. There are several ways to warn the public of imminent severe weather: television, Internet, radio, NOAA weather radio, and a Community Outdoor Warning System (COWS). However, according to a study conducted after Hurricane Floyd struck the United States in 1999, about 75% of people get their warnings via television (Jones 2004). This means that a great number of people get their warnings through a visual device. This is fortunate because the polygon-warning method is a visual product. On the contrary, there are people who get warnings through radio or the COWS, which are auditory products. These warning disseminators must be able to portray polygon warnings as effectively as television or Internet.

Nate Johnson, chief meteorologist at KTXS-TV in Abilene, Texas, began broadcasting polygon warnings in 2005. Johnson works closely with Patrick McCullough and the San Angelo WFO. In an e-mail sent on July 22, 2005, he discussed two methods his television station uses for warning dissemination: crawls and cut-ins. A weather crawl is a single line of text that moves right to left on the television screen that displays a weather statement, usually a severe weather warning. A cut-in is an interruption in programming by the on-camera meteorologist concerning an important weather statement. (Johnson 2005)

The crawl system compromises warning-by-county and warning-by-polygon. A county map that supplements a crawl highlights every county affected by the storm, regardless of the storm's position. However, the NWS text statement is unmodified, so it gives a more specific threat area, e.g., northeast Crockett County. The viewers see the counties included in the warning on the map, but they receive more specific information regarding the actual threat area. (Johnson 2005)

During cut-ins, warnings are shown as polygons on the radar display system. Only the polygon is highlighted; the entire counties that contain the warning are not highlighted. Johnson also tries to make reference to the warned area, not to all the counties a storm affects (2005). The crawls and cut-ins display warnings using both methods so that citizens can observe the differences and understand the extent of the warnings.

Johnson realizes that this change may still be confusing for his viewers; therefore, he clarifies the new warning method during his cut-ins by issuing a statement such as the following:

> Starting this year, our weather service office is now issuing severe thunderstorm [and] tornado warnings using these boxes instead of issuing them for whole counties. That way, they warn only the part of our area that's likely to be affected by the storm instead of warning areas that aren't going to be affected (2005).

According to Johnson, the citizens in his viewing area have been quiet regarding the new warning method; he has hardly received any feedback. Johnson and McCullough interpret the silence as a positive response because they think west Texans tend to be vocal about changes they do not like (2005). McCullough said that the NWS is limited in what they can ask in surveys; they can only ask for general feedback through their web pages and through NOAA weather radio. Therefore, the only comments received would be from citizens who felt strongly about the new warning method, one way or another (McCullough 2005).

Although Johnson endorses the polygon-warning approach, he has a few concerns. Technology is lagging behind the progress the NWS has made with the polygon-warning method. Johnson says that the weather crawls and the NOAA weather radio cannot represent the polygon warnings as effectively as the NWS technology does. He thinks that it is difficult to correctly convey a polygon warning when only the crawl system is needed. Johnson also discusses a possible misconception by his viewers. If a storm is straddling several county lines, a polygon warning that is issued for the storm may look like several warnings, or it may appear that one warning covers all the counties affected by the storm. While the polygon warning was intended to shrink the warning area, it may appear that the warning area was actually enlarged. (Johnson 2005)

Johnson concludes that the task of interpreting polygon warnings ultimately comes down to the warning disseminators, such as television and radio personnel. If these people could help citizens understand polygon warnings, then the new warning method would operate much more effectively. In addition, Johnson believes that the NWS and other warning disseminators must work together to provide the public with the most simplified and straightforward method of warning possible. (Johnson 2005)

Johnson is correct in saying that the effectiveness of the polygon-warning method falls in the hands of the warning disseminators. Since the general public receives warnings mostly through television, on-camera meteorologists must be able to display the polygon warnings in a way that the public understands them. Again, it is important to distinguish between each polygon on the radar screen. In addition to their being numbered, perhaps each polygon warning should be a different color. It would also be helpful if the on-camera meteorologist could show one polygon at a time, especially if there is a case when several polygons are overlapping.

As for the Internet, many NWS WFOs are already more specific with the location of a warning. The block quote beginning on page 7 offers an example of the traditional way a threatened location is named; the text statement only gives the name of the county or counties that are warned. The contemporary way of describing the location of a warned area involves putting an orientation in front of it and specifying cities in the storm's path:

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BULLETIN - EAS ACTIVATION REQUESTED
SEVERE THUNDERSTORM WARNING
NATIONAL WEATHER SERVICE NASHVILLE TN
1233 PM CDT WED JUL 27 2005

THE NATIONAL WEATHER SERVICE IN NASHVILLE HAS ISSUED A

* SEVERE THUNDERSTORM WARNING FOR...
EASTERN CHEATHAM COUNTY IN TENNESSEE
NORTHERN DAVIDSON COUNTY IN TENNESSEE
THIS INCLUDES THE CITY OF NASHVILLE

* UNTIL 100 PM CDT

* AT 1224 PM CDT...NATIONAL WEATHER SERVICE DOPPLER RADAR INDICATED
A SEVERE THUNDERSTORM CAPABLE OF PRODUCING PENNY SIZE HAIL...AND
DAMAGING WINDS IN EXCESS OF 60 MPH.  THIS STORM WAS LOCATED 15
MILES NORTHWEST OF NASHVILLE...OR ABOUT NEAR ASHLAND CITY...AND
MOVING EAST AT 25 MPH.

* THE SEVERE THUNDERSTORM WILL BE NEAR...
8 MILES NORTH OF NASHVILLE BY 1250 PM CDT
OLD HICKORY...GOODLETTSVILLE AND LAKEWOOD BY 100 PM CDT

THIS IS A DANGEROUS STORM. IF YOU ARE IN ITS PATH...PREPARE
IMMEDIATELY FOR DAMAGING WINDS...DESTRUCTIVE HAIL...AND DEADLY CLOUD
TO GROUND LIGHTNING. PEOPLE OUTSIDE SHOULD MOVE TO A SHELTER...
PREFERABLY INSIDE A STRONG BUILDING BUT AWAY FROM WINDOWS.

LAT...LON 3639 8703 3613 8705 3609 8658 3634 8665

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END/ORCHANIAN
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(NWS WFO 27 July 2005)

This text statement is more specific than the statement on page 7 because the former outlines the threat area by narrowing down portions of each county affected by the storm. Instead of unnecessarily warning every resident in Cheatham and Davidson counties, the NWS only warns the residents in immediate danger, those who reside in eastern Cheatham and northern Davidson counties.

The central issue of the polygon-warning method with regard to auditory devices, such as radio and NOAA weather radio, is that the polygon-warning method appeals to visual products, such as television and the Internet. Persons receiving warnings via radio would have difficulty in comprehending polygon warnings. The polygon-warning method validates the old saying "a picture is worth a thousand words." Dissemination of a polygon warning must be handled differently when one is using an auditory device.

For radio, a polygon warning must be detailed and specific to compensate for the absence of visual representation. When announcers issue a polygon warning over the radio, each broadcast should contain the current location of the storm, the direction and velocity of the storm, and proposed communities in the storm's path that could be affected for the duration of the warning. While these three items are already included in radio broadcasts, the third item should be redefined.

The width of a polygon increases with distance from a storm because of the uncertainty of the storm's path. Therefore, a radio broadcast should state that the communities that could be affected toward the end of a warning are uncertain because of the storm's path. The statement could define these communities as "from Richardsville south to 1.5 miles north of Bowling Green," for example. Most residents know where they are with respect to other communities; they also usually know in which direction these communities are. Although those few extra seconds would consume valuable broadcast time, they would be worth the explanation that residents would need.

Emergency management is yet another important warning disseminator. The polygon-warning method would also affect how emergency management officials operate the COWS. Ronnie Pearson, director of Warren County Emergency Management, stated that although the COWS is currently activated for the entire county when it is put under a warning, he would like to see sectional warnings. However, when the exact location of a storm cannot be determined, he said it becomes a liability issue that could lead to the failure to warn citizens in the storm's path. (Pearson 2005)

Once again, the consistency issue is reintroduced. If the polygon-warning method is going to be implemented, then emergency management must adhere to the new method and have sectional warnings. Each county could be divided into sections. The method at which a county is divided would depend on a number of things, e.g., topography, zones, etc. The COWS would be activated in each section the polygon warning included. Sectional warnings would be no more of a liability issue for emergency management than it would be for the NWS. This method does seem to just create more counties, but each area would be smaller. If there were an instance when a storm moved right through the center of a county, then every section in the county would have to be warned.

Partnerships

If the polygon-warning method is to be effective, the three main warning disseminators – the NWS, media, and emergency management – must collaborate to provide the best service to the public when severe weather is imminent. Consistency is the key to effectively warning the general public that is in danger. As the NWS develops the technology to use and continue to improve polygon warnings, the media and emergency management must be able to make appropriate adjustments. It is also important that on-camera meteorologists convey polygon warnings in a way that the public can understand them, because, as mentioned earlier, the majority of citizens receive their warnings via television.

One of the greatest issues to overcome is providing a smooth transition from warning-by-county to warning-by-polygon. The best way to do this is by using the method Nate Johnson discussed. Johnson displays polygon warnings on radar and displays county warnings on the map that supplements the weather crawl. Citizens see the difference between a polygon warning and a county warning. To clear up any confusion, Johnson describes the change the NWS is making (see quote on pg. 20). After seeing the difference between the two warning methods on the television screen, citizens can then hear the difference from an on-air weather personality. According to Johnson, neither he nor the San Angelo WFO has received any negative feedback on the new warning method, so the explanation of the polygon-warning method must be sufficient. This dual explanation is the best way to make the transition between the two warning methods.

As for the NWS, publishing pamphlets on the new warning method may be helpful. Additionally, the NWS, the media, and emergency management could all participate in open forums to discuss the new warning method. For some citizens, an explanation by an on-camera meteorologist may not suffice, but a public talk or reading material could minimize confusion.

Conclusions

The polygon-warning method is an effective and innovative way to disseminate warnings to the public; however, the method should be calibrated to accommodate the various organizations that transmit severe-weather warnings. If the polygon-warning method is going to be a practical alternative to the county-warning method, then warning disseminators will have to work together to provide the most consistent method of communicating severe-weather warnings to citizens who are in immediate danger.

The paramount issue the NWS faces concerning the polygon-warning method is implementing a new warning system that exacerbates public confusion instead of alleviating it, resulting in injuries and loss of life during a severe weather event. The NWS can avoid this problem in the following two ways: 1) the implementation of a consistent method that can be easily utilized by the media and emergency management, and 2) the transition from the warning-by-county method to the warning-by-polygon method through educating the public on the application of polygon warnings.

Recent technology, such as the invention of the Global Positioning System (GPS) and the cellular telephone, could improve the reaction time of the public when severe weather occurs and could supplement the polygon-warning method. The GPS has become widely popular with citizens who travel often and who enjoy outdoor activities. These people are particularly vulnerable to severe weather because they may be in an unfamiliar area. The coordinates of a storm would be helpful to a person with a GPS because it would not be necessary to know the county or community he or she was in or near.

As of June 1, 2003, approximately 146 million Americans owned cell phones (Torabi 2004, 101). This number continues to increase as the price of cell phones goes down and the qualifications for getting them become easier. Additionally, most cell-phone owners keep their phones with them at all times. It would be advantageous if cell-phone owners could receive severe-weather warnings on their cell phones. A signal could be sent to all cell-phone towers within the threatened area so that only those citizens in the threatened area would be warned. Not only would this method center the focus on warning citizens who are actually in danger, but it would also help to get warnings out more quickly.

Cell phone companies are now required to manufacture each phone with a GPS unit installed in it. A warning could be sent to the cell phone, along with the storm's coordinates; then, the GPS could display the location of the storm relative to the location of the cell phone. From this device, citizens would know that they were in the warned area, they would know their exact location and whether or not the storm was heading toward them or away from them, and they would know which direction the storm was moving. This method would be ideal when warning the public of severe weather.

Because too many people have died or been injured as a result of severe weather, it is the hope of most warning disseminators to do something about such misfortunes. The invention of the polygon-warning system is certainly a step in the right direction. If all the proper adjustments are made, the polygon-warning method will truly become a more effective warning dissemination in the future.

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