BLOWN AWAY:
MONETARY AND HUMAN IMPACTS OF THE 2011 TORNADOES

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Deadly Season

Analysis of the 2011 Tornado Outbreaks

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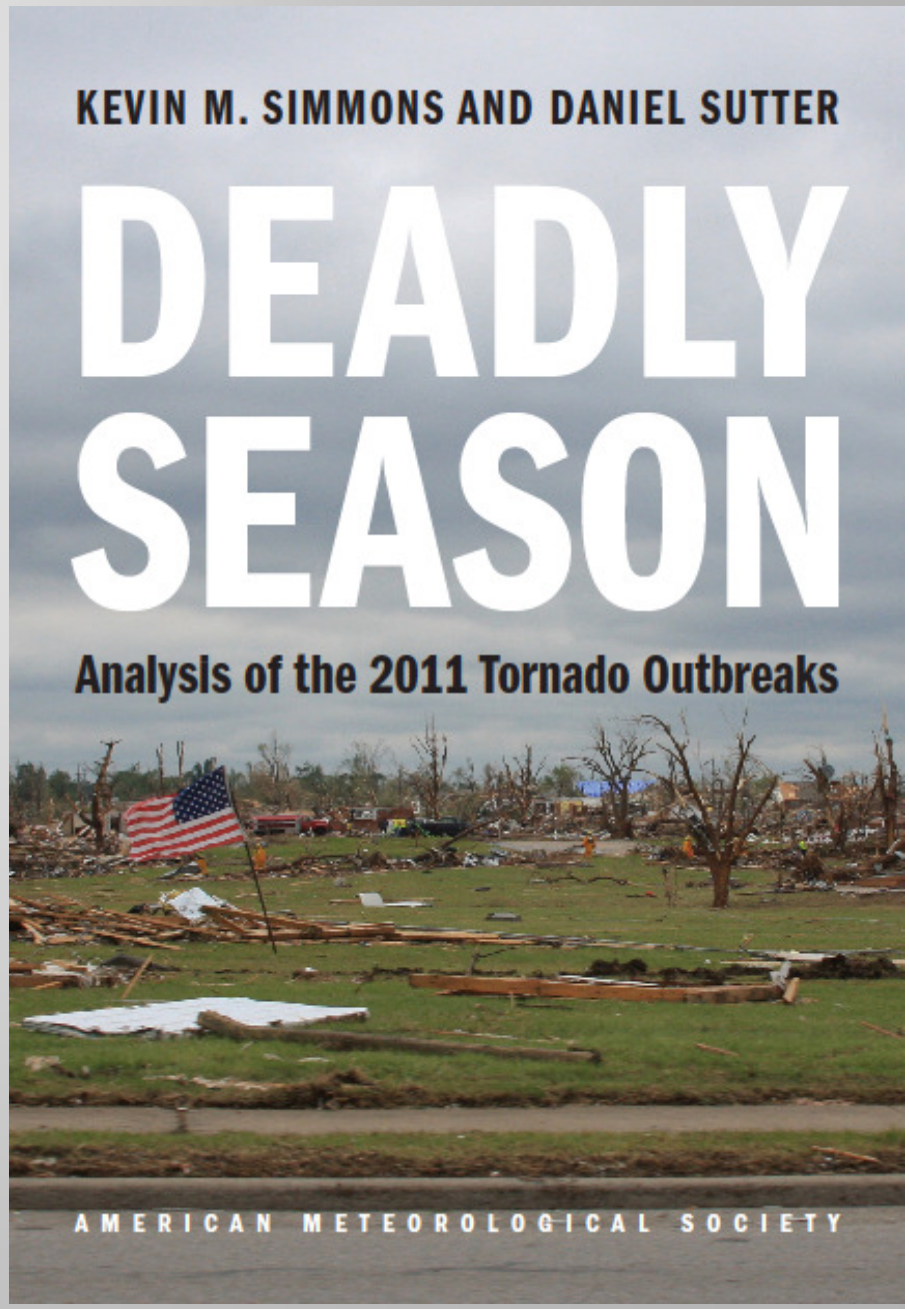
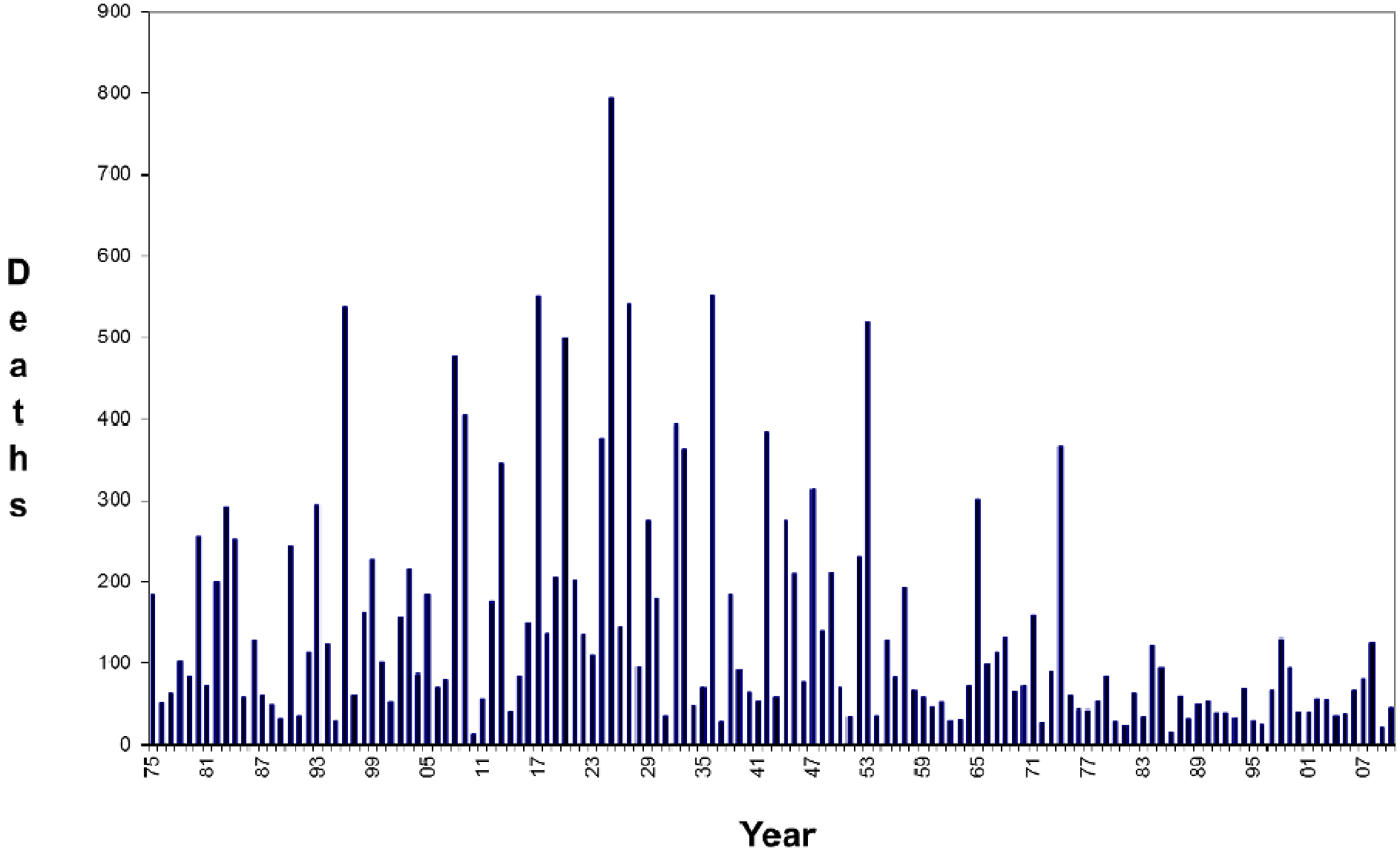
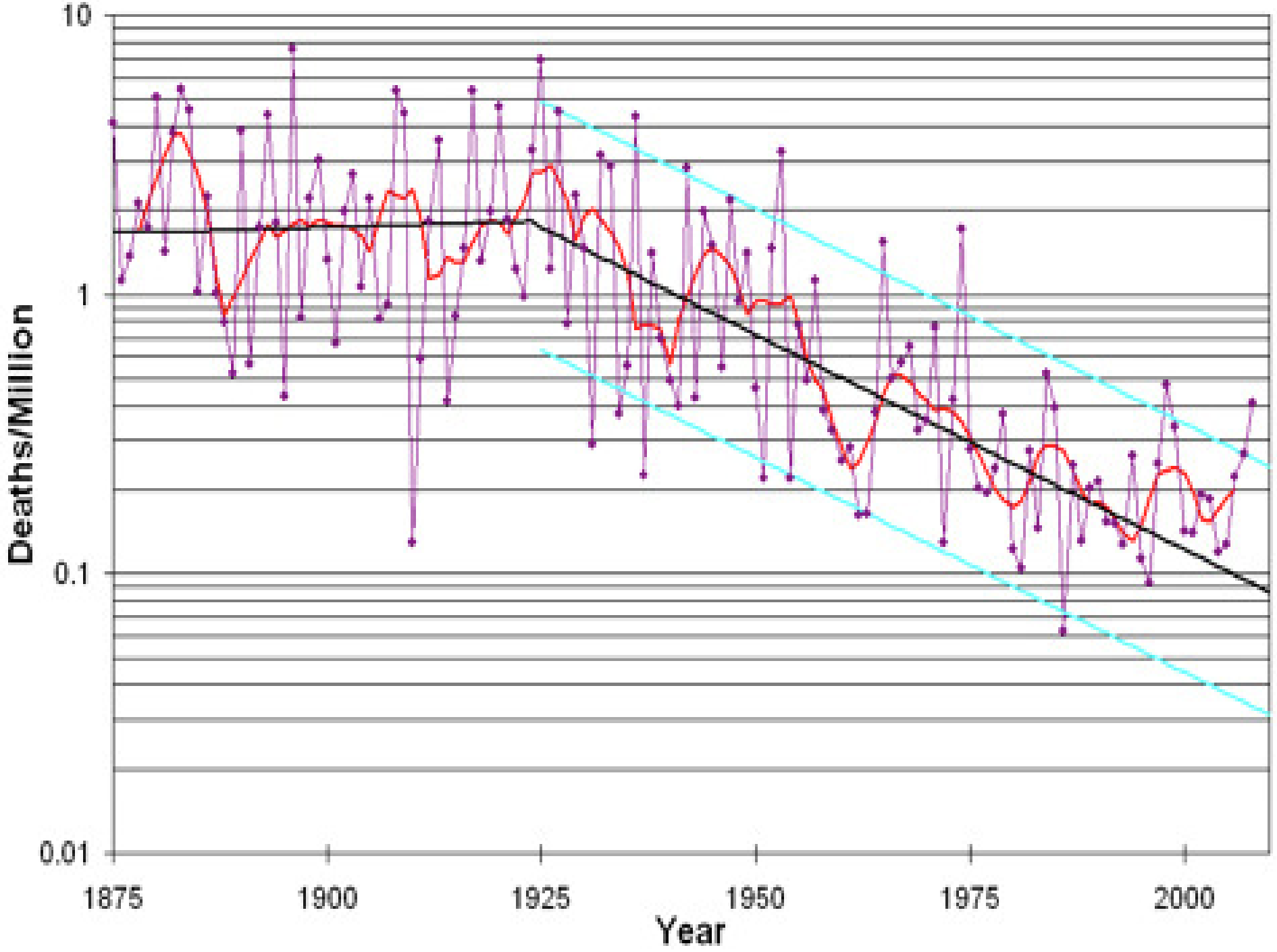
AMS BOOKS
RESEARCH | APPLICATIONS | HISTORY

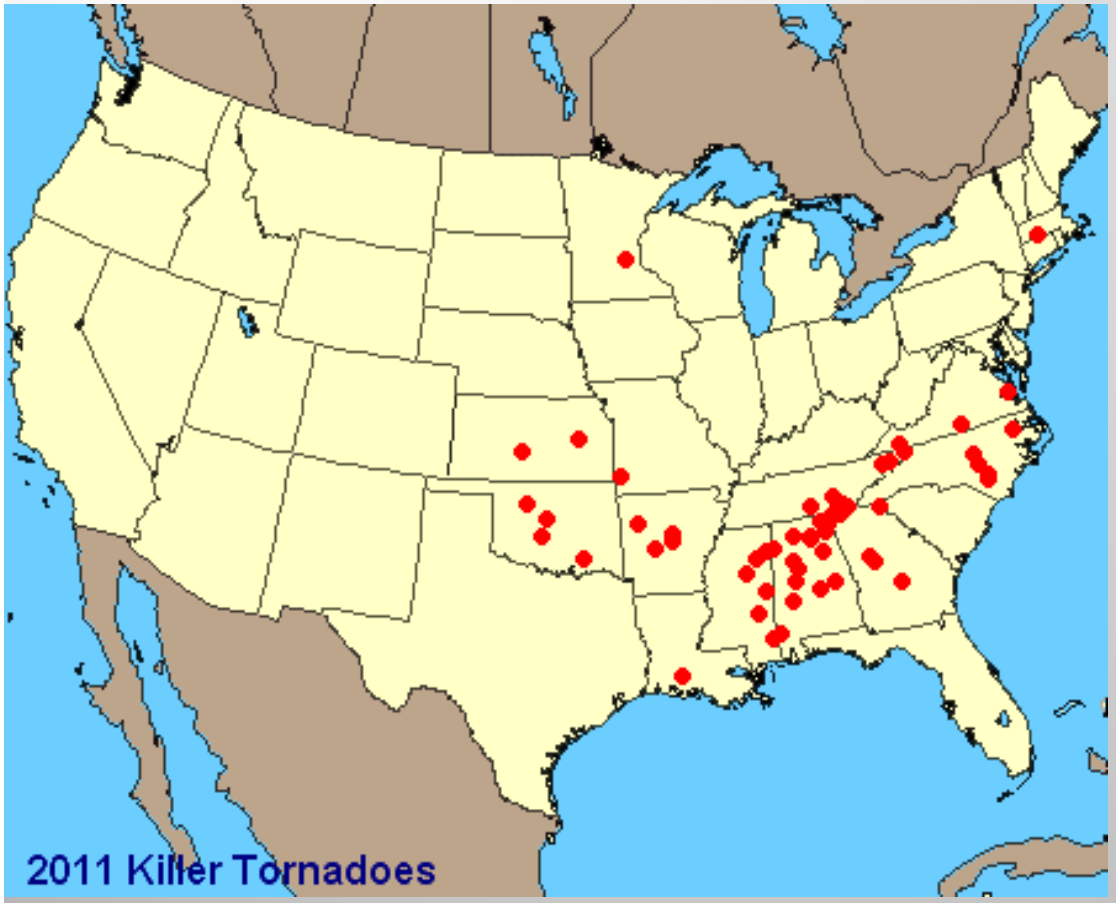


Annual Tornado Fatalities 1875-2010




10
1
0.1
0.01
Deaths/Million
1875
1900
1925
1950
1975
2000
Year

Killer Tornadoes of 2011



- Average annual number of killer tornadoes 2000-2010
  - 21
- Number of killer tornadoes 2011
  - 59

Tornado Fatalities

- Average annual number of fatalities
  - 50-60
- This year?
  - 552

Joplin MO May 22, 2011

Street in Joplin – Before

Google Street Level

Same Street in Joplin - After

Comparing Peak Tornado Fatality Seasons

Year	Fatalities	Recent Average	Recent Maximum	Ratio of Fatalities to Average	Ratio of Fatalities to Maximum
1908	523	286	588	2.56	0.81
1917	588	253	805	2.32	0.73
1925	805	238	543	3.38	1.37
1936	555	183	543	3.04	1.02
1953	515	118	327	4.36	1.57
1965	301	96.0	348	3.14	0.86
1974	348	83.9	301	4.15	1.16
1998	130	54.5	126	2.39	1.03
2011	552	57.6	130	9.58	4.25

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Estimated Property Damage 2011

Month	Insured Losses	Total Losses
April	$9.6 Billion	$16.2 Billion
May	$5.5 Billion	>$7 Billion
Total	$15.1 Billion	>$23.2 Billion

Source: NOAA's National Climatic Data Center

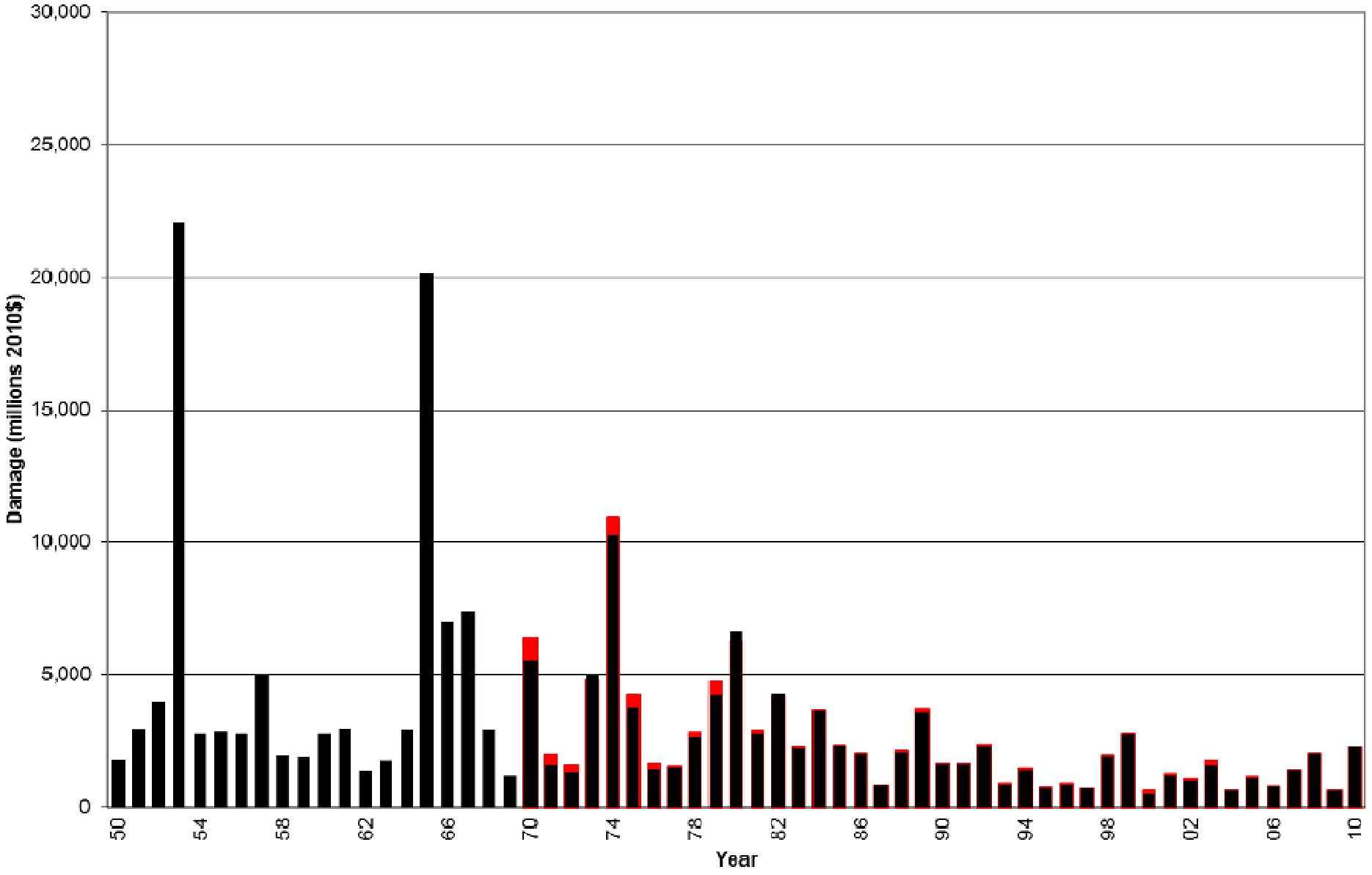
Partial List of Insured Losses

Reported as of July 1

Allstate Corp	$2 Billion
State Farm	$1.75 Billion
Travelers Companies	$1.05 Billion
Chubb	$310 Million
Zurich Financial	$295 Million
Cincinnati Financial	$290 Million
MetLife	$180 Million
State Auto Financial	$135 Million
Hanover Insurance	$85 Million
Validus	$75 Million
Assurant	$75 Million
PartnerRe	$70 Million
Aspen Insurance	$60 Million
Hiscox	$56 Million
Hannover Re	$45.6 Million
Montpelier Re	$35 Million
Flagstone Re	$30 Million
Total	$6.56 Billion

Source: Company statements (Reporting by Ben Berkowitz, Editing by Bernard Orr and Lisa Von Ahn)

US Tornado Damage: 1950-2010, Housing Unit and Income Normalized



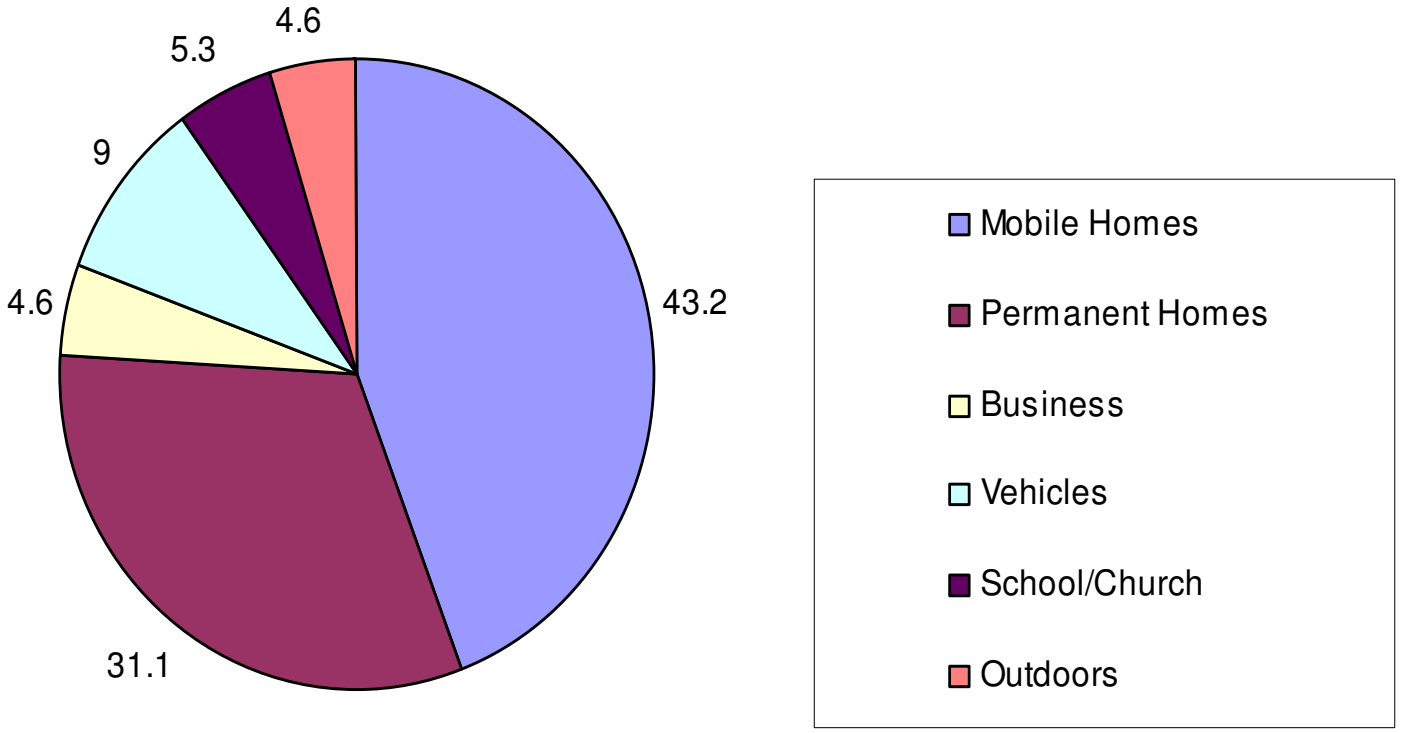
Question to Consider

- What drove the damages/casualties, extreme weather or extreme vulnerability?

Extreme Vulnerability?

- Three areas of known vulnerability
  - **Location**
    - Mobile Homes
  - **Timing**
    - Nocturnal Tornadoes
  - **Geography**
    - Dixie Alley

Extreme Vulnerability?
Fatality Distribution – By Location



Source: National Weather Service

Extreme Vulnerability? Mobile Homes

- Since 1996, mobile homes account for 43% of all fatalities
- Even though they are only about 7.5% of the housing stock
- In 2011 they account for about 20% of the fatalities

Extreme Vulnerability? Nocturnal Tornadoes

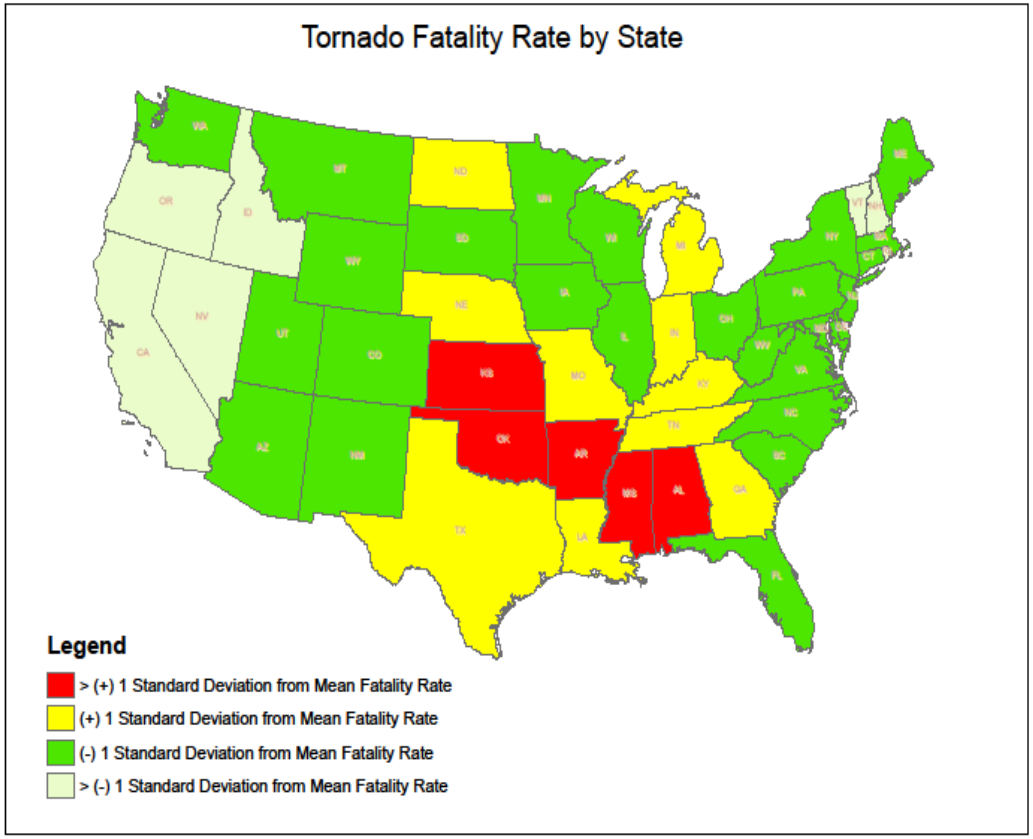
- Overnight tornadoes are a known vulnerability
- Our models suggest that a tornado that occurs overnight will have fatalities double that of a similar afternoon tornado

Extreme Vulnerability? Nocturnal Tornadoes

- Of the 59 killer tornadoes, only 6 occurred overnight with 7 fatalities

Extreme Vulnerability? Geography

- 94% of the fatalities came from states colored red or yellow
- 86% came from red or counties bordering a red state



Extreme Vulnerability? Dixie Alley

- Hard to ignore the fact that so many of the fatalities occurred in the southeast.
- But much of the southeastern effect is driven by:
  - Disproportionate share of deaths from
    - Mobile Homes
    - Nocturnal Tornadoes
    - Off Season Tornadoes

Extreme Weather?

- To address this question, we employ a casualty model we've developed over the last 10 years.
- If the range of fatality estimates from our model come close to the observed fatalities, then extreme weather is most likely the culprit.

Model

- Uses data from 1990-2010
- SPC tornado archive
- Census Bureau for socio-economic and demographic data
- Several important variables
  - Percent of mobile homes
  - Population Density
  - Tornado Intensity – F(EF) Scale

Model Limitations

- No single tornado in our data with fatalities in excess of 36
- Demographic data is at county level

Out of Sample Projections

- We used the model coefficients to estimate fatalities for the 2011 tornadoes

Results

- We run 4 variations of our casualty model
- The lowest estimated fatalities is 489
- The highest is 570 fatalities
- Average of the 4 models is 526 fatalities

Relative Measures of Lethality

- Deaths per damaged building
  - 335
- Deaths and injuries
  - 358
- Deaths and monetary damages
  - 401

Results

- This suggests that given the number of violent tornadoes, the fatality total of 552 is not unexpected.

Can it Happen Again? Fatalities

- Over the last 60 years, 85% of all fatalities are from Long Track Strong/Violent tornadoes
  - Defined as F2+ and a path of 5 or more miles
- This year saw 178
- 60 year average? 91
- Other years with large fatalities
  - 1953 LTSV Tor – 103 Fatalities - 515
  - 1965 LTSV Tor – 144 Fatalities - 301
  - 1974 LTSV Tor – 175 Fatalities - 348

Can it Happen Again? Damage

Normalized Damage

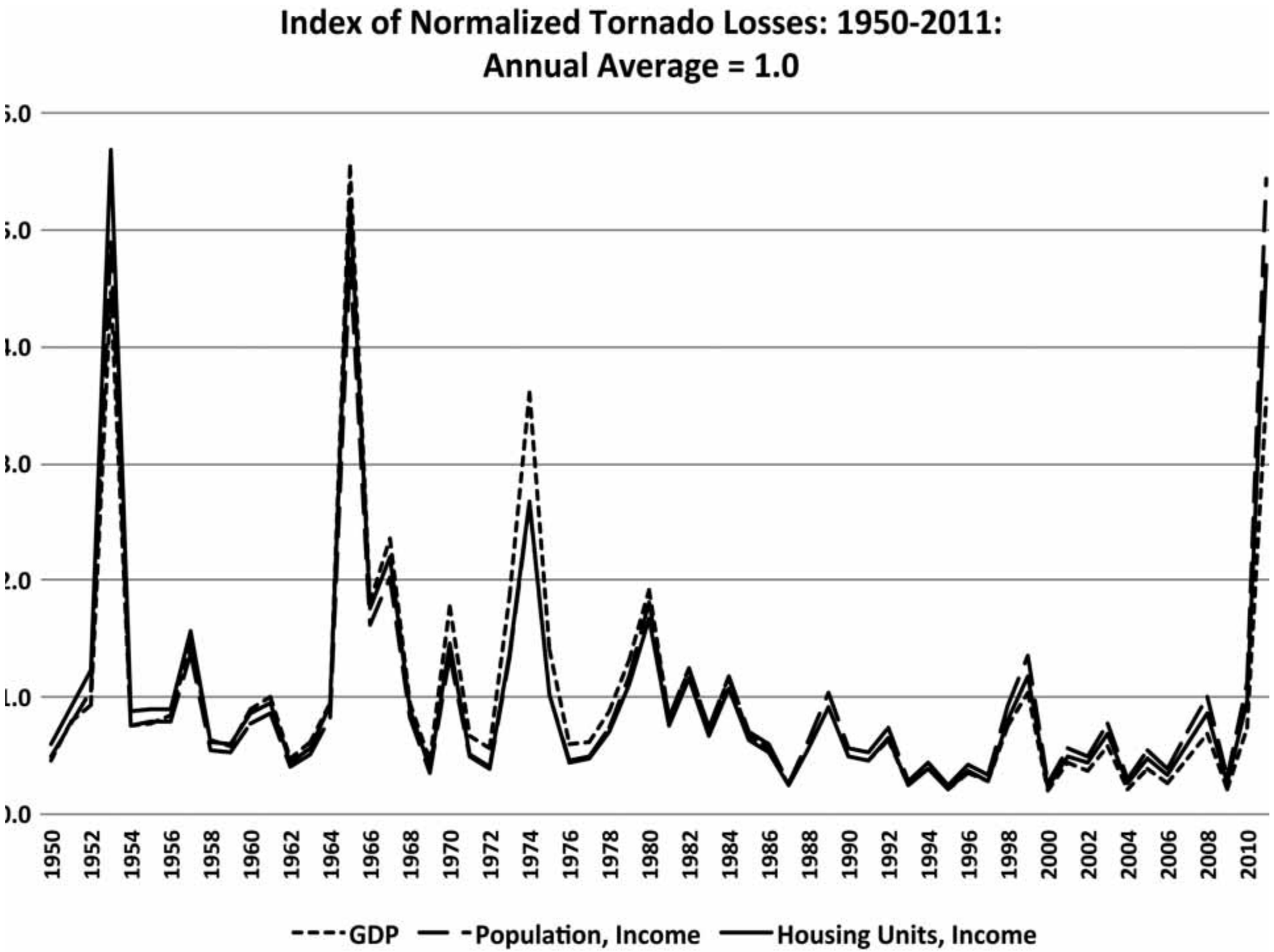
What damage would have occurred if the tornadoes from a previous year happened in the same place but at a future date?

Adjustments must be made for changes in population and wealth.

We perform 3 ways to get at that adjustment and then scale previous years to 2011.

Can it Happen Again? Damage

- Over the last 60 years, 75% of all damage is from Long Track Strong/Violent tornadoes
  - Defined as F2+ and a path of 5 or more miles
- Other years with large damage
  - 1953 LTSV Tor – 103 Damages - $32 Billion
  - 1965 LTSV Tor – 144 Damages - $29 Billion
  - 1974 LTSV Tor – 175 Damages - $14 Billion


Index of Normalized Tornado Losses: 1950-2011:
Annual Average = 1.0
5.0
4.0
3.0
2.0
1.0
0.0
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
GDP
Population, Income
Housing Units, Income

Tornado Losses Compared to Other Hazards

- Tornadoes 1950-2011

  $339 Billion Normalized Losses

- Earthquakes 1950-2011

  $150 Billion Normalized Losses

- Hurricanes 1950-2011

  $621 Billion Normalized Losses

Future Policy Considerations Limiting Fatalities

- Extended Lead Time
- Public Funding of Shelters
- Dissemination of issued warnings
- Warning Quality – False Alarms

Extended Lead Time

- Currently, average lead time is about 15 minutes
- This is triple the average lead time from 20 years ago

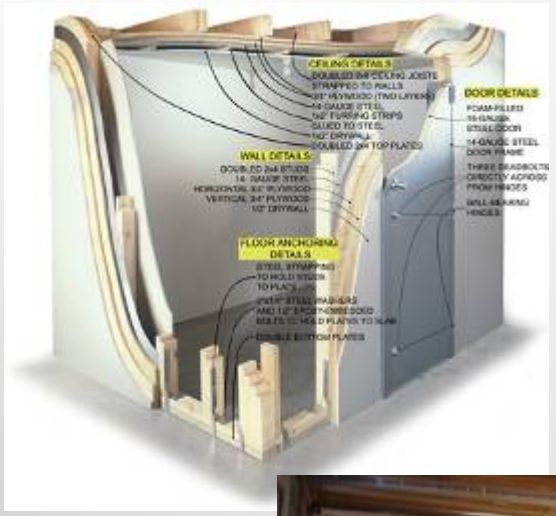
Extended Lead Time

- Our models show diminishing returns for lead time beyond 15 minutes
- Which begs the Question:
  - What will people do with the additional time?

Extended Lead Time

- Warn on Forecast could extend lead time measured in hours, not minutes.
- Evacuation?

Tornado Saferooms



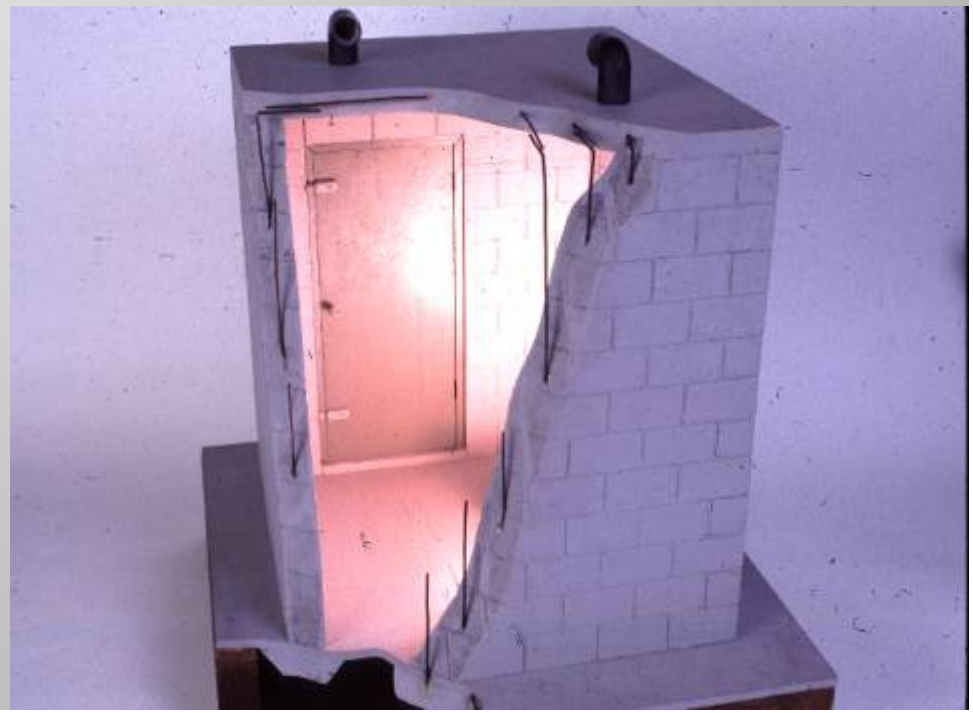
- Engineers at Texas Tech designed an indoor shelter that can withstand the winds of an EF-5 tornado.

Public Funding of Shelters The Tradeoff

- Such a large event prompts discussion of public subsidies for saferooms.
- Several states, most notably Oklahoma have had such programs.
- If public funds are used, there exists a tradeoff on potential uses of the same money to save lives elsewhere.
- Value of Life estimates:
  - A common range is $5-$10 million

Our Approach

- For each state we have calculated a "Cost Per Avoided Fatality"
- Inputs to the calculation:
  - Average annual fatalities
  - Average shelter cost
  - Housing Units
  - Discount Rate
  - Estimated shelter life



Example: Alabama Permanent Homes

- Housing Units (2010 Census – Single Detached)
  1,535,146
- Average Annual Fatalities (1950-2011)
  3.07
- Shelter Cost
  $2,500
- Shelter Life
  50 Years
- Discount Rate
  3%

Example: Alabama Mobile Homes

- Housing Units (2010 Census)
  291,373
- Average Annual Fatalities (1950-2011)
  4.26
- Shelter Cost
  $2,500
- Shelter Life
  50 Years
- Discount Rate
  3%

Estimate Cost Per Avoided Fatality

- Permanent Homes

  $47.2 Million

- Mobile Homes

  $6.5 Million

Estimate Cost Per Avoided Fatality With Some Consideration for Peace of Mind

- Permanent Homes

  $22.2 Million

- Mobile Homes

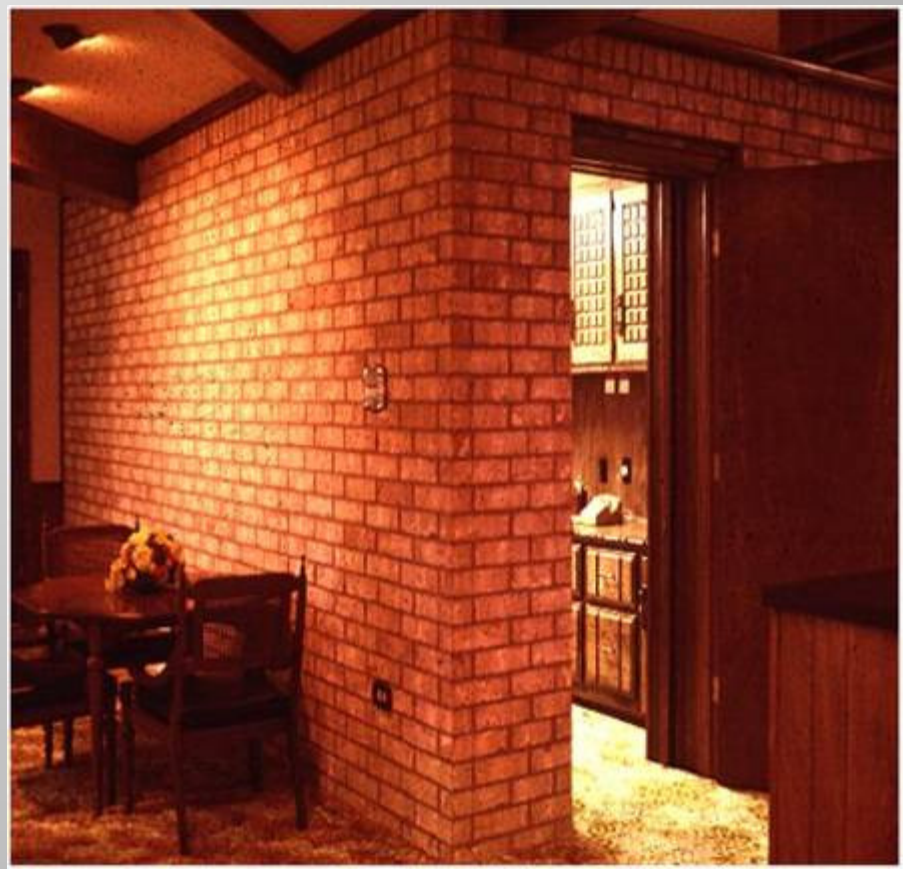
  $3.0 Million

Observations on Public Funding

- There appears some merit for mobile homes given the increased vulnerability
- Permanent homes, however, are harder to justify

Private Mitigation

- One way to examine the value of saferooms is to see if they affect the value of the property
- Study: Oklahoma County Residential Sales
- We were looking for any premium to sales price if a shelter was present



Private Mitigation Results

- The presence of a shelter added about 3.5% to the sales price of the home
- For our sample that was an increase of $4,200 to the average home

Continued Progress in Reducing Casualties

- Warning Dissemination
  - Nocturnal Tornadoes

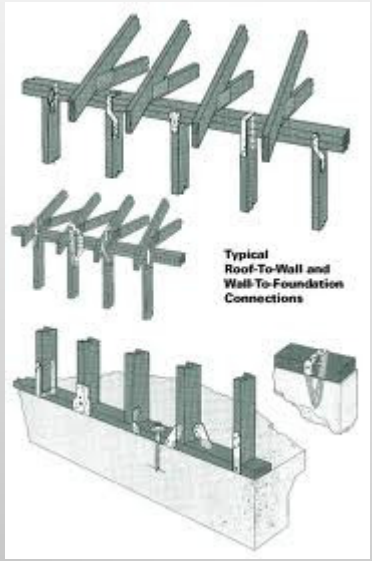
    A lethal tornado at 2:00 a.m. will kill over twice as many people as the same tornado occurring at 2:00 p.m.

- Warning Quality
  - False Alarms

    Our research shows that there is a "cry wolf" effect.

Future Policy Considerations Limiting Damage

- Better Construction
  - Load path connections



Future Policy Considerations Limiting Damage

- IIBHS Fortified Program

- Tornadic Winds are different than hurricane wind forces
  - Wind speeds in an EF-5 tornado exceed 200 mph
  - Winds are not straight line creating special forces on the structure.

Future Policy Considerations Limiting Damage

- Current study on the effect of enforced building on hail damage
- Study participants
  - Wharton Risk and Decision Analysis Center
  - Insurance Services Office
  - Travelers Insurance
- Research Question:
    - How much is good enforcement worth when a hail storm strikes?
- Result:
    - Damage is reduced by about 20%

Could it Have Been Worse?

- 1953
  - Population of Affected Counties
    - 3.9 Million
  - Fatality Rate
    - 131.7 per million

- 2011
  - Population of Affected Counties
    - 8.6 Million
  - Fatality Rate
    - 64.3 per million

Conclusion

- The tragic results of 2011 remind us that nature can be violent and unforgiving.


Thank You For Your Attention