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Economic Decision Making in Fire and Electrical Safety: A Workshop on Needs and Resources

**NFPA Headquarters
Quincy, MA
August 17, 2016**

Acknowledgements

Executive Summary

Today's fire departments and other fire and electrical safety advocates are focused on reducing the overall risk through a combination of protection, prevention, and other programs. They seek tools to evaluate the socio-economic benefit of these interventions, to inform policy decisions with cost-benefit information on this aspect of safety. On August 17, 2016 NFPA conducted a one day workshop to explore the resources currently in the fire and electrical safety community, what we might learn from other fields of endeavor that are exploring related questions, and most importantly hear from our stakeholders about their needs in this regard. The outcome was a prioritized roadmap of research activities designed to meet those needs.

Background

Decision making in the public policy arena is increasingly being based on economic indicators. Here are two recent examples of questions posed to NFPA by our stakeholders:

- From fire departments – can you provide me with information that I can use with my local government to demonstrate the value that my fire department operations provide in my community?
- From state/local advocates for fire safety regulation change – can you provide me with cost-benefit information for a specific code change related to fire or electrical safety?

NFPA traditionally has focused on measuring the various dimensions of fire loss – death, injury, property, and in some cases economic loss. In today's environment of extreme economic pressures on local jurisdictions, our enviable success in reducing those losses has turned the focus more toward the costs of protection. One resource is this regard is NFPA's 2012 report, the Total Cost of Fire, which provided information on the cost of fire protection/prevention – fire departments, fire protection systems, etc.

Today's fire departments and other fire and electrical safety advocates are focused on reducing the overall risk through a combination of protection, prevention, and other programs. They seek tools to evaluate the socio-economic benefit of these interventions, to inform policy decisions with cost-benefit information on this aspect of safety.

Workshop Goal and Participants

On August 17, 2016 NFPA conducted a one day workshop to explore the resources currently in the fire and electrical safety community, what we might learn from other fields of endeavor that are exploring related questions, and most importantly hear from our stakeholders about their needs in this regard. The anticipated outcome was a prioritized roadmap of research activities designed to meet those needs.

Workshop attendance blended members of the fire and electrical safety enforcement community and economists and others engaged in providing economic tools and assessments in this and other fields. The attendance roster can be found in Appendix B.

Workshop Program
The workshop consisted of a series of short presentations of models/tools that are available or under development to address economic decision making related to risk reduction – for fire and related fields. Fire service and other fire and electrical safety advocates provided case studies demonstrating the need and application of these tools. Breakout sessions identified and prioritized gaps. The full agenda for the workshop can be found in Appendix A and speaker biographies in Appendix C. Here is a brief summary of the presentations at the workshop; PowerPoint presentations can be found in Appendix E:

Sean DeCrane, International Association of Fire Fighters, provided an overview of the increasing challenges faced by large and small fire departments as they face staffing challenges and increased response requests. The data collected in the National Fire Incident Reporting System (NFIRS) is not enough to meet their needs and is often of poor quality due to a lack of training of fire officers and staffing challenges. Further, data of value to the fire service is fragmented in different systems locally and regionally and does not meet the near term data reporting and analysis needs of departments. New technologies in the form of apps and big data analytics could make a tremendous difference in the application of data to meet firefighter needs.

Gregg Cleveland, City of Lacrosse, provided a case study example of the use of data on fire fighter injuries to demonstrate the positive impacts of fire protection through the use of automatic sprinklers, which had a major impact on reducing firefighter injury. Challenges in this study were the different systems used to report injuries, the lack of consideration of opportunity costs related to people and to neighborhoods, the cost of pension penalties, and the common under reporting and underestimating of the costs of injury. He challenged the group to consider the difference between the price of loss and the overall cost of fire.

Casia Sinco, Florida State Fire Marshal's office, described Florida's challenges related to data supported economic impact assessment of codes and standards. These include the lack of consistent data from insurers and others, the lack of data on costs to the community for NOT installing fire protection systems (worker compensation, health insurance, pension penalties, etc.), and other community costs such as diminished tax based and displacement of residents. Florida mandates a Statement of Estimated Regulatory Costs (SERC) for building codes and elected officials need a cost methodology to demonstrate the economic impact of the policy option which includes not only price but cost.

Robert Fash, Las Vegas Fire & Rescue, described a recent project in response to a Nevada mandate requiring cost-benefit analysis for residential fire sprinklers, involving the fire marshal, University of Nevada Las Vegas (UNLV) with Christine Springer, and others. The project explored the impact (not only of cost of installation and savings due to fatality and injury reduction) of homeowner incentives and insurance premium credits. It was found that water costs/savings, along with positive outcomes for public policy formulation, is a challenging area of analysis without good data.

Steve Regoli, State of Ohio Board of Building Standards presented a unique methodology for analysis of proposed changes to the OH building, mechanical, and plumbing codes, created in response to an request to the board to study cost-benefit of rule adoptions. The approach considers all proposed changes that are impactful and develops a profile of factors by which each change is evaluated including initial and long term costs and macro impacts. Costs and savings to builder, owner, and public are

considered, including intangibles such as environmental. The methodology has been a useful tool to present the cost impact of changes.

David Kish, Purdue University, described a recent project to examine the costs and benefits of installing arc fault circuit interrupters (AFCIs) in homes. A simplified supply and demand analysis was used to explore the effect of increased cost from AFCIs on the housing market. Some challenges are determining the costs of arcing fires in new and old construction over the available range of residential housing, information and assumptions about changes in insurance expense, and the actual price of AFCI equipment.

Jeff Case, Phoenix Fire Department, and Anthony Evans, Arizona State University, presented the Arizona State University's Seidman Research Institute Study of the Economic Impact and Return on Investment of the Phoenix Fire Department to their community as a result of intervention on commercial fire responses. The study considered both direct and indirect savings from fire intervention using a sophisticated model from Regional Economic Models, Inc. (REMI) for 45 fires affecting 51 businesses. Recommended improvements that can be made include the costs of medical services, expanding the model to residential structures and to a national basis, evaluating opportunity costs, estimating savings from prevention, and continuing to explore similar 3rd party relationships nationwide.

Francine Amon, SP Swedish Fire Research Institute, presented a recent tool, Enveco, developed for the Fire Protection Research Foundation. The goal of the project was to evaluate the feasibility of developing a tool that anyone can use to assess the savings in environmental and economic impact to community resulting from fire department intervention. The prototype tool developed provides a means for any fire department to estimate the impact of fire department intervention on a warehouse fire. Data for the tools includes information on the structure and its contents and the potential fire spread and various levels of intervention can be compared. There are many uncertainties in the current data and future work may include some high level assumptions to simplify the tool and expand use to other occupancies.

David Butry, NIST, presented a recent study on the effect of fire prevention programs on wildfires on tribal lands, which included a cost-benefit analysis. Major factors were fire prevention education and law enforcement. The study was able to demonstrate the positive impact of these factors and there is promise that more research can identify the relative impact of different fire prevention/education strategies.

Andrew Wang, Harvard University, presented an economics perspective on the impact of the fire service. He noted that output in the services sector, and especially government services, is difficult to measure. He discussed measurement of output, or outcomes, of the fire service, and provided an outline for empirical modeling of fire risk and loss, using NFIRS data on fire incidents, U.S. Census data on demographic and housing characteristics in local areas, and U.S. Census data on local government fire protection expenditures. He suggested the need for more detailed, building-level data on characteristics of buildings, i.e., building "quality", that explain the risk of fire and loss from fire. Beyond fire protection, he highlighted the importance of the fire service in providing emergency medical services (EMS) and other services that are highly valued by the public. Finally, beyond the fire service, he pointed out the importance of industries that produce new technologies and innovations that improve fire protection and fire safety.

Jun Zhuang, University at Buffalo, presented a model and case study of Cost-Benefit Analysis of Fire Protection Resource Allocation in the United States. The model enables mapping of vulnerability to investment and can be used as a tool to optimize investments of fire department resources, which vary greatly across the country.

Breakout Sessions

Participants divided into four breakout groups (two focusing on fire department needs and two focusing on needs for code change assessment) and considered the following questions:

- Do we see the need emerging for dollars and cents types of arguments related to fire safety decision making?
- What types of economic tools are needed?
- What data sets are needed?
- How could NFPA help?

The notes taken in each group are compiled in Appendix D.

Summary of Recommendations

The breakout groups shared several key findings and recommendations:
1. There is an increasing need to demonstrate return on investment related to fire and electrical safety requirements to demonstrate the value of fire protection systems, fire department interventions, and community risk reduction efforts.
2. There is no standard approach toward this type of evaluation. Simple models that can be used by non-economics trained individuals are needed, with relatively simple inputs but with rigorous back end independent models.
3. Outputs need to be in a form that can be used at the local jurisdiction level.
4. Data is needed for all of these applications and includes both direct and indirect costs, opportunity costs, more sophisticated assumptions related to injuries, life cycle costs, and various community related data sets.
5. NFPA can play an important role as an independent source of fire related data and tools that are standardized and can be used across jurisdictions.
6. Collaboration with other organizations with similar needs can extend the resources and the impact of these activities.

Economic Decision Making in Fire and Electrical Safety:
A Workshop on Needs and Resources
8:30 a.m. – 4:00 p.m., Wednesday, August 17, 2016
NFPA Headquarters, 1 Batterymarch Park, Quincy, MA

APPENDIX A AGENDA

1. **Welcome, Workshop Purpose**
2. **Economic Decision Making in the Fire Service**
   a. Sean DeCrane, International Association of Fire Fighters
   b. Gregg Cleveland, City of Lacrosse, WI, "*Economic Impact to Local Governments for Building Fire Safety*"
3. **The Use of Cost/Benefit Analyses in the Code Adoption Process**
   a. Casia Sinco, Florida Fire Marshal's Office, "*Economic Impact Analysis in Florida's Rulemaking Processes*"
   b. Robert Fash, Las Vegas Fire Department, "*Nevada's Mandate Requiring a Cost-Benefit Analysis for Residential Fire Sprinklers*"
   c. Steve Regoli, State of Ohio Board of Building Standards, "*A Methodology for Evaluating the Impact of Rule Adoption and Developing a Statement of Fiscal Analysis: Subjective Expert Analysis of the Proposed Changes to the Ohio Building, Mechanical, and Plumbing Codes.*"

Coffee

4. **Research Snapshots: Tools for Economic Decision Making**
   a. David Kish, Purdue University "*Clearing the Fiscal Impact Hurdle*"
   b. Jeff Case, Phoenix Fire Department, Anthony Evans, Arizona State University, "*Phoenix Study*"
   c. Francine Amon, SP Swedish Research Institute, "*Development of an Environmental and Economic Assessment Tool (Enveco Tool) for Fire Events*"

Lunch

5. **Research Snapshots, cont'd**
   a. David Butry, NIST "*Effect of Fire Prevention Programs on Accidental and Incendiary Wildfires on Tribal Lands in The United States*"
   b. Andrew Wang, Harvard University, "*Economic Perspectives and Research Ideas for the Fire Service*"
   c. Jun Zhuang , SUNY Buffalo, "*Cost-Benefit Analysis of Fire Protection Resource Allocation in the United States: Models and a 1980-2011 Case Study*"

6. **Breakouts:** How can economic decision tools be applied to meet the needs of the fire community?   What tools are needed? What data sets are needed?
    a) Quantifying the economic benefit of fire protection measures employed by fire departments
    b) Cost/benefit analyses in the fire and electrical code adoption process

7. **Breakout Reports**
8. **Conclusion; Next Steps**

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Appendix B
Participants

Francine Amon, SP, Swedish National Fire Research Institute

Cameron Bardas, City of Edmonton, Alberta, Fire Department

Adam Behrendt, SUNY Buffalo

Brett Brenner, ESFI

David Butry, National Institute of Standards and Technology

Jeff Case, Phoenix, AZ Fire Department

Gregg Cleveland, City of Lacrosse, WI

Jay Crandell, ARES consulting

Sean DeCrane, representing International Association of Fire Fighters

Anthony Evans, Arizona State University

Robert Fash, Las Vegas, NV Fire Department

Kirk Grundahl, Qualtim

Gary Keith, FM Global

David Kish, Purdue University

Melissa Knight, representing International Association of Fire Chiefs

Andre LaRoche, National Research Council of Canada

Jack Lyons, National Electrical Manufacturers Association

Vineet Madasseri Payyappalli, SUNY Buffalo

Steve Regoli, State of Ohio Board of Building Standards

Casia Sinco, Florida Fire Marshal's office

William Stewart, Chief, retired, City of Toronto Fire Department, Canada

Doug Thomas, National Institute of Standards and Technology

Andrew Wang, Harvard University

X. Zhang, UC Davis

Jun Zhuang, SUNY Buffalo

Don Bliss, Tim McClintock, Russ Sanders, Meghan Housewright, Amanda Kimball, Kathleen Almand, Nathaniel Lin, Christina Holcroft, Chris Dubay, Nicole Comeau, Sreeni Ranganathan, Dan Gorham, Shayne Mintz, Michele Steinberg, NFPA

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Appendix C

Speaker Biographical Sketches

Sean DeCrane is a 25+ year veteran of the Cleveland Division of Fire. He has risen through the ranks and currently serves as a Battalion Chief covering Cleveland's Westside. He has served as the Director of Training and Acting Chief of Operations.

Sean has been very involved in the research at Underwriters Laboratories and the National Institute of Standards and Technology. He serves on the UL Fire Council, is a member of the UL Fire Fighter Safety Research Institute's Advisory Board and is currently on a number of technical panels for research and standards.

Chief DeCrane also represents the International Association of Fire Fighters in the International Code Council process and has served on the 2009, 2012, 2105 and 2018 Fire Code Developing Committee and as Chair for 2015 and 2018. Sean serves on the NFPA 1 Technical Advisory Panel, NFPA Research Foundation on Tall Wood Buildings and was recently appointed as the IAFF alternate to the NFPA Fire Behavior Research Technical Committee.

Chief Gregg Cleveland is the fire chief for the La Crosse Fire Department. Located on the Mississippi River in western Wisconsin, he manages the fire department consisting of four fire stations and 103 personnel serving 22 square miles. The fire department provides numerous regional services such as water/dive rescue, technical rescue, hazardous material, Urban Search and Rescue in addition to emergency medical services, fire suppression and fire prevention and public education services. In 2014 the fire department merged the city's building department into the fire department creating the Division of Fire Prevention and Building Safety. Chief Cleveland has an Associate Degree in Fire Protection Technology, Bachelor's Degree in Business Administration and a Master's Degree in Public Administration. Chief Cleveland is a graduate of the Executive Fire Officer Program from the National Fire Academy. He has served on numerous committees for the State of Wisconsin and is currently the chairman of the State's Fire Prevention Code Council. Chief Cleveland is a past president of the Wisconsin State Fire Chiefs' Association, and is secretary of NFPA's Fire Service Executive Board. He has been in the fire service for 37 years and served as fire chief in two other communities in Wisconsin.

Casia Sinco is the Bureau Chief for the Bureau of Fire Prevention in the Florida State Fire Marshal's office. The Bureau's variety of compliance and enforcement programs include boiler inspections, licensure of fire related industries, explosives, fire code enforcement, and fire code development. Ms. Sinco's responsibilities include oversight of the Bureau's four functional areas of Plans Review, Inspections, Boiler Safety, and Regulatory Licensing. She is also responsible for the triennial

development and adoption of the Florida Fire Prevention Code. Ms. Sinco possesses a Bachelor of Arts from Mars Hill University, a Juris Doctorate from Florida State University, and holds an Executive Fire Officer designation from the National Fire Academy.

<mark>Robert Fash</mark> currently serves as a Deputy Fire Marshal for Las Vegas Fire & Rescue. He manages the community risk reduction Section under the Fire Prevention Division. Robert serves on a number of national fire code development committees and is a recipient of the Robert W. Gain Award presented by the Western Fire Chief's Association for fire code development work. Robert has participated on a number of Fire Protection Research Foundation projects related to hazardous chemicals. Robert has over 34 years in the fire service in both a volunteer and career capacity. Robert has obtained a Master of Public Administration from the University of Nevada in Las Vegas. Robert has a number of fire service certifications including Fire Officer IV, Fire Service Instructor, and Fire Inspector and is an appointed Commissioner to the Nevada State Emergency Response Commission.

<mark>Steve Regoli</mark> is presently employed by the Ohio Board of Building Standards as Architect Administrator with primary technical responsibility for development of Ohio's construction codes and its technical staff, oversight of the Board's MIS resources, Board budgeting and planning, and related Board activities. Steve is a licensed architect in Ohio and is a past member of: Building Officials and Code Administrators (BOCA) Int. board of directors, past chairman of the International Code Council – Evaluation Services (ICC-ES) board of directors, and past member of the ICC-ES Advisory Board, the ICC Standards Council, and has been an NFPA member since 1981. He consults regularly with architects, engineers, trade associations, code officials, regulatory agencies, testing and inspection agencies, the Ohio Legislature, the general public, and other departments and agencies of the state on construction code issues. Mr. Regoli has previously been employed as Executive Secretary of the Ohio Board of Building Standards;

<mark>David Kish</mark>, PE, received a bachelor's degree in Electrical Engineering from Purdue University in 1987; he subsequently earned an MSEE and PhD from Purdue in 1989 and 1993 respectively. David received a Master of Science, Management (MBA) from Purdue's Krannert School of Management in 1998. He started working in Purdue's Physical Facilities organization in 1993 and currently works as a Fire Protection Engineer in the Department of Environmental Health and Public Safety. In addition to his NFPA membership, David is a member of IEEE, ICC, IAEI, and NSPE. He is currently President of the Indiana Society of Professional Engineers. David served as a member of the Indiana Code Review Committees for the 2008 Indiana Building Code, the 2008 Indiana Electrical Code, and the 2011 Sprinkler Code. He is a volunteer member of the Board of Directors of the Purdue Federal Credit Union; he currently is board treasurer.

<mark>Jeff Case</mark> currently works as the Deputy Chief over the Phoenix Fire Regional Dispatch Center. His previous assignments included the following; Deputy Chief over Technical Services Division, a responding Deputy--Shift Commander and manager of training at the department's Command Training Center, Deputy of Training, Support Services and Company Officer and a Paramedic for 26 years. Chief Case was instrumental in the design and implementation of Mesa Community College's Virtual Incident Command Center. Chief Case is a faculty member of Mesa Community College, and an adjunct instructor with TEEX in their WMD/EMS response program. Chief Case has a Bachelor's degree in Fire Service Management and a Master's degree in Education

Dr. Anthony Evans is the Staff Director and Senior Researcher at the L. William Seidman Research Institute, W. P. Carey School of Business, Arizona State University. Seidman offers business and economics consulting and contract research services to public and private sector clients throughout the Southwest. Dr. Evans' recent clients include Intel, Republic Waste Services, the Arizona Diamondbacks, Wells Fargo and the NFL for SuperBowl XLIX. Prior to joining Seidman, Dr. Evans held a number of senior U.K. and European marketing roles in the private sector, including 18 months as Commercial Manager at a semi-professional football club. Dr. Evans can also draw upon significant management experience from the entertainment world, leading and implementing European marketing strategies for such well-known brands as Thomas the Tank Engine, Bob the Builder, Barney, Fireman Sam, and Guinness World Records. Dr. Evans has a B.A. in Philosophy from Kings College London (England), an M.A. in Sociology of Sport from the University of Leicester (England), and a Marketing Ph.D. from the University of Sheffield (England).

Dr. Francine Amon has been working for the past 5 years at SP Fire Research, where her research focus has been on studying the effects of fire on the environment. Projects have included ignition mechanisms of wildland fires, life cycle assessment of flame retardants and nanoparticles, and work supporting the development of standard documents in ISO TC 92 SC3 WG6 (Fire Threat to the Environment). Prior to SP, Francine was a researcher at the National Institute of Standards and Technology, working in the area of firefighter technology. During this time she was also active in NFPA standards development for electronic equipment for the fire service.

Dr. David Butry is an economist in the Applied Economics Office of the Engineering Laboratory (EL) at the National Institute of Standards and Technology (NIST). Dr. Butry joined NIST in 2006. Currently, he leads research in the areas of community resilience and fire protection and mitigation. His projects include: (1) developing economic-based standards and tools to assess the resilience of communities to disruptive events; (2) measuring the economic performance of life-safety technologies, building codes, and regulations; (3) evaluating the spatio-temporal dynamics of fire ignition patterns, and measuring the economic effectiveness of wildfire prevention activities.

Andrew Wang is Senior Research Associate at the Harvard Center for Green Buildings and Cities, Harvard University, and Research Economist at the National Bureau of Economic Research. He conducts empirical research on productivity and performance in U.S. industry, and the economic impact of R&D and science and technology. Previously, he was Economist at the National Institute of Standards and Technology, U.S. Department of Commerce, in the Advanced Technology Program, a public-private partnership supporting technology R&D and innovation in industry. He received a B.A. in History and Economics from University of California, Berkeley, and a Ph.D. in Economics from Harvard University.

Dr. Jun Zhuang is an Associate Professor and Director of Undergraduate Studies, Department of Industrial and Systems Engineering at the University at Buffalo (UB). Dr. Zhuang has a Ph.D. in Industrial Engineering in 2008 from the University of Wisconsin-Madison. Dr. Zhuang's long-term research goal is to integrate operations research, game theory, and decision analysis to improve mitigation, preparedness, response, and recovery for natural and man-made disasters. Other areas of interest

include applications to health care, sports, transportation, supply chain management, sustainability, and architecture. Dr. Zhuang's research has been supported by the U.S. National Science Foundation, by the U.S. Department of Homeland Security, by the U.S. Department of Energy, and by the U.S. Air Force Office of Scientific Research.

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Appendix D
Breakout Group Reports

Group A
Participants: Amanda Kimball, moderator, Adam Behrendt, David Butry, Jay Crandell, Anthony Evans, Melissa Knight, William Stewart, Meghan Housewright, Nicole Comeau

- Do we see a need emerging for dollars and cents types of arguments?
    - Yes, group agreed that we are seeing a need emerging.
    - Noted that dollars and cents are what politicians understand.
    - People pay attention to arguments when finances/economics is involved.
    - Examples of arguments being made/requested:
        - Need to be able to prove the value for current FD budgets.
        - Starting to see the impact of the elimination of prevention/educational resources in FDs – economic analysis of the impact of prevention would be beneficial to gaining back some of these resources.
        - Need arguments to keep the current staffing levels.
        - Impact of the aging workforce is also of interest (related to injuries, etc.).
- What types of economic tools are needed:
    - Would like to be able to put a value on a successful intervention (in various occupancies, locations, etc.)
    - In order to be used by the fire service, need to have simple inputs and simple understandable outputs, but sophisticated/rigorous analysis in the background in order to have a strong argument.
    - Need for a repeatable methodology that can be used anywhere.
    - Specifically need a tool for small volunteer based departments with limited resources.
    - Focus on benefit/cost analysis (rather than cost/benefit analysis)
    - For economic loss data, it was noted that we need to break down by:
        - Injuries
        - Property damage
        - Business continuity
        - Etc.
    - Who is the audience?
        - Whoever signs off on the budget including policy makers (local, regional, and/or state).
        - General public
            - Raising awareness of the actual impact of the FD on the community.
            - If the FD gathering the data, they can control the message (like what Phoenix has done).

- ▪ And the FDs themselves (by showing how the data is used, could result in better quality data being gathered)
- What data sets are needed?
  - o Generally, data requirements depend on end goal and type of economic model being used (there are various levels).
  - o Can data sets be grouped regionally? The more local that you have to drill down, the harder data is to get.
  - o Need more information on the values at risk
    - ▪ Potential loss (people and property)
    - ▪ Understanding the values that FDs are protecting
  - o Need more state specific data (does a state that invests less in fire protection increase their risk?)
  - o Data related to the impact of health and wellness programs.
  - o Need more information about the characteristics of the building inventory for a specific department for fire pre-planning purposes, analysis, etc. What percent are protected by sprinklers, construction materials, occupancy types, etc.
  - o Need better more consistent data around response times.
  - o Need estimated input parameters for modeling (for consistency)
    - ▪ Coefficients for simulations
    - ▪ Theoretical impact of fire protection
  - o What is the confidence level of data?
  - o Noted that Europe uses data around quality adjusted life year (related to health care) – this could be of interest.
  - o Residential fuel load is changing, is the potential for bad outcomes greater?
  - o Role of FDs are changing with more medical calls, etc. Fire loss may not be the best metric to measure success anymore. But what is?
- What can NFPA do to help?
  - o Develop a standard model to calculate economic impact that is:
    - ▪ Industry accepted
    - ▪ User-friendly/intuitive
    - ▪ Consensus based
  - o Develop a data analytics standard for fire protection
    - ▪ Developing consistent basis for analysis
    - ▪ Developing consistent values for fire prevention/fire protection context on value of life, value of injuries, etc.
  - o Revisit the methodology used in the total cost reports and update with newer data/methods.
  - o Partnering with insurance companies to get more accurate injury and loss data.
    - ▪ Noted that this could be used to compare against NFIRS data (are we even on the same order of magnitude?)
  - o Continue this discussion with researchers and stakeholders through more meetings like this one.
  - o Assist researchers with getting grants related to fire protection/prevention.

Group B

Participants: Andre LaRoche, Marty Ahrens, Gary Keith, Shayne Mintz, Sean DeCrane, Kirk Grundahl, X. Zhang, Robert Fash, and Don Bliss

1. **Discussion on what is the goal of the economic tools?**

- Identify a mission with economic tool
- Tools should not be restricted for local levels. Should be applicable to multiple levels.
- Tools should help FD to have weekly/monthly reports (Timely deliverables/reports)
- Goals –
    - Risk Reduction:
        - Performance/effect/impact of fire prevention, public education, codes, code enforcement
    - Response effectiveness
        - Fire service impact and cost
        - Impact of no fire service
        - Impact of other FD services: hazmat, wildfire, disaster response, EMS (Not just Fire!)

- Marty Ahrens: pointed out that NFIRS does not tell us what the fire service does.
- Andre LaRoche: great need for a consistent data collection system (especially Canada)
- It is difficult to measure the impact of fire prevention activities/programs.
- There is a huge variance in the estimation of costs. Need more data for evaluation.

2. **What economic tools would be useful?**

- There is no consensus on the value of life. More studies are needed based on current economic data. We shouldn't ignore the cost of injuries: burns, firefighter cancer, and psychological impact of fire.
- Quantify the cost of death, & cost of injuries
- Recommendation: establish a standard for statistical analysis/economic analysis.
- It is possible to rely on the predictive power of a good statistical model.
- Forecasting tools for – commercial, residential, socio-economic factors
- Need to improve the quality of local data. Find improved way for data gathering.
- The Phoenix methodology is a useful tool that could be used in other jurisdictions.
- Clarify indirect costs
- There is a lack of statistics collection
- We need to change the paradigm on inspection requirements. Instead of inspecting those properties that we have always inspected, focus on the occupancies where the greatest losses or measurable risks are.
- Another useful approach might be to implement a specific public policy in a variety of jurisdictions and then measure the impact.
- Fire service fear: success with community risk reduction could result in loss of resources (staffing, fire stations, etc.)

- The results of any economic analysis has to be in a form that can be presented and understood by the fire chief, elected leaders, and the public. Hence simple templates are preferred.
- Phased approach to develop tools
- Use California as the basis for evaluating the impact of residential sprinklers.
- A tool to code from a narrative.
- Should have targeted goals/evaluations. Data collection should be framed properly.

3. **What data sets are needed?**

- California study on residential sprinkler impact
- Quantitative data on FD services and FD performance (quantify what fire service provides?)
- Information on what codes/standards a property is build?
- Building demographics
- Data base (national & international) on what codes are adopted where, combined with an enforcement metric (Levels of enforcement)
- Insurance loss data
- Investigative outcomes
- Building performance information

4. **How can NFPA help?**

- Connect researchers to build data (facilitation)
- Implementation of recommendations
- Funding projects (California study)
- Code adoption data clearinghouse
- Consensus building documents
    - Guidance on how to perform a cost benefit analysis
- Consistent reporting of data on Fire, Health etc.
- Assessment of NFIRS and FD data
- Research on the feasibility of voice recognition/AI software tools for incident reporting

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Breakout Group C
- Participants: Tim McClintock – facilitator; Dan Gorham – staff; Jack Lyons; Steve Regoli; Casia Sinco; Brett Brenner; David Kish; Andrew Wang; Doug Thomas

- Need to communicate <u>benefit</u>
    - Quantifying the value of life as it relates to code changes.
    - Pointing to the societal benefits that includes safety and economic benefits
- Performance statistics using historic data
- Building specific data to be used

- o Age
- o Codes applied during construction
- o Code compliance
- Code adopters need information about why the changes to the code were made in order to do an economic analysis - Justification for changes at state/local adoption level – state/local agencies are defending the national code development process. The lack of detail/substantiation for some changes has made it difficult to avoid amendments.
- There is a "chicken and the egg" problem in developing changes to codes and standards requirements. Information on impact is needed to justify a change, but need the change to happen in order to measure impact.
- State of Indiana has a good natural experiments case study in their adoption of AFCI requirements. AFCIs were included for a three period in Indiana before the state rescinded the requirements.
- Fair and effective impact of code changes – how to evaluate in a way that adopters are comfortable with
- Need standardized fire & electrical cost/benefit numbers – agreeable to clear communication and evaluation
- The time-scale of cost/benefit – how to emphasis and advocate for long-term effects? Code adoption opponents do not look beyond first costs.
- Fixed costs for code changes: hardware & software (labor, salaries, etc.)
  - o Is it possible to provide a range of these for different parts of the country as part of economic analysis?
- Development of a standardized methodology for conducting a cost impact analysis that NFPA can contribute to.
- What data is needed?
  - o Historic fire data
  - o More detail for reporting, e.g., fires caused by electrical arcing.
  - o Natural experiments
  - o Non-incident data
- Justification and substantiation for code revisions should consider economic impact
  - o Bad substantiation – what was changed
  - o Good substantiation – why is was changed (technical basis)
  - o Great substantiation – perceived impact
- Code revision and adoption cycles are getting out of sync and can cause up to 10 years between new code and implementation

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Group D
Moderator Russ Sanders, NFPA, recorder Matt Hinds Aldrich, NFPA
Participants: Gregg Cleveland, Jeff Case, Francine Amon, Cameron Bardas,
Vineet Madasseri Payyappalli

Question: Do we see the need emerging for dollars and cents types of arguments on this issue?

Answer: Yes, There is widespread agreement that we need to develop and utilize more robust economic arguments to support our efforts in fire and life safety.

Q: What types of economic tools are needed?

A: There is neither one universal need, nor one universal solution needed. We have only scraped the surface of how we can or should utilize economic analyses and methodologies to support fire and life safety decision making. The more we can expand the quantity and quality of fire and life safety data the more we can expand and validate our economic tools. The Economic and Environmental tool that SP is creating is a good example. At present it requires considerable data collection and entry effort but as systems get more complex and data more readily available these types of complex tools can be much more prevalent. Further, the tool developed by the Phoenix FD and ASU and the Purdue study are also good examples.

Q: For example, for fire departments, do they need to prove that they are reducing loss through fire prevention?

A: There is an absolute need to quantify the amount of loss saved by fire prevention. The group noted this is an extremely difficult challenge as there isn't even consensus among experts over the economic value of a life saved. Proving what "didn't happen" is the biggest challenge of fire prevention—or any prevention campaign. (See related conversation below regarding estimating fire loss more accurately, so we can get a better handle on the economics of fire prevention.) It was noted that during the recession, the lack of a fire prevention standard was a significant issue for fire chiefs trying to justify staffing in their FP Bureaus. The NFPA 1730 standard should help in the future.

Q: Do they need to prove that they are reducing loss through fire fighting?
A: The buzz that the Phoenix study has created is indicative of widespread interest in quantifying the economic benefit that the fire service provides. However, the Phoenix study also illustrated that we do not typically collect sufficient data about the outcome(s) of fires (short-term or long-term) to be able to make useful predictions about different levels of fire protection. Models that look at fire protection as binary (FD responds vs. FD doesn't respond) are problematic as they are over-simplified. To be useful the models need to be sufficiently complex to be able to suggest whether crew size, tactics, equipment, time to task, etc. have an impact on outcome and resilience. The group was hoping a new fire data system would help provide additional data to answer these questions.

Q: Do they need sophisticated analyses or simple templates?
A: The group universally agreed, we need both. We need complex and analytically robust models that are hidden behind rather simple or easy to interpret interfaces/tools. There is a danger if the analysis is too complex that it may be poorly understood by the intended audience and too difficult for local fire service leaders to explain and defend. Yet, the tools need to be sufficiently complex and analytically sound that they can provide nuanced conclusions that are both statistically and politically defensible.

Q: Who is the audience?
A: There are many audiences thus there is no one-size-fits-all approach that fits all questions. Given how politically charged some of the questions are, some audiences may be convinced by simple models while other audiences, that may have preconceived opinions may be unconvinced by even the most complex analyses. If it is possible to provide agencies user-friendly tools that they can quickly customize using local data that will help with the former. And there is likely need for groups like the NFPA, other non-profits or academic institutions to help provide the more complex analyses.

It was noted that there is also something to be said for "distance" in terms of perceived neutrality. For instance, the AZ study benefitted from having an academic research group do the study as it provided the local agency much needed expertise and independence. It was noted that even though NFPA is non-profit it might be perceived by skeptics (especially on topics like sprinkler installation) that NFPA has an agenda, so partnerships with academic institutions are vital.

Q: For code adoption, are holistic tools that look at the overall cost/benefit of a code adoption needed or is specific data/models for specific types of changes needed at this time?

A: There was only a brief discussion that centered on the Purdue model. The group did not have enough information to provide a specific recommendation, but the general consensus was that a "model" tool would be sufficient for most studies.

Q: What types of arguments have been successful?
A: The group was specifically impressed by the argument and analysis regarding AFCI breakers highlighted by the 2008 Ohio study. As they say all politics are local, so there was some hesitation about focusing primarily upon large scale national studies or results. Most state officials require state-specific data.

Q: Who are the competitors and what are they doing?
A: It wasn't clear whether there were "competitors" as such, rather there are opponents that may be pushing different political agendas. This is such an under developed field there is great opportunity for NFPA and others, especially academic researchers, to develop this into its own sub-discipline/area.

Q: What data sets are needed?
A: The biggest take away is that economic loss data in NFIRS is wildly speculative. While firefighters should be directed to and encouraged to look at the property assessors websites or at the very least at real estate tools like Zillow, there needs to be a paradigm shift in the way this data is collected and entered. One person noted that there is a Property Loss Estimation Tool that was developed by the KS SFMO then updated by MA SFMO and Atlanta Fire Rescue. That tool is an Excel spreadsheet that uses the latest ICC Building Valuation Data and Census data to estimate the value and loss of a building and using state and ZIP code level modifiers. It was noted that this could easily be adapted into a free app that might help improve the quality of loss estimation in the short term. It was noted by the group that any new fire data system should ideally pull in this parcel data directly and give users the ability to confirm that the supplied information is correct and update it if not.

It was also discussed that there isn't generally very good information about anything that happens after the fire department leaves a fire. It was noted that the REMI model that Phoenix used required them to do some sort of survey after the incident to see whether the business had plans to re-open, how long they anticipated being closed, and how many people/jobs this might impact.

Q: How could NFPA help?
A: There were several ways NFPA could drive development in this area discussed. First was through the development or at least incorporation of previously or widely used economic analyses methodologies in applicable NFPA standards. For example, it was noted that NFPA 950 has information about data but it could include a section on different types of economic models/methodologies that could or have been used for fire and life safety decision making. Though the group was hesitant with the idea of the NFPA "approving" or otherwise "blessing" one analysis over another or the specific data points within a

model. It was felt that NFPA should stay at a high level and simply highlight the various models that have been used to analyze the economic impact of fire and life safety.

It was also discussed that NFPA can integrate contemporary thinking and necessary data points into the fire data system it is developing to facilitate economic analyses. Moreover, if a consensus emerges about some common and straightforward economic analytical methodologies, it is possible to incorporate those into built-in, "canned reports" that the NFDS provides.

Economic Decision Making in Fire and Electrical Safety:
A Workshop on Needs and Resources

Appendix E

PowerPoint Presentations

Cleveland Division of Fire

- Establish as a Career Department in 1863

- 81 Square Miles

- Ninth Department to Achieve 150 years of continuous service

- In 2013 Average Age was 49 years-old

- SOP #1 "Fire in a Structure" Revised in 1999

Cleveland Division of Fire

- 2002 – 1048 Members

- Today – 719 with 40 Cadets in Training

- 2002 – Approximately 48,000 Incidents

- 2014 – Approximately 64,000 Incidents

- Needing to do more with less

Data Challenges

- ▶ RMS Updates

- ▶ Reduced Personnel to Scrub

- ▶ Reduced Personnel to Create Data Reports

- ▶ Accuracy of Data

- ▶ Limited Drop Down Options

- ▶ Officer Training

Data Challenges

- NFIRS Updates

- Clear Picture

  - Suppression

  - Fire Prevention/Public Education

  - Training

  - Code Requirements

- Officer Training

Data Challenges

- Better Record Keeping

- Better Reporting – Timely Reporting

- Applicable Reporting

- Easy to Understand

Challenge Answers?

- Develop On-Scene App for Recording Information

- Develop On-Scene App for Emergency Scene Information Use

    - FireCares

    - Structure History

    - Building Plans

    - Contact Information

    - Special Hazards – Building Identification Card

Challenge Answers?

- Voice Reporting
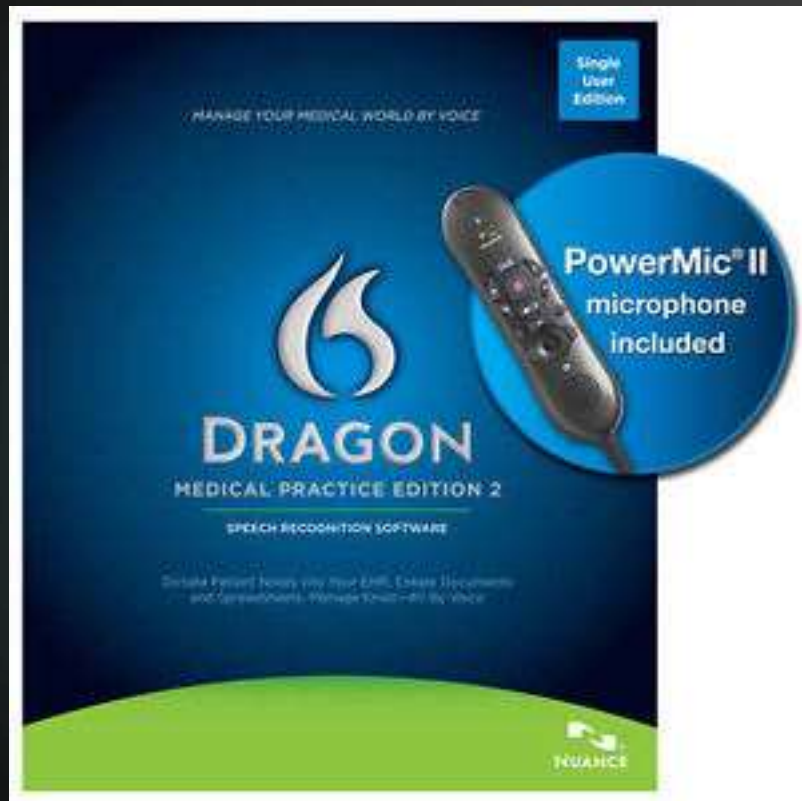
Challenge Answers?

▶ Permits Wide Variety of Information

▶ Officer Reporting What They Encountered

▶ No Drop Down so Accurate Information

▶ Do Not Need to Wait for NFIRS Updates

▶ Accurate Recording of Work Efforts

   ▶ NFORS

   ▶ Workers Comp

Pociana Avenue

3 D Printing
Just Don't Melt It!

Reporting Out

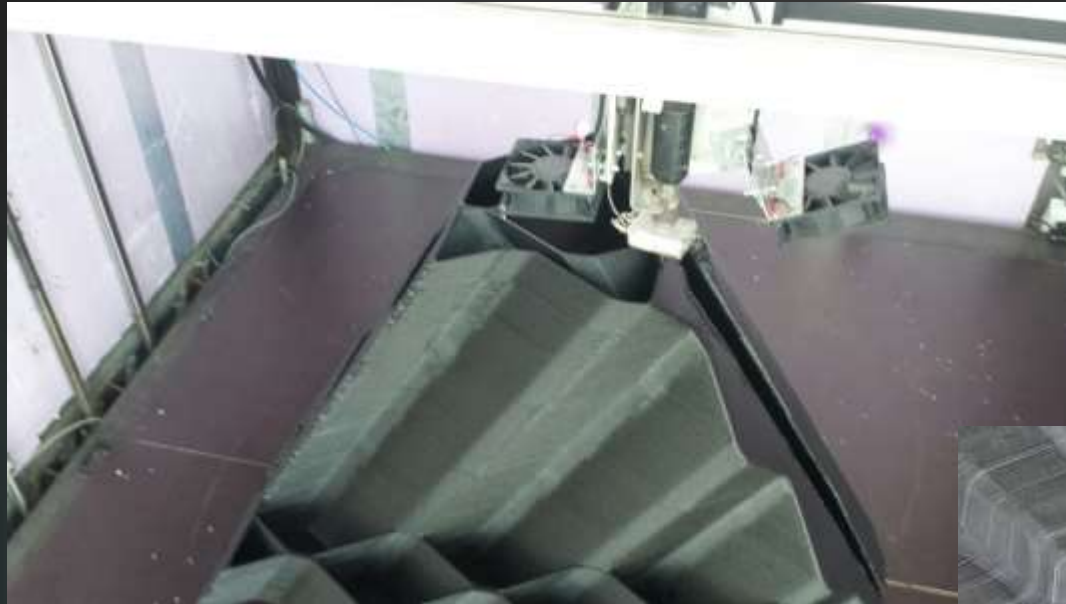- Narrative Science

  - Process Known as Natural Language

  - Began by Publishing Big 10 Game Reports

  - Evolved into International Finance Reports

  - Takes Info from Charts and State

  - Creates Narrative

  - Can be Daily, Weekly, Monthly, Etc

  - Can be Automatically Generated

Travelers Guide

SAN DIEGO, CALIFORNIA

Sunny San Diego is the perfect family getaway. The city is filled with a mix of tasty restaurants, beautiful parks, and plenty of fun activities for all ages.

Head to Balboa Park for a serene bit of nature tucked inside the big city. If you're feeling a little more adventurous, the San Diego Zoo is a great place to check out some exotic creatures. In the mood for an indoor activity? The New Children's Museum is a fun place for kids to explore and learn.

The Goal
No More Names

Economic Decision Making in Fire and Electrical Safety

Economic Impact to Local Governments for Building Fire Safety

Gregg A. Cleveland, Fire Chief, EFO, MPA

La Crosse, WI Fire Department

Literature Review

- *Automatic Fire Sprinklers, a 10 Year Study,* Rural Metro Fire Department, City of Scottsdale. 1997

- *The Fires,* Flood, Joseph. 2010

- *Impact of Home Fire Sprinklers on Firefighter Injuries,* Hall, John R. NFPA 2012

- *The Case for Fire Sprinklers in One-and Two-Family Dwellings,* NFPA Fire Sprinkler Initiative. October 2014

- The University of Hard Knocks (AKA Experience). Cleveland, Gregg 1979 to present

Cost Savings to Communities

- Focus on measuring cost savings to local communities (taxpayers) that lead to lower operating costs and increased tax base to a community from residential buildings

  o A similar costing can be performed on commercial properties protected by automatic fire sprinklers; however, this presentation will focus on residential properties

- Specifically looking at firefighter injuries and their costs to communities in one and two-family dwellings

National Impact

- Firefighter injuries in one and two family dwellings
    - 25,600 firefighter injuries (2006-2010)
        - Source: _The Case for Fire Sprinklers in One and Two Family Dwellings_, NFPA Fire Sprinkler Initiative, October 2014

    - 18,750 firefighter injuries (2007-2011)
        - Source: _Patterns of Firefighter Injuries_, Karter, Michael Jr. NFPA 2013

Local Impact

- La Crosse Fire Department
  - Injuries in one and two family dwellings
    - 2010-2015 - 20 of the 32 fireground injuries (62.5%) occurred in one and two family dwellings
  - Total costs to the La Crosse community are difficult to obtain because of federal, state, and local regulations, i.e. HIPPA
  - Injury categories used by insurance companies do not coincide to fire service injury categories or classifications
  - Many injuries are not reported for a variety of reasons (fire service culture)

Smithtown, WI Fire Department Case Study

- Firefighter Injury - Single Family Dwelling
  - Workers' compensation report filed for a sore neck following fire operations in a single family dwelling fire
  - Smithtown is self-insured for the first million dollars of medical losses
  - Sore neck results in 32 days of loss work days
  - Net medical costs to community - $16,815.00
    - Following stop loss insurance reimbursement
  - Salary paid to employee and to other employees who had to work in his place - $31,833.00
  - Benefit calculation on overtime - $6,685.00
  - Direct dollar loss to the city for injury - $55,333.00

Smithtown Fire Department Outcome

- One Injury
  - Direct community cost - $55,333.00*
  - Taxpayer cost
    - Owner of a median value ($120,000) home in Smithtown, WI paid $2.01 for this firefighter injury
    - This represents costs borne by all taxpayers for this preventative loss
    - What are the <u>opportunity costs</u> for injuries sustained in fires in non-sprinklered buildings?
  - $55,333 represents the cost of <u>one</u> firefighter injury
    - What are the costs statewide and nationally
  - How many residential sprinklers systems could have been installed for $55,000.00

    *Cost includes: overtime, workers' compensation, FICA , retirement, and life insurance, hospitalization

Cost Savings in the Built Environment

- One and Two Family Dwelling Fires
  - John R Hall, Jr. (NFPA) in his 2012 report *Impact of Home Sprinklers of Firefighter Injuries* found:
    - 65% reduction in firefighter injuries on the fireground per 1,000 fires (73 firefighter fireground injuries per 1,000 fires to 25 firefighter fireground injuries per 1,000 fires)
      - Note: includes fire reported to NFPA from municipal fire departments based on NFIRS 5.0 and does not include fires reported from federal, state, or industrial brigades. Fires are excluded if sprinklers are not reported or status unknown or building under construction.

Policy Considerations – Residential Sprinklers

- To calculate the economic benefit of automatic fire sprinklers in residential buildings within a community there is a trade off
  - Cost to the developer for the installation of fire sprinklers
    - Pass through cost to owner
  - Cost to the community (taxpayers) for not installing automatic fire sprinklers
    - Worker compensation rates
    - Health insurance
    - Pension penalties (duty disabilities)
    - Overtime and other benefits

Policy Considerations – Residential Sprinklers

- Other costs to the communities
  - Loss or diminished tax base and taxes (future value of dollars lost)
  - Infrastructure savings (cost avoidance)
    - Water mains sizes, hydrant reduction and spacing
    - Need for additional fire stations, apparatus, and staffing
  - Maintenance of neighborhoods and displacement of residents to other neighborhoods or communities
  - More competitive tax rates for communities

Policy Considerations for Elected Officials

- Price versus cost
  - o Elected officials, especially local officials, must have a cost methodology to demonstrate the economic impact of their policy options
  - o Elected officials understand the price of policy decisions; however, they do not understand the costs of their decisions
  - o Cost models must be developed and targeted at local or state officials using the most reliable information concerning injuries/deaths, property loss, construction costs, etc.

Summary

- There is a real economic impact to local communities that do not incorporate residential fire sprinklers in their building codes
  - o Firefighter injuries/deaths have a local economic impact on municipal budgets, especially personnel costs
  - o Injuries to firefighters are cost drivers that escalate each year factoring in health insurance and other benefits typically found in collective bargaining agreements
  - o The cost of firefighter injuries in non-sprinklered properties may be greatly under estimated
  - o The impact of firefighter injuries and deaths in buildings without sprinklers has not "taken hold"

Recommendations

- More study of firefighter injuries and their costs need to be evaluated further and expanded to understand the full economic impact to communities

- More fire service awareness is required concerning the National Fallen Firefighters Life Safety Initiative "Code Enforcement and Sprinklers"

Recommendations

- The Fire Service should promote the integration of building departments into fire departments
    - o Fire Service understands loss and the contributing factors to loss, injuries, and death (civilian and fire service)
    - o Building inspection personnel generally have a disconnect regarding their impact on fire safety and property loss
    - o Building departments have significant influence on building and fire codes concerning new and existing construction, remodeling, and alterations in buildings
    - o Fire officials understand the aftermath of substandard construction and lack of fire safety codes
    - o The Fire Service can promote "resiliency" in the built environment from natural and man-made disasters
    - o Fire service influence on safety in the built environment is greatly under utilized

Questions

CHIEF FINANCIAL OFFICER
JEFF ATWATER
FLORIDA DEPARTMENT OF FINANCIAL SERVICES

National Fire Protection Association Workshop:
Economic Decision Making in Fire & Electrical Safety
August 17, 2016
Economic Impact Analysis in Florida's Rulemaking Processes

Casia Sinco, Chief of Fire Prevention, Florida State Fire Marshal's Office

Historical Background

Prior to 1987, Florida law allowed for the local adoption of a fire code. Local municipalities or counties adopted standard codes or their own codes.

- Standard Building Code Congress (SBCCI)

- NFPA 1

- EPCOT

- South Florida Fire Prevention Code

Chapter 87-287, s. 6: Adopted NFPA 101®, Life Safety Code as the statewide fire code.

Historical Background

Chapter 98-287, s. 58:

- Effective January 1, 2001

- The State Fire Marshal "shall adopt the National Fire Protection Association's Standard 1, Fire Prevention Code. The department shall adopt the Life Safety Code, Pamphlet 101, current editions, by reference."

- Creation of the Florida Fire Prevention Code. Also mandated a triennial update to this code.

Current State

Currently, the Department of Financial Services, Division of State Fire Marshal, adopts the National Fire Protection Association's(NFPA)

- NFPA 1, Fire Code (2012 edition)
- NFPA 101, Life Safety Code (2012 edition)
- Florida-specific amendments are also permitted.
    - These must "accommodate the specific needs of the state."

Rulemaking in Florida

Rulemaking in Florida is governed by Chapter 120, F.S., *Administrative Procedure Act*

- State agencies may only adopt rules:
    - If they have been granted rulemaking authority and specific law implementation
    - Rules may only implement or interpret the specific powers and duties granted by the enabling statute

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Rulemaking in Florida
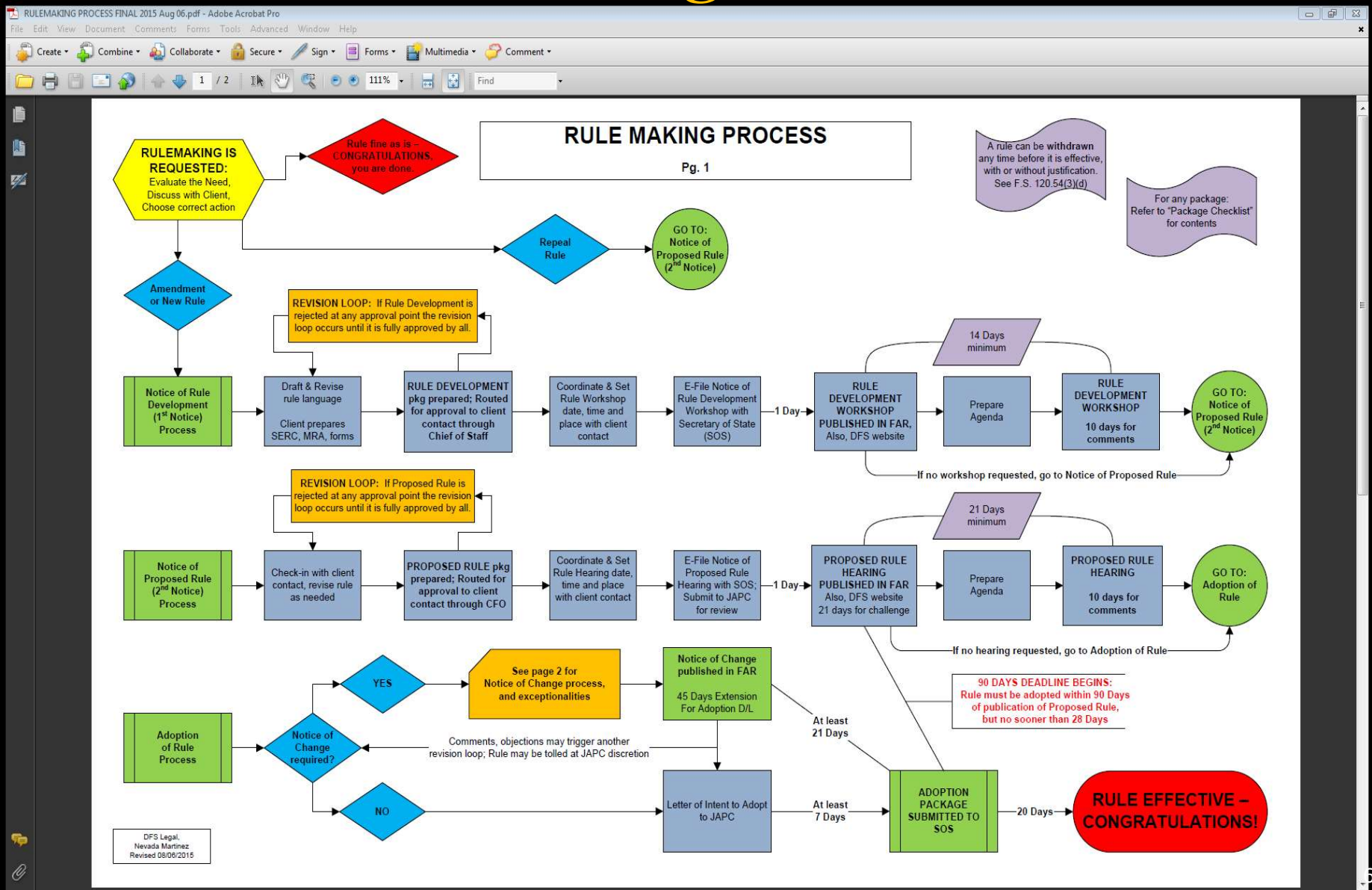
Statement of Estimated Regulatory Costs (SERC)

▶ A Statement of Estimated Regulatory Costs (SERC) must be filed if:

- A proposed rule will have an adverse impact on small business or if the rule is likely to increase regulatory costs in excess of $200,000 within 1 year after the implementation of the rule

- A substantially affected person submitted a good faith written proposal for a lower cost regulatory alternative

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Statement of Estimated Regulatory Costs (SERC)

▶ SERCs must include:

  ◦ An economic analysis showing whether the rule:

    • Will have an adverse impact on economic growth, private sector job creation or employment, or private sector investment

    • Will have an adverse impact on business competitiveness (including competing with persons doing business in other states)

    • Is likely to increase regulatory costs

  ◦ The standard for these is "in excess of $1 million in the aggregate within 5 years of implementation of the rule."

Statement of Estimated Regulatory Costs (SERC)

▶ SERCs must also include:
- A good faith estimate of the number of individuals likely to be required to comply with the rule
- A good faith estimate of the cost to the agency and local government entities required to comply with the requirements of the rule
- A good faith estimate of the transactional costs likely to be incurred by individuals required to comply with the rule
  - Transactional costs are defined as "direct costs that are readily ascertainable based upon standard business practices, and include filing fees, the cost of obtaining a license, the cost of equipment required, monitoring and reporting, and any other costs necessary to comply.

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Statement of Estimated Regulatory Costs (SERC)

▸ SERCs must also include:
  ◦ An analysis on the impact on small businesses and small counties and cities
  ◦ Any additional information that the agency determines may be useful

Legislative Ratification

▸ If the adverse impact or regulatory costs of the rule exceed the $1 million in the aggregate within 5 years threshold, the rule must be submitted to the President of the Senate and the Speaker of the House for legislative ratification

▸ The rule may not take effect until it is ratified by the Legislature

▸ Currently, the statute excludes the triennial update to the Florida Fire Prevention Code from the requirement of legislative ratification

Mandatory Regulatory Analysis

▸ Executive Order 11-01 signed January 4, 2011 by Governor Scott, mandates that all state agencies reporting to the Governor submit proposed rule amendments to the Office of Fiscal Accountability and Regulatory Reform.

▸ That Office evaluates the proposed rules to determine their impact on job creation/retention and costs for businesses.

Mandatory Regulatory Analysis

▸ Questions Asked in the MRA:

○ Does the rule unnecessarily restrict entry into a profession or occupation?

○ Does the rule affect the availability of professional or occupational services to the public?

○ Does the rule negatively affect job creation or retention in Florida?

○ Does the rule place restrictions on individuals obtaining employment in this related field?

Mandatory Regulatory Analysis

▸ Does the rule impose additional known costs on any business directly impacted by this rule?

  ▸ Examples: increased licensing fees, requirement for installation of new technology, etc.

  ▸ Must list types of costs and the total collective annual cost increase throughout Florida.

▸ Will indirect costs to consumers occur from the rule?

Contact Information

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Nevada's Mandate Requiring a Cost-Benefit Analysis for Residential Fire Sprinklers

Nevada's Mandate Requiring a Cost-Benefit Analysis for Residential Fire Sprinklers

- Background

- Homebuilders Argument

- Approach to addressing the Cost Benefit

- Findings

Background

- 2015 Nevada Legislature modified Nevada Revised Statute to require a governing body to perform a cost benefit analysis that shows a direct benefit to the buyer of a dwelling that exceeds the cost of an automatic fire sprinkler system before the governing body can mandate the installation.

- There was a similar effort in the 2009 Legislative session, but failed to move out of committee.

- The 2015 Legislatures' composition allowed for one perspective to outweigh common sense.

- Nevada state law was changed despite code official and local jurisdiction opposition.

- Elections have consequences

Cost Benefit Analysis Team

- Robert Nolan – Deputy Fire Chief/Fire Marshal

- Robert Fash – Battalion Chief – Deputy Fire Marshal, MPA

- Dr. Christine Springer – Professor University of Nevada (UNLV) – Las Vegas, Director of Executive Crisis and Emergency Management (ECEM) program.

- Sandy Mangold – Instructor for ECEM at UNLV, Colonel US Airforce (Retired)

- Chad Hofius – Research Analyst UNLV, Graduate of ECEM and MBA, Police Officer Minn., MN (retired), Major US Army - Reserves.

- Project overseen by Dr. Christopher Stream, Director of the School of Public Policy and Leadership at UNLV

Homebuilders Argument

- Current trends in fire incidents do not warrant the installation of fire sprinklers.

- Home fires continue to decline despite the growth in housing stock.

- Fire injuries and deaths continue to decline despite population growth.

- Incidents can be further reduced with new safer housing stock, maintenance of existing smoke alarms, and fire safety education.

- Difficulty in meeting model energy code requirements – Air leakage

- Southern Nevada Home Builders hired a local respected economic and policy analyst company (Applied Analysis)to show a potential negative impact on homebuyers and homebuilding industry.

Applied Analysis Approach

- Use Benefit-Cost Analysis of Residential Fire Sprinkler Systems (NIST) as a platform for their report.

- Plug in local numbers to illustrate potential negative return on investment of fie sprinklers.

- Interject arguments removed from the CBA such as the probability of dying in Clark County or retrofitting systems at a cost of a billion dollars.

Applied Analysis Findings

- Fatality Occurrence

- Injury Occurrence

- Cost of Installation

**Summary of Benefit-Cost Analysis per Housing Unit:
National Study vs. Unincorporated Clark County**

	National Study (2005 dollars)	National Study (2014 dollars)	Unincorporated Clark County (2014 dollars)
Benefits[9]			
Fatalities Averted	$3,725.57	$4,516.01	$1,019.61
Injuries Averted	224.74	272.74	145.18
Direct Uninsured Property Losses Averted	79.64	96.54	36.95
Indirect Costs Averted	15.93	19.31	7.39
Insurance Credit	948.41	1,149.63	1,341.15
Benefits Subtotal	4,994.29	6,054.23	2,550.29
Cost[10]	$829 - $2,075	$1,005 - $2,515	$4,780.00
Net Present Value: Net Benefit (Net Cost)	**$2,919 - $4,166**	**$3,539 - $5,049**	**($2,229.71)**

UNLV CBA Team Approach

- The CBA Team decided to use the same approach the proponents of Senate Bill 477 used in their argument. Based on the data at hand, it was apparent that variables used by Applied Analysis were subject to distortion to create a worse case outcome of the potential cost of a residential fire sprinkler system.

- Using the approach and algorithms as Applied Analysis lessens the chance of the homebuilding representatives that a new methodology was devise to support the findings that residential fire sprinklers have a positive CBA.

- The CBA did evaluate other variables that showed additional benefits (incentives) that developers and homebuilders could utilize in their planned communities.

Incentives

- Exterior Wall Ratings. <u>+</u> $4,480

- Fire Hydrant Distribution. + $110

- Fire Flow Reduction. <u>+</u>$50

- Reduced Cul-De-Sac Widths. 52' Rad to 50' Rad, 640 sq ft = <u>+</u> $5,433 per cul-de-sac

- Increased Dead-End Street Length. Additional building lot ($5-$6 per square foot, <u>+</u> $48,769)

- Secondary Access Points. Additional building lot ($5-$6 per square foot, $48,769)

- Developers gain potential green space required by Planning Departments without sacrificing building lots.

Findings

5,000 SF Single Family Home	$570,000									
Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Fire Sprinkler Cost	$ (4,750)									
Home Appreciation		$15,960	$16,407	$16,866	$17,339	$17,824	$18,323	$18,836	$19,364	$19,906
Insurance Premium Credit		$89	$89	$89	$89	$89	$89	$89	$89	$89
Total Benefits Per Year/ FCF	$ (4,750)	$ 16,049	$ 16,496	$ 16,955	$ 17,428	$ 17,913	$ 18,412	$ 18,925	$ 19,453	$ 19,995
Cumulative Benefits	$ 156,875.15									
Discount Factors										
Discount Rate	4.6%									
Base Year	2015									
Year Index	0	1	2	3	4	5	6	7	8	9
Discount Factor	1.0000	0.9560	0.9140	0.8738	0.8354	0.7986	0.7635	0.7299	0.6978	0.6671
Discounted FCF	$ (4,750)	$ 15,343	$ 15,077	$ 14,815	$ 14,558	$ 14,306	$ 14,058	$ 13,814	$ 13,574	$ 13,339
Cumulative FCF	$ (4,750)	$ 10,593	$ 25,670	$ 40,485	$ 55,044	$ 69,349	$ 83,407	$ 97,221	$ 110,795	$ 124,135
NPV	$ 124,135									
IRR	341%									

Conclusion

▪ The CBA Team also concluded that cost is the wrong metric. The impact that fire has on a community as a whole and to the occupants of a dwelling that has experienced a fire quickly outweighs the cost of a residential fire sprinkler system. As a public policy issue, community leaders need to realize the sunk costs of reacting to fires and lingering financial burden imposed by those impacted by a fire event.

Local Impact

New Home Permits	2016*	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001
Boulder City	1	22	15	10	9	3	11	7	9	19	13	26	45	52	46	69
Clark County	930	3593	3410	3567	2966	1604	2137	1931	2470	5859	9765	13535	14367	11132	10644	10329
Henderson	496	1689	1222	1274	1117	799	707	505	1097	2387	4249	4923	4595	4267	3980	4109
Las Vegas	378	1662	1438	1517	1233	808	926	744	1085	2356	2998	4268	6200	6861	4451	4281
Mesquite	45	202	196	202	169	134	201	106	379	487	303	599	429	387	289	404
North Las Vegas	199	630	471	497	618	510	648	498	834	2365	4262	7007	6105	4599	2735	2665
Totals	2049	7798	6752	7067	6112	3858	4630	3791	5874	13473	21590	30358	31741	27298	22145	21857

*2016 (Jan-Mar)

http://socds.huduser.gov/permits/

Clearing the Fiscal Impact Hurdle

Discussion Background

- Member, advisory committee to the Indiana Fire Prevention and Building Safety Commission regarding adoption of the 2008 NEC.

- A separate advisory committee reviewed adoption of a new Residential Code (which includes electrical provisions).

- Additional work when I was invited to participate with you!

Fiscal Impact Statements

IC 4-22-2-19.5
Standards for rules
Sec. 19.5. (a) To the extent possible, a rule adopted under this article or under IC 13-14-9.5 shall comply with the following:
    (1) Minimize the expenses to:
        (A) regulated entities that are required to comply with the rule;
        (B) persons who pay taxes or pay fees for government services affected by the rule; and
        (C) consumers of products and services of regulated entities affected by the rule.
    (2) Achieve the regulatory goal in the least restrictive manner.
    (3) Avoid duplicating standards found in state or federal laws.
    (4) Be written for ease of comprehension.
    (5) Have practicable enforcement.
  (b) Subsection (a) does not apply to a rule that must be adopted in a certain form to comply with federal law.
As added by P.L.17-1996, SEC.2.

… an agency shall submit the proposed rule to the office of management and budget for a review under subsection (d), if the agency proposing the rule determines that the rule will have a total estimated economic impact greater than five hundred thousand dollars ($500,000) on all regulated persons.

History of AFCI's in Indiana

☞ Feb 12, 2000   Indiana adopts the 1999 National Electric Code (NEC). The 1999 NEC has a provision for branch circuit AFCI protection that "shall become effective January 1, 2002."

☞ June 22, 2001   Indiana adopts a new residential code. The residential code has AFCI requirements that match those of the electric code.

☞ Sept 13, 2002   2002 Indiana Electric Code is adopted; article 210.12(B) is amended to cover only receptacle outlets in dwelling unit bedrooms to have AFCI's.

☞ Nov 21, 2005   Indiana adopts the 2005 NEC and eliminates requirements for AFCI protection.

2009 Indiana Electrical Code Timeline

- Jan 2008 — First public meeting to consider adoption of 2008 NEC
- Jan – Oct 2008 — Scheduled committee meetings
- Sept 2008 — First draft of the proposed rule
- Oct 2008 — Final committee meeting & email to committee indicating fiscal impact statement is under development – AFCI provisions intact
- Feb 2009 — Staff directed to remove AFCI provisions from final draft rule
- May 2009 — Public Hearing on proposed rule
- Aug 2009 — Indiana Electrical Code effective date

Class 2 structures (single family homes) by year in Indiana

permits
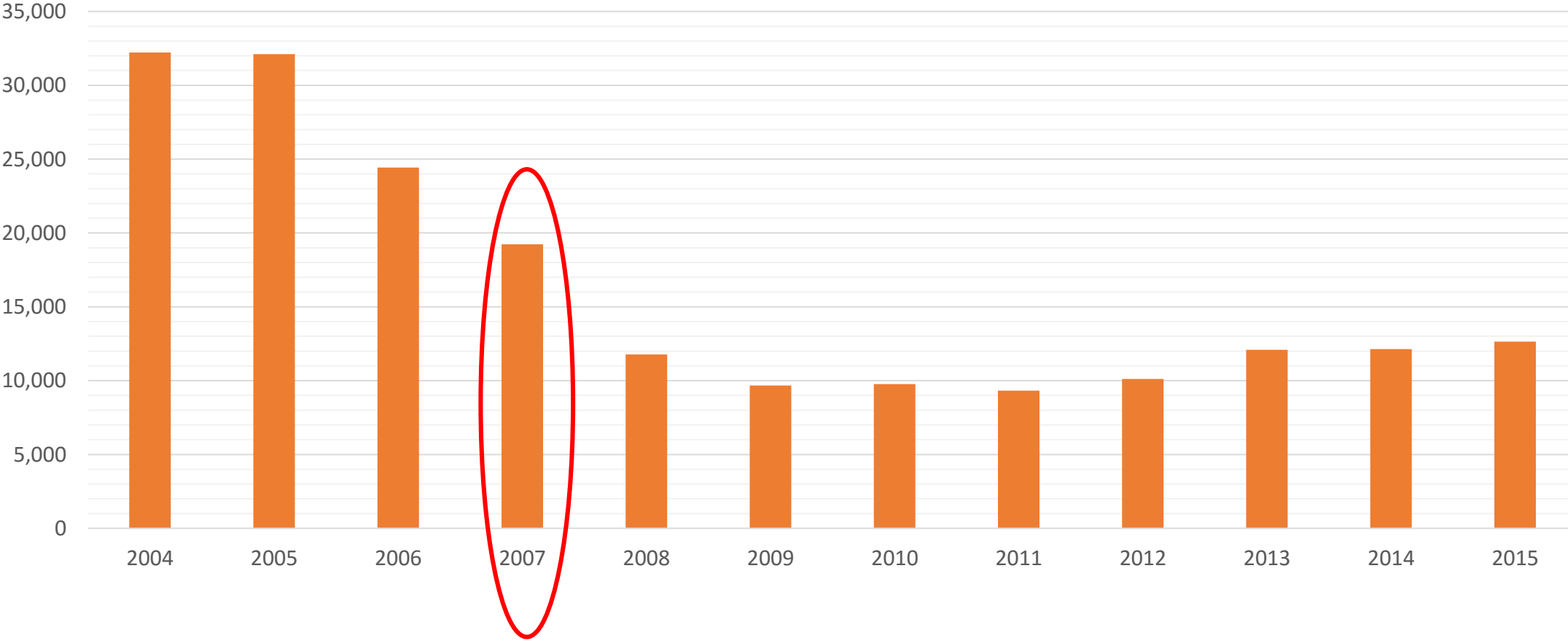
What is the fiscal impact of the 2008 NEC in Indiana?

- Indiana Builders Association was concerned with added costs relating to AFCI's and tamper resistant receptacles.

- State staff based cost estimates on an analysis of the cost impact of the 2008 NEC prepared members of the Ohio Chapter of the International Association of Electrical Inspectors

20,000 homes x ~$250 per home = $5,000,000

Indiana Housing Market - 2007

Housing Market

$350,000
$300,000
$250,000
$200,000
$150,000
$100,000
$50,000
$0

0   5,000   10,000   15,000   20,000   25,000

—— Supply   —— Demand

Housing Market

$100,400
$100,300
$100,200
$100,100
$100,000
$99,900
$99,800

19,960   19,970   19,980   19,990   20,000   20,010   20,020

—— Supply   —— Demand   —— Supply w/ NEC
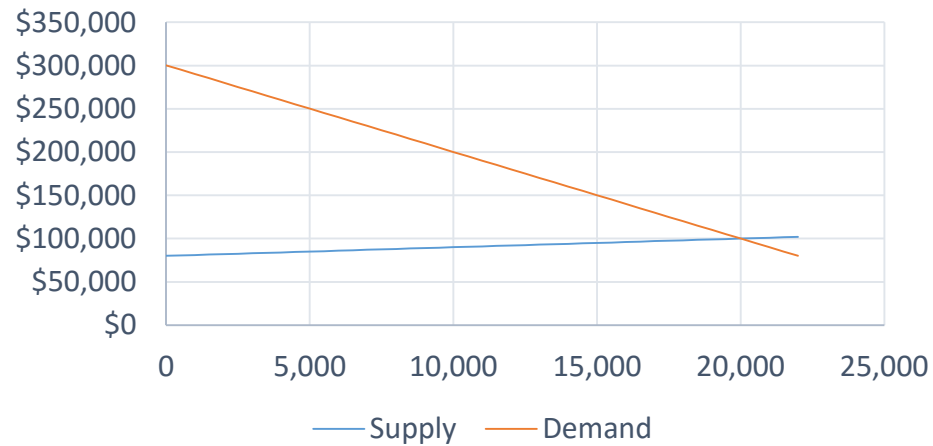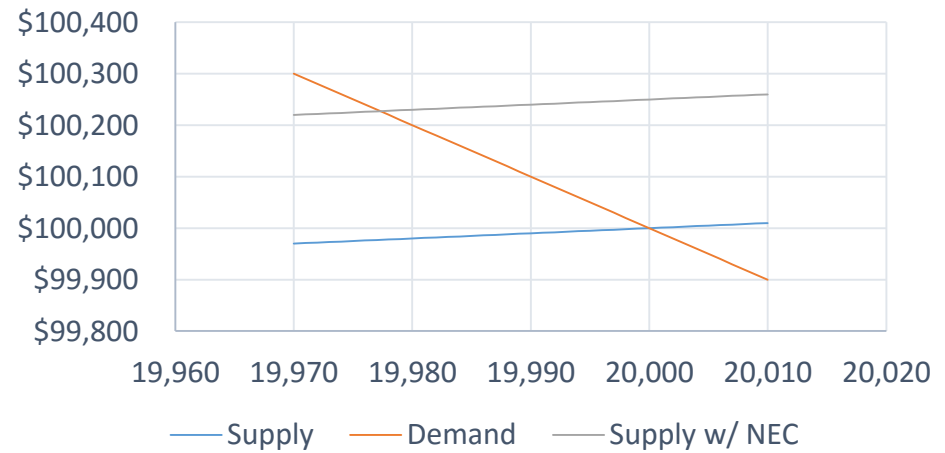
Elasticity

- How much does the change in price of a particular good influence the quantity demanded?

- The price elasticity of demand is a measure of the responsiveness of quantity demanded by consumers to a change in price.

$$\text{Price elasticity of demand} = \frac{\%\Delta Q_d}{\%\Delta P} = \frac{\Delta Q_d / Q_d}{\Delta P / P}$$

Elasticity

Factors that influence elasticity

1. Substitutes – the more substitutes there are for a good, the more elastic the demand

2. Proportion of budget – the larger the proportion of the budget devoted to a particular good, the more likely the demand is elastic

3. Time – the longer the period of time consumers have to react to a price change, the more elastic the demand for the good.

Elasticity*		Price Change	Change in Total Expenditure
Elastic	(>1)	Increase	Decrease
		Decrease	Increase
Inelastic	(<1)	Increase	Increase
		Decrease	Decrease
Unit	(=1)	Increase	No change
		Decrease	No change

*for a demand curve, elasticity is negative

Elasticity

- "What is the Price Elasticity of Housing Demand", Eric A. Hanushek and John M. Quigley, *The Review of Economics and Statistics*, Volume 62, Issue 3 (August, 1980), pp 449-454.

- "Based upon the simple adjustment model … the estimated price elasticity of demand is -0.64 in Pittsburgh and -0.45 in Phoenix."

- I decided to use an elasticity of demand = -0.50

Indiana Housing Market - 2007

Housing Market
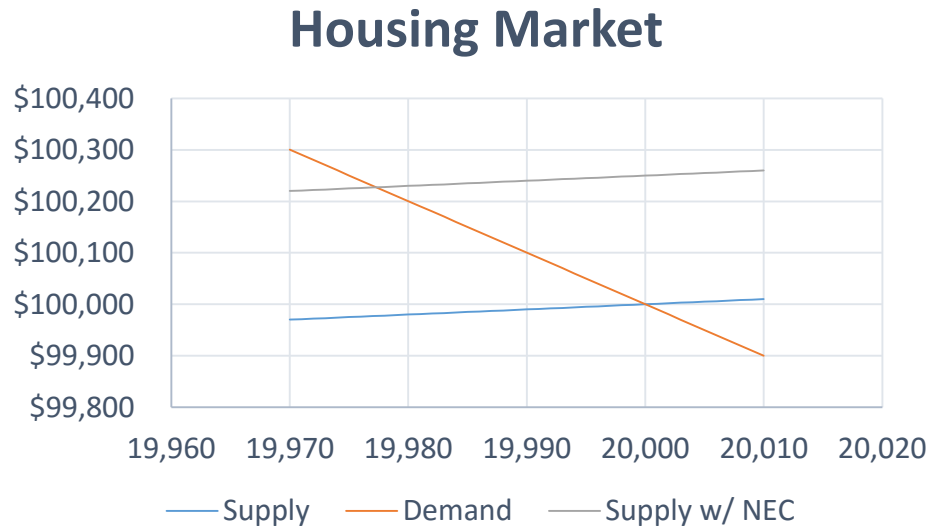
Price elasticity of demand $= \dfrac{\%\Delta Q_d}{\%\Delta P}$

Change in price of \$250 leads to a change in quantity ~25 units

New equilibrium (\$100,250 ; 19,975)

Observations

- Old equilibrium 20,000 homes @$100,000 each = $2,000,000,000

- New equilibrium 19,975 homes @$100,250 each = $2,002,493,750

- Fiscal impact is $2,493,750

		# homes	$/home
home cost	$2,493,750	19,975	$124.84
$ not spent	$2,506,250	25	$100,250
	$5,000,000	20,000	$250.00

- I wasn't smart enough to see this until much later!

Housing Market

Supply — Demand — Supply w/ NEC
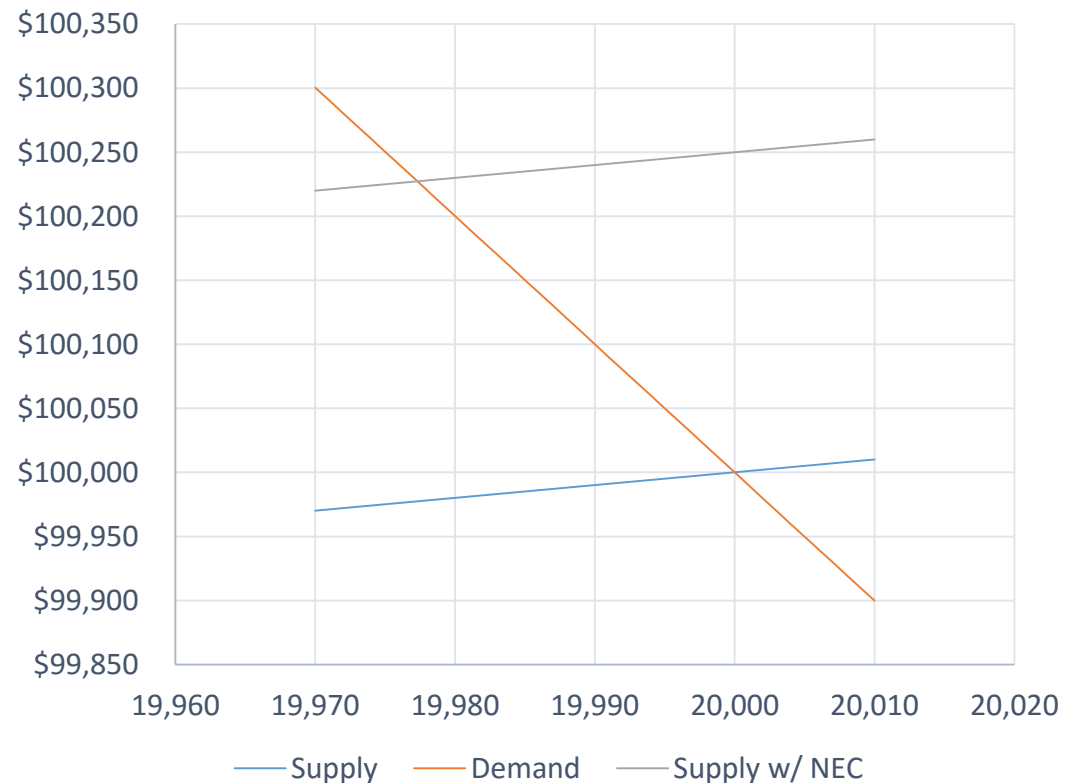
What about different elasticities or home prices?

- If average home prices are larger than assumed, change in quantity is smaller

- Larger (in magnitude) elasticities lead to larger quantity changes

Elasticity	Change in Quantity ($100k home)	Change in Quantity ($150k home)	Change in Quantity ($200k home)
-0.2	(10)	(7)	(5)
-0.3	(15)	(10)	(8)
-0.4	(20)	(13)	(10)
-0.5	(25)	(17)	(13)
-0.6	(30)	(20)	(15)

What is the cost of an arcing fire?

Residential Structure Fire Causes - electrical distribution

from IDHS Current Fire Service Statistics (available at IDHS web site)

year	# of fires	Civilian Deaths	Civilian Injuries	Firefighter Deaths	Firefighter Injuries	Property Loss	Contents Loss	Total Loss	Arcing Fire Loss
2007	59		2		1	$1,507,400	$354,715	$1,862,115	$847,262
2006	50					$617,501	$211,850	$829,351	$377,355
2005	43		1			$1,648,101	$158,751	$1,806,852	$822,118
2004	73	1	9			$1,266,150	$496,550	$1,762,700	$802,029
Total	225	1	12	0	1	$5,039,152	$1,221,866	$6,261,018	$2,848,763

Leading Factors Contributing to Ignition, Electrical Fires, 2003-2005[*]

Factor Contributing to Ignition	**% of fires**
Unspecified short-circuit arc	26.0%
Short-circuit arc from defective, worn insulation	15.1%
Arc from faulty contact, broken conductor	4.4%
	45.5%

*from FEMA Topical Fire Report Series, Volume 8, Issue 2, March 2008

I still haven't offset the "cost" of code compliance!

My sales pitch …

- At our new equilibrium, buyers and sellers are satisfied
- The "cost" to builders from new code adoption was 25 homes at a "profit" of $20,000; total cost is $500,000
- The average arcing fire loss for the period 2004-2007 was ~$712,000
- Now I have a savings!

- New homeowners do pay an extra cost for their homes - $250.
- Assume the home is financed for 30 years at 6% interest, the additional payment is $1.50

How did this turn out?

When the proposed rule was submitted to the State Budget Agency for review and approval, these provisions were omitted because of the following fiscal impact calculated by staff:

a) $2,963,909
b) $28,728
c) $2,048,101

TOTAL FISCAL IMPACT in the first 12 months of the rule's effective date = $5,040,738.

These fiscal impacts were calculated on the basis of the average number of affected locations in a Class 2 structure times the number of Class 2 structures for which permits were pulled in 2007.

a) The installation of arc fault circuit interrupters in branch circuits in dwelling units that supply outlets in kitchens, bathrooms, unfinished basements, garages, and outdoors (for the first time in Indiana).
b) All 15- and 20- ampere, 125- and 250-volt nonlocking receptacles installed in wet locations to be of the listed weather-resistant type (for the first time in Indiana).
c) All 125-volt, 15- and 20-ampere receptacles installed in dwelling units in specified areas to be tamper resistant (for the first time in Indiana).

What more could I have done?

Economic Considerations – AFCI Replacements. Memorandum. United States Consumer Products Safety Commission, March 2003

unit cost	category	number	total	
$5,000,000	deaths	326	$1,630,000,000	
$56,000	injuries	1,481	$82,936,000	
	property loss $646,000,000		$646,000,000	
			$2,358,936,000	
85% of fires involve housing > 20 years old		< 20 years	> 20 years	
	# housing units	98,700,000		
		29%	71%	
	cost of fires	$353,840,400	$2,005,095,600	
	# homes	28,623,000	70,077,000	
		$12.36	$28.61	

discount rate	3.00%	3.00%	3.00%	3.00%	3.00%	3.00%
NPV	$319.05	$419.61	$422.20	$522.76	$560.82	$661.38
	install when built		install after 10 yrs		install after 20 yrs	
AFCI life	30	40	30	40	30	40
1	$12.36	$12.36	$12.36	$12.36	$28.61	$28.61
2	$12.36	$12.36	$12.36	$12.36	$28.61	$28.61
3	$12.36	$12.36	$12.36	$12.36	$28.61	$28.61
4	$12.36	$12.36	$12.36	$12.36	$28.61	$28.61
5	$12.36	$12.36	$12.36	$12.36	$28.61	$28.61
6	$12.36	$12.36	$12.36	$12.36	$28.61	$28.61
7	$12.36	$12.36	$12.36	$12.36	$28.61	$28.61
8	$12.36	$12.36	$12.36	$12.36	$28.61	$28.61
9	$12.36	$12.36	$12.36	$12.36	$28.61	$28.61
10	$12.36	$12.36	$12.36	$12.36	$28.61	$28.61
11	$12.36	$12.36	$28.61	$28.61	$28.61	$28.61
12	$12.36	$12.36	$28.61	$28.61	$28.61	$28.61
13	$12.36	$12.36	$28.61	$28.61	$28.61	$28.61
14	$12.36	$12.36	$28.61	$28.61	$28.61	$28.61
15	$12.36	$12.36	$28.61	$28.61	$28.61	$28.61
16	$12.36	$12.36	$28.61	$28.61	$28.61	$28.61
17	$12.36	$12.36	$28.61	$28.61	$28.61	$28.61
18	$12.36	$12.36	$28.61	$28.61	$28.61	$28.61
19	$12.36	$12.36	$28.61	$28.61	$28.61	$28.61
20	$12.36	$12.36	$28.61	$28.61	$28.61	$28.61
21	$28.61	$28.61	$28.61	$28.61	$28.61	$28.61

Compare CPSC data with Indiana data

Consumer Product Safety Commission

	40 year life		
	at build	10 years	20 years
#ckts	10		
incremental breaker cost	$17.50		
total cost	$175.00		
breaker cost	($175.00)	($175.00)	($175.00)
potential savings	$419.61	$522.76	$661.38
effectiveness	42%	33%	26%
actual savings	$175.00	$175.00	$175.00
AFCI cost	$0.00	$0.00	$0.00

Indiana Fire History

	40 year life		
	at build	10 years	20 years
#ckts	4		
incremental breaker cost	$35.00		
total cost	$140.00		
breaker cost	($140.00)	($140.00)	($140.00)
potential savings	$36.63	$46.15	$58.94
effectiveness	100%	100%	100%
actual savings	$36.63	$46.15	$58.94
AFCI cost	($103.37)	($93.85)	($81.06)

What is wrong with my analysis?

- Treated the housing market as a single entity

- Straight line supply and demand aren't realistic

- Looking at lost profit isn't enough … an attempt to appeal to homebuilders

- I still have a fiscal impact issue of $2,493,750

What do we need?

1. Information from insurance companies about discounts.

2. Better information about cost and prevalence of arcing fires.

3. Info about arcing fires in new construction vs old construction.

4. Generally, if we have to face a battle like this again, better information about cost of new code provisions along with ways to defend them.

Ongoing follow-up work

- Outreach to key fire prevention and building safety commission members in June / July 2015

- Tim McClintock presented on cost savings provisions in 2011 & 2014 NEC to the Indiana Fire Prevention and Building Safety Commission in August 2015

- Indiana Senate Bill 70, 2016 would have required state to adopt new edition of NEC – outreach to Senator Kruse ongoing

- ISPE attend the Indiana Chamber Technology & Innovation Council

Questions?

Development of an Environmental and Economic Assessment Tool (Enveco Tool) for Fire Events

Presented by:

Francine Amon

Senior Scientist

SP Technical Research Institute of Sweden

Work also conducted by **Jonatan Gehandler** & **Selim Stahl**

Outline

- Goal of project

- Introduction/background

- Quantitative Risk Assessment (QRA)

- **Cost Benefit Analysis (CBA)**

- Sensitivity Analysis

- Case studies

- Conclusions

- Future work

Goal of project

The goal of this project was to determine whether it is feasible to develop a tool that provides a consistent methodology for assessing the performance of the fire service with respect to two impacts of fire on communities: Environmental and Economic impacts.

- Started with warehouse fires for feasibility study, many simplifying assumptions.

- Users do not need to have specialized knowledge of economic theories

- Compares actual case of a warehouse fire with a hypothetical case of no fire service response

- Savings = no fire service response – fire service response

Introduction/background

- Many aspects of fire impact are evaluated periodically at a national level by NFPA and others.

- Local reporting is usually less comprehensive
  - number of fires,
  - deaths and injuries,
  - property damage

- Need for a consistent methodology for estimating savings to the economic health of a community

- Challenge: estimating what would have happened with no fire service response… used QRA

Approach

Common input
- Structure area
- Burned & damaged areas for structure & contents
- Fill factor

Input
- People unemployed
- Business interruption
- Time to reopening
- Fire fighter fatalities & injuries

Input
- Distance to adjacent structures
- Wind direction
- Hole in roof size & location
- Hazard occupancy class
- Size of fully developed fire compartment

Input
- Structure height
- Sprinkler water flowrate and activation time
- Type of contents
- Number of trucks responding & distance travelled
- Extinguishing water volume
- Percent run-off from sprinklers and extinguishing water

Cost Benefit Analysis (CBA)

Quantitative Risk Assessment (QRA)

Life Cycle Assessment (LCA)

Output
Savings associated with:
- Firefighter fatalities & injuries
- Property & job loss
- Direct & indirect business interruption
- Rent loss

Output
Saved property due to prevented fire spread

Output
Savings associated with:
- Global warming, acidification, eutrophication

Includes impacts from:
- Fire emission, structure & contents replaced, fire response

Approach

- Spreadsheet platform
- Worksheets for:
  - User input
  - Output
  - Reference worksheet (for information only)
- Default values are given if local input is unknown
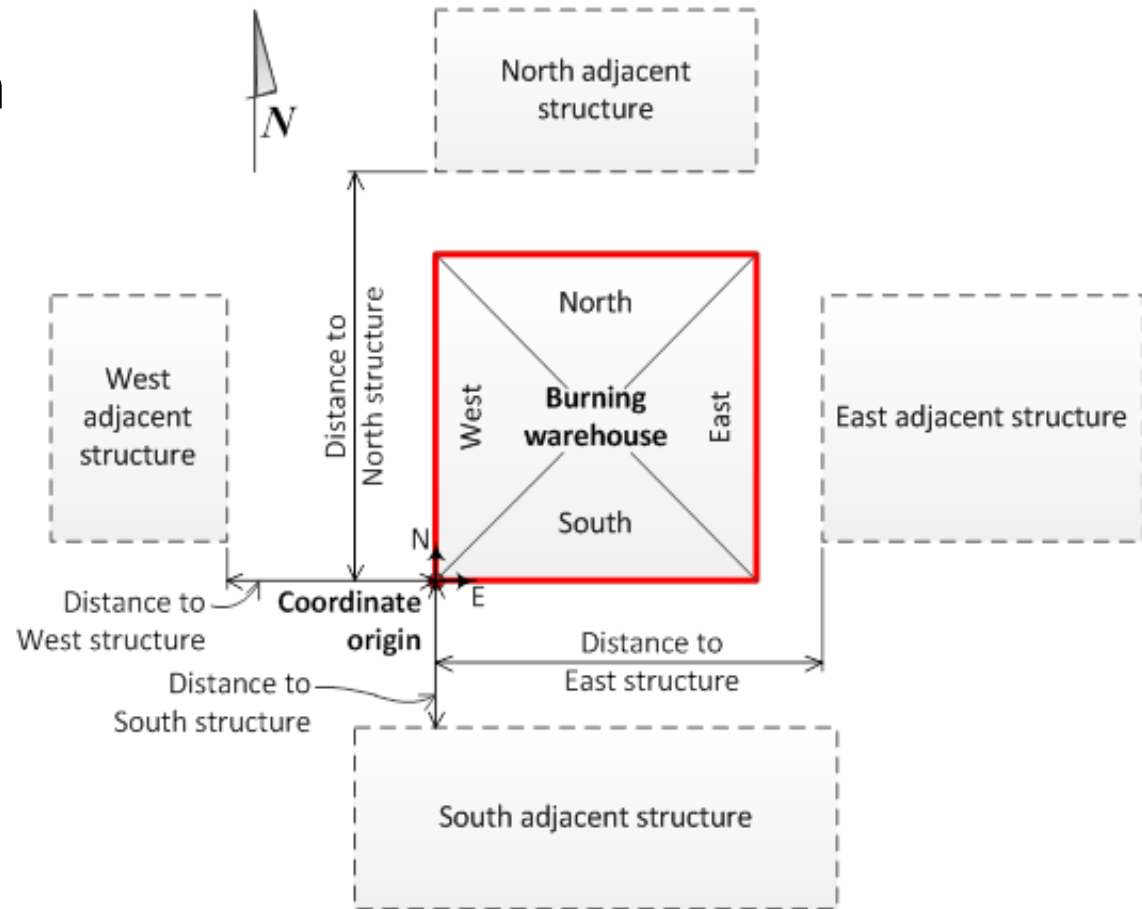
Quantitative Risk Assessment (QRA)

- Estimates fire spread to adjacent structures using deterministic and probablistic methods

- Assumptions:

  —The adjacent structures are the same basic type as the burning warehouse

  —A defensive firefighting response was necessary (insufficient information available for offensive attacks)

  —At least part of the roof collapsed during the fire

  —No civilians were killed or injured

Cost Benefit Analysis (CBA)

- Uses local input when possible, default values if necessary
  - Most default information is based on NFPA statistics[1-3] and report from BRE Global[4]

- All cash flows are represented in net present value (NPV)

- Includes both direct and indirect consequences of fire

[1] Hall, J., "The Total Cost of Fire in the United States", NFPA, 2014

[2] Campbell, R., "Structure Fires in U.S. Warehouses", NFPA, 2013

[3] Dinaburg, J. and D. Gottuk, Fire Detection in Warehouse Facilities, in Fire Detection in Warehouse Facilities. 2012

[4] Fraser-Mitchell, J., Abbe, O., and Williams, C., "An Environmental Impact and Cost Benefit Analysis for Fire Sprinklers in Warehouse Buildings", BRE Global, 2013.

Cost Benefit Analysis (CBA)

- CBA input:
  - People unemployed
  - Business interruption
  - Time to reopening
  - Fire fighter fatalities & injuries

- CBA output is savings related to:
  - Firefighter fatalities & injuries
  - Property & jobs
  - Direct & indirect business continuity
  - Rents

Sensitivity Analysis

Input	Unit	Input value range		Results
		low	high	
Hazard occupancy classification	-	light	Extra-Group 2	Property damage, rent reduction = 138. Jobs & direct business interruption = 332. **Total economic savings = 64.7.**
Compartment size % of warehouse size	%	20	80	Property damage, rent reduction = 2.64. Jobs & direct business interruption = 5.75. **Total economic savings = 5.40.**
Warehouse structure area	%	50	200	Property damage, rent reduction, jobs, direct business interruption = 1.01. **Total economic savings = 1.06.**
Damaged area - Structure	%	25	100	Property damage, business interruption, and rent reduction = 1.0. **Total economic savings = 1.00.**
Number of firefighter fatalities/injuries	each	0	5	Firefighter fatalities = 4.5×10^7. Firefighter injuries = 1.7×10^5. **Total economic savings = 5.00.**

Model Input – Fire Spread

Risk of Fire Spread

This part estimates the extent of damage to adjacent structures in the case of **no fire service intervention**.
It assumes a fully developed fire within the whole compartment.
When entering distances and directions, refer to the diagram on the right and the coordinate origin.

Value	Unit	Default	Parameter	Comments:
Distance from coordinate origin to threatened structure(s)				
430	ft	n/a	north	Enter distance to adjacent structure(s) based on diagram at right. If there are no threatened buildings in a particular direction, enter a large number, e.g. 10000 (m or ft).
313	ft	n/a	east	
75	ft	n/a	south	
105	ft	n/a	west	
Direction wind is coming from				
30	%	25	north	Enter wind conditions. Wind direction can be approximated using this website: http://www.esrl.noaa.gov/gmd/dv/iadv/graph.php?code=MLO&program=met&type=wr (see the wind rose chart example at right), or use local weather sources.
0	%	25	east	
0	%	25	south	
70	%	25	west	
Range of possible sizes of hole in roof				
49	ft	49	smaller diameter	Range of diameters of hole in roof during the time of highest risk of fire spread. Enter 0 in both cells if there was no hole.
9		98	larger diameter	
Approxim... roof		anywhere	hole location	Placement of hole in roof if known (north, east, south, west side according to the designated coordinate system), otherwise choose "anywhere".
Hazard occupancy class				
Extra - Group 1		Ordinary - Group 2	occupancy class	Hazard Occupancy class as defined in NFPA 13.
Fully developed fire compartment				
220	ft	0	x-dimension	If the fire was confined to a compartment during the time of highest risk of fire spread, enter dimensions of the compartment based on the diagram at upper right. Enter 0 in both cells if there was no compartmentation.
208	ft	0	y-dimension	

Opening
The opening is assumed to be round, enter the approximate diameter. Click on "unit" cell at right to select ft or m.

Model Input - Warehouse

Warehouse Description

Value	Unit	Default	Parameter	Comments:
Region				
	n/a	USA	>>	Not implemented yet.
Structure area				
400	ft	n/a	x-dimension	Enter dimensions of the warehouse footprint area based on the diagram at the right. It is assumed the warehouse is rectangular.
208	ft	n/a	y-dimension	
Storage rack height				
20	ft	20	rack height	A rack height of 6 m (20 ft) will be assumed as default.
Sprinklers				
0.3	gpm	0.3	sprinkler water	Enter discharge rate of sprinkler system. Default = 12 lpm/m^2 (0.3 gpm/ft^2). Enter 0 if there was no functional sprinkler system.
20	min	n/a	sprinkler activation time	Length of time sprinkler system was activated and working properly.
0	%	0	Sprinkler water run-off	Percent of sprinkler water that ran off into soil or surface water.
Other fire protection measures				
	>>	>>	>>	Not implemented yet.
Fire damage with fire service intervention (known damage)				
100	%	100	**burned** structure area	Enter the percent of warehouse structure area that burned (including adjacent damaged buildings). **See Note 1, CBA calcs worksheet.**
100	%	100	**damaged** structure area	Enter the percent of warehouse structure area to be rebuilt (including adjacent damaged buildings).
265	each	265	people unemployed	Enter the number of people unemployed by the incident, including suppliers and customers. **See Note 2, CBA calcs worksheet.**
376497	USD	376497	business interruption	Enter total business interruption loss due to fire. **See Note 3, CBA calcs worksheet.**

Model Input - Contents

Contents Description

Value	Unit	Default	Parameter	Comments:
50	%	50	fill factor	Percentage of the warehouse area that is NOT occupied by contents.
100	%	100	**burned** contents area	Percentage of the warehouse area in which the contents burned.
100	%	100	**damaged** contents area	Percentage of warehouse area in which contents require replacement.
				See Note 4, CBA calcs worksheet for guidance about contents.
10	%	10	plastic	Includes plastic products, packaging, film wrapping.
15	%	15	paper	Includes paper products, packaging, cardboard.
15	%	15	wood	Includes wood products and pallets.
10	%	10	textile	Can be any kind of textile except plastic-based.
15	%	15	soft furniture	Anything with foam cushions.
10	%	10	chemicals	Paint is the representative chemical, this can be expanded in future.
15	%	15	dry food	Human or animal dry food.
10	%	10	electronics	Consumer electronics such as TVs or computers, also any components.

Model Input – Fire Response

Fire Service Response

Value	Unit	Default	Parameter	Comments:
				See Note 5, CBA calcs worksheet for guidance about fire response.
600	USD	600	cost of response	Cost to fire department of responding to incident, per truck per hour.
6	#	6	trucks	How many trucks responded to the incident?
6	miles	6	distance travelled	Enter the average distance travelled one-way to the warehouse.
12	hr	12	time at incident	Enter average time of trucks at incident.
1620000	gal	1620000	water used	Total amount of water used.
10	%	10	water to environment	Amount of run-off water released to soil or surface water (was not collected by strom drain/sewage system).
0	person	0	firefighter fatalities	Fatalities directly resulting from response to warehouse fire.
0	person	0	firefighter injuries	Injuries directly resulting from response to warehouse fire.

Case Study

46 300 m^2 warehouse containing household appliance parts

- Fire started near the center of the building

- Holiday – operating with reduced staff

- Employee and sprinkler alarm system detected fire

- Sprinkler system was undergoing upgrades but was inadequate for fuel load

- Fire service had weather related difficulties responding to call

- Defensive strategy was used

Case Study – Economics

No Fire Service - Quant...			
Likelihood for fire spread...			
South			
0.00			

Fire Service Interven...

Savings due to Fire Service Response - QRA

On average: **0.08 Warehouses**

No Fire Service - Econ...	Fire Service Interventi...	Savings - Economic Assessment		
Value	**Value**	**Value**	**Unit**	**Description**
0	0	0	USD	Firefighter fatalities
0	0	0	USD	Firefighter injuries
8357571	7719253	638318	USD	Property damage
16258547	15016783	1241764	USD	Job disruption
1538274	1420787	117487	USD	Direct business interruption
153827	142079	11749	USD	Indirect business interruption
0	1152000	-1152000	USD	Fire service intervention
215679	199207	16473	USD	Rent reduction
26523899	**25650108**	**873791**	USD	**TOTAL ECONOMIC SAVINGS**

Savings = no fire service response – fire service response

Conclusions

- Within the scope of the feasibility study, it is possible to estimate the influence of the fire service on economic impacts to communities.

- There are many uncertainties, some are applied to both scenarios and are therefore partially cancelled out of the results.

- As higher quality input data becomes available, the functionality and accuracy of the tool will improve.

- This tool was originally intended for use by the fire service but it may have value for other interested parties as well.

Suggestions for Future Work

- The platform can change to increase accessibility to the fire service and other organizations.

- **Additional functionality-**
  - **structure types** (single family residences, commercial buildings, apartment buildings, mixed types, etc.), **locations** (wildland area, suburban neighborhood, central business district, etc.), and **materials** (with unusual HRRs)
  - allow comparisons of outcomes (predictions) when different levels of response are taken
  - input several fires at once, however, this would require special conditions for the QRA.
  - A more advanced CBA with the fire station lifetime and NPV calculations

Suggestions for Future Work

- **Additional functionality-**
  - include firefighter jobs and jobs created by the competitors of the business during the rebuilding phase
  - address intentionally set vs accidental fires. Capture the value of fire investigative efforts
  - include costs of health degradation due to smoke and particles based on established studies
  - include the impact/value of fire department salvage and overhaul operations
  - include offensive fires and successful interventions that will result in financial impacts within the primary fire occupancy
  - Distinguish between career and volunteer responses or assume something about the mix.

Thank you!

This project was funded by the Fire Protection Research Foundation and the National Fire Protection Association, together with contributions from SP.

Questions?

THE ECONOMIC IMPACT OF SUCCESSFUL COMMERCIAL FIRE INTERVENTIONS

August 17, 2016

ASU W. P. CAREY SCHOOL of BUSINESS — ARIZONA STATE UNIVERSITY | seidman research institute

City of Phoenix

THE PERFECT SAVE

STUDY ORIGINS: TRENDWOOD FIRE

STUDY ORIGINS

- Traditional KPIs include response time & # fires extinguished

- Wanted something new: to show the positive impact of successful "saves" on the economy

- Approached Seidman at ASU

- Agreed to initially estimate economic impact for one commercial fire

ECONOMIC IMPACT OF SUCCESSFUL COMMERCIAL FIRE INTERVENTIONS

CASE STUDY METHOD

- Focus on single commercial fire in post-incipient phase

- Data sourced from follow-up fire incident survey

- AZ-specific REMI input-output model

- Measure direct, indirect and induced effects

- Estimate changes in GSP, employment, and real disposable income

$20 MILLION SAVE (2012 $)
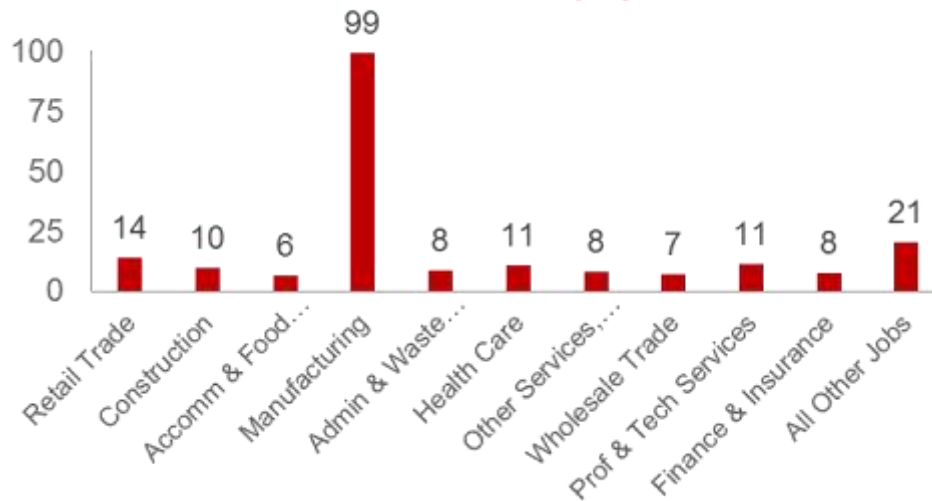
MEDIA COVERAGE

NEXT STEPS

- Surprised by size of impact

- Partnered with Underwater Laboratories to fund 1-year study

- Needed independent outside agency to implement research and validate findings

- Seidman agreed to continue

1-YEAR STUDY SAMPLE

- 45 commercial fires (June 2012 – May 2013)
  - 2 at vacant premises
  - 1 at a church staffed by volunteers
- **Total**: 42 interventions affecting 51 businesses
- Without successful Fire Dept. intervention
  - 49 businesses would have closed for 1+ years
  - 2 others would have closed for 3+ months

3,073 direct employees – average wage of $35k

ECONOMIC SAVINGS (2012 $)

$650M
GSP **7,446**
Jobs **$296M**
RDPI **$35M**
Taxes

$641M
GSP **7,326**
Jobs **$284M**
RDPI **$34M**
Taxes
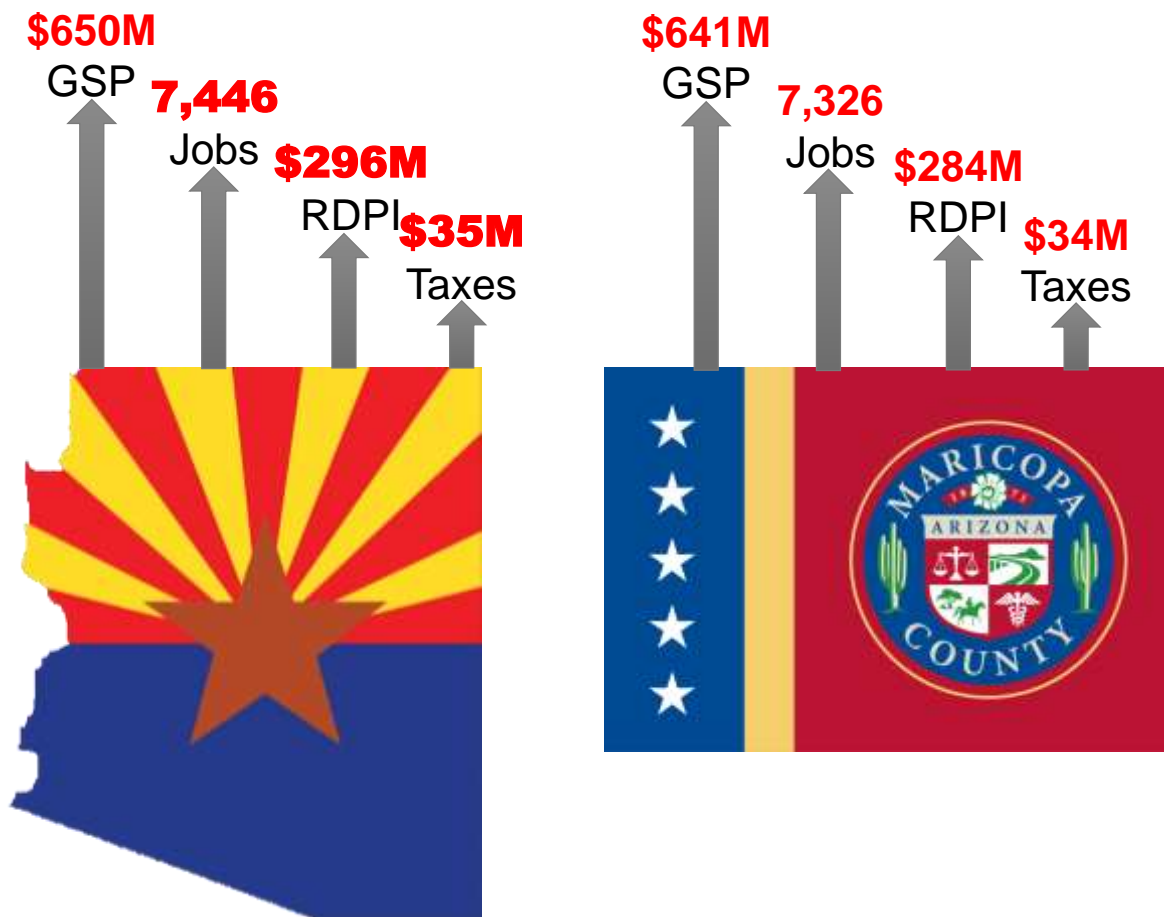
PRIVATE EMPLOYMENT IMPACTS (1-YEAR)
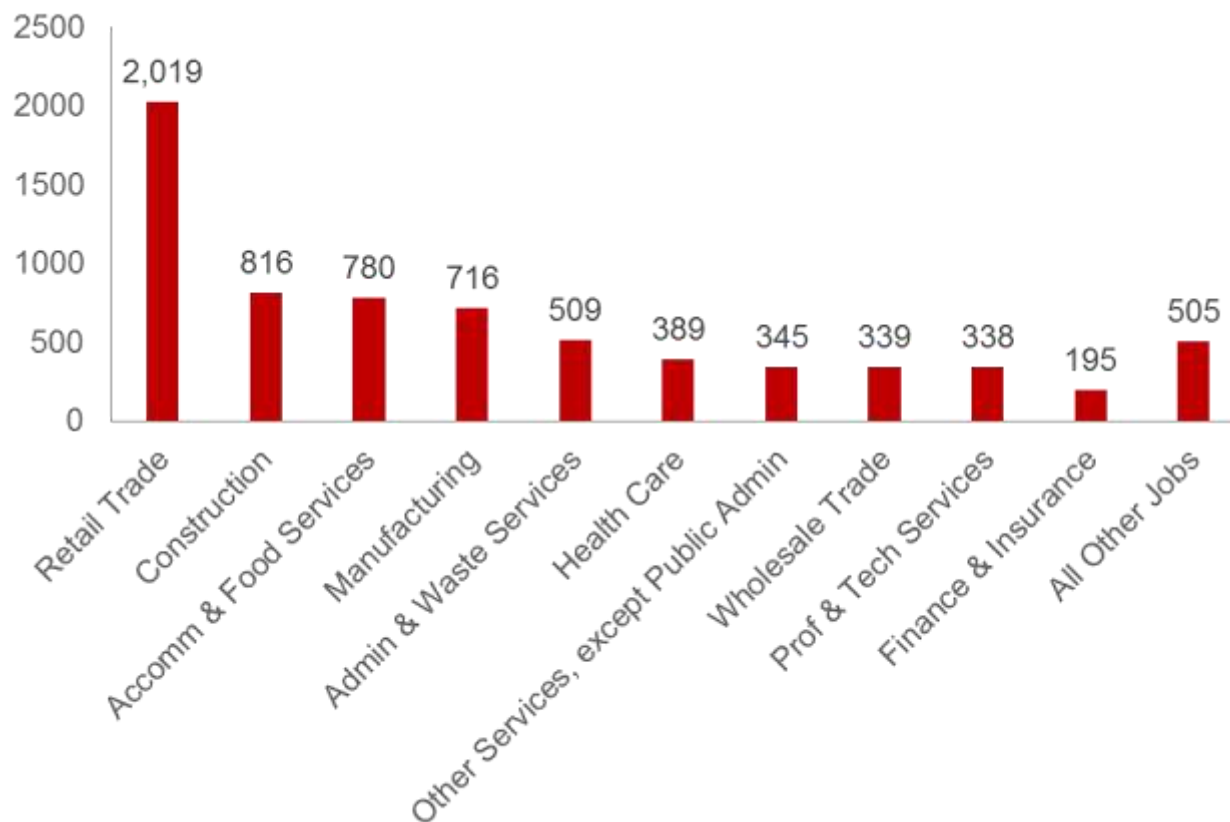
ABC15 ARIZONA

ASU FIREFIGHTER STUDY P
STUDY UNDERSCORES ECONOMIC IMPACT OF FIREFIGHTERS

abc 15

5:09 88°

SCALE OF IMPACTS PER COMMERCIAL INTERVENTION

	Gross State Product (2015$)	Ratio of Indirect & Induced Jobs to Direct Jobs	Real Disposable Personal Income (2015$)
Initial Single Fire Case Study	$21.1M	1.26	$9.5M
12-Month 42 Fire Study	$16M	1.30	$7.3M
2014 Single Fire Case Study	$33.8M	2.8	$16.5M

WHAT'S NOT MEASURED?

- Value of Emergency Medical Services

- Value (emotional & financial) of our response to all other fires (non-commercial)

- Value of our Technical and Special Operations responses

- Value of our Fire Prevention Efforts

- Value of our Community Education Efforts

NATIONAL ROLL-OUT POTENTIAL

- Economic impact models are geography-specific

- Identify more cost-effective economic impact model

- Compare scale of impacts in different geographies

- Insure the data generated is usable to the non-analytical mind…but completely defendable to the most analytical analysis

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Effect of Fire Prevention Programs on Accidental and Incendiary Wildfires on Tribal Lands in the United States

David T. Butry, National Institute of Standards and Technology

Collaborators

- Karen L. Abt, USDA Forest Service
- Jeffrey P. Prestemon, USDA Forest Service
- Sam Scranton, Bureau of Indian Affairs

Intro

- Humans cause > 55 % of wildfires on lands managed by Forest Service & Department of Interior

- Ignition prevention avoids the variable costs associated with suppression
  - Prevention activities include:
    - Education
    - Permitting
    - Law Enforcement

- Prevention return-on-investment is not well-known
  - Is it useful? Is it cost-effective?

Objectives

1. Evaluate whether wildfire prevention programs and law enforcement have a statistical effect at limiting human-caused wildfire ignitions
   - Six causes examined:
     - Escaped campfire
     - Escaped fire-use
     - Juvenile-set wildfire
     - Incendiary wildfire
     - Equipment-set wildfire
     - Smoking-caused wildfire
   - Prevention measured as months of program existence
   - Law enforcement measured as the number of full-time sworn officers
2. Estimate the number of avoided wildfires attributable to prevention
3. Measure the benefit-cost performance of prevention

Study Sites

Table 1. US Bureau of Indian Affairs (BIA) tribal units used in the analysis and percentage of wildfires and area burned on each unit

Fire data identifier	Fire data name	State	Fiscal year when funded prevention began	Percentage of fires in our data[A]	Percentage of area burned in our data[A]
AZSCA	San Carlos Agency	Arizona	2001	14.5	0.9
IDNPT	Northern Idaho Agency	Idaho	2005	1.3	1.4
KSHOA	Horton Agency	Kansas	2006	0.5	0.5
MNMNA	Minnesota Agency	Minnesota	2006	5.6	0.8
MNRLA	Red Lake Band of Chippewa Indians	Minnesota	2001	20.5	11.8
MTFHA	Flathead Agency	Montana	2005	2.7	1.4
NDTMA	Turtle Mountain Agency	North Dakota	2005	9.0	2.2
OKANA	Anadarko Agency	Oklahoma	2006	3.4	4.2
OKCHA	Chickasaw Agency	Oklahoma	2005	2.9	10.4
OKOSA	Osage Agency	Oklahoma	2005	4.1	15.7
OKTLA	Talihina Agency	Oklahoma	2004	4.4	8.8
OKWEA	Wewoka Agency	Oklahoma	2004	1.2	2.6
ORWSA	Warm Springs Agency	Oregon	2005	3.4	12.9
SDPRA	Pine Ridge Agency	South Dakota	2008	18.0	8.3
WACOA	Colville Agency	Washington	1996	3.8	12.8
WASPA	Spokane Agency	Washington	2004	1.8	0.7
WAYAA	Yakama Agency	Washington	2004[B]	2.8	4.5

[A]Source: National Wildfire Coordinating Group (2012) (pchaffp.txt files).

[B]The Yakama Nation website (Yakama Nation 2015) on fire prevention indicates the presence of a program in existence for 30 years. Our data, however, show that funding for the Yakama program began in 2004. To account for the presence of an unfunded effort on prevention by the Yakama Nation, we also include a dummy variable for WAYAA for the years 1996–2004.
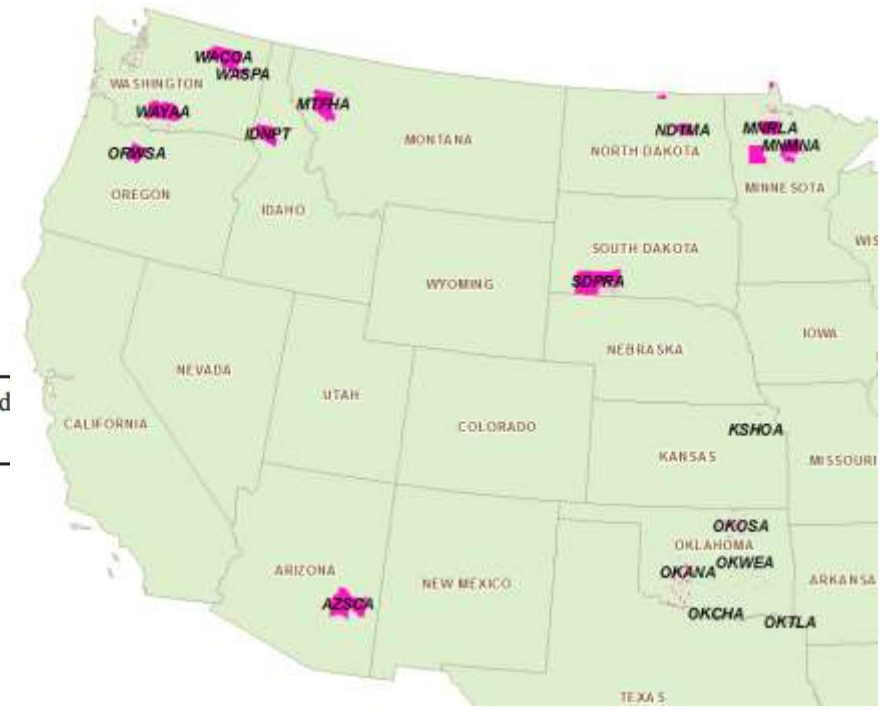
Wildfire Ignitions Percentage by Cause

% DOI

- Miscellaneous 19%
- Natural 38%
- Juveniles 7%
- Railroads 0%
- Equipment 8%
- Incendiary 15%
- Fire Use 8%
- Smoking 2%
- Campfire 3%

% BIA STUDY AREA

- Miscellaneous 16%
- Natural 17%
- Campfire 2%
- Smoking 2%
- Fire Use 16%
- Incendiary 27%
- Equipment 6%
- Railroads 0%
- Juveniles 14%
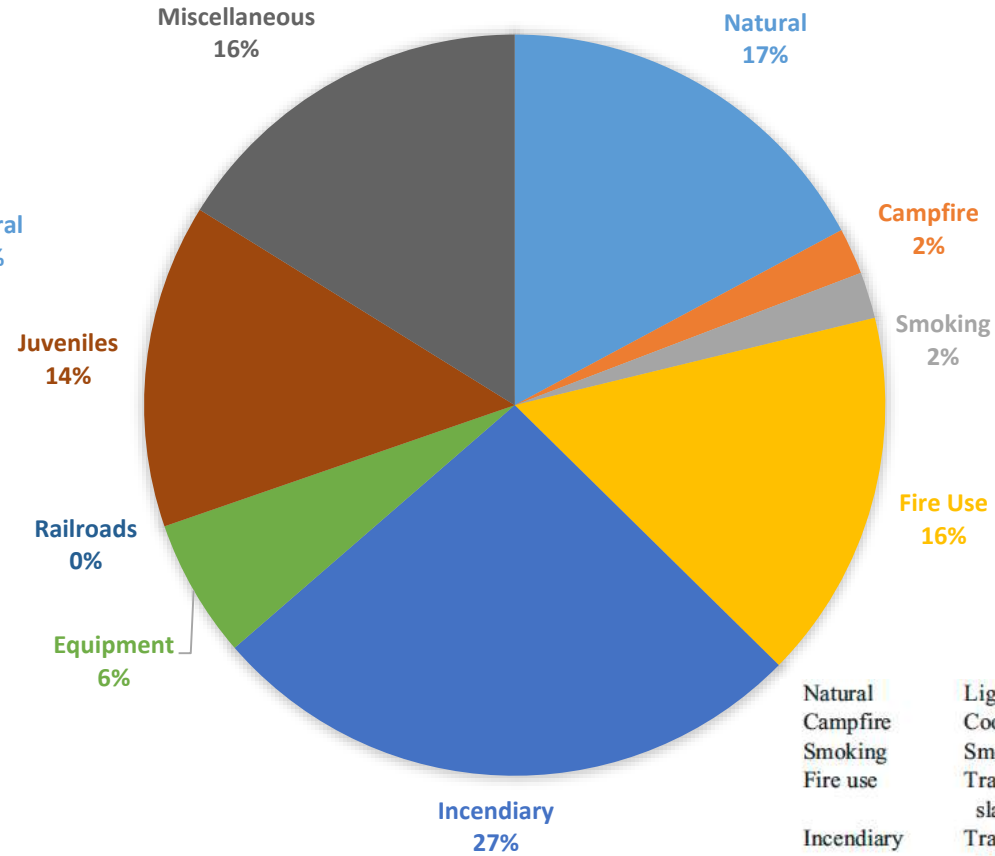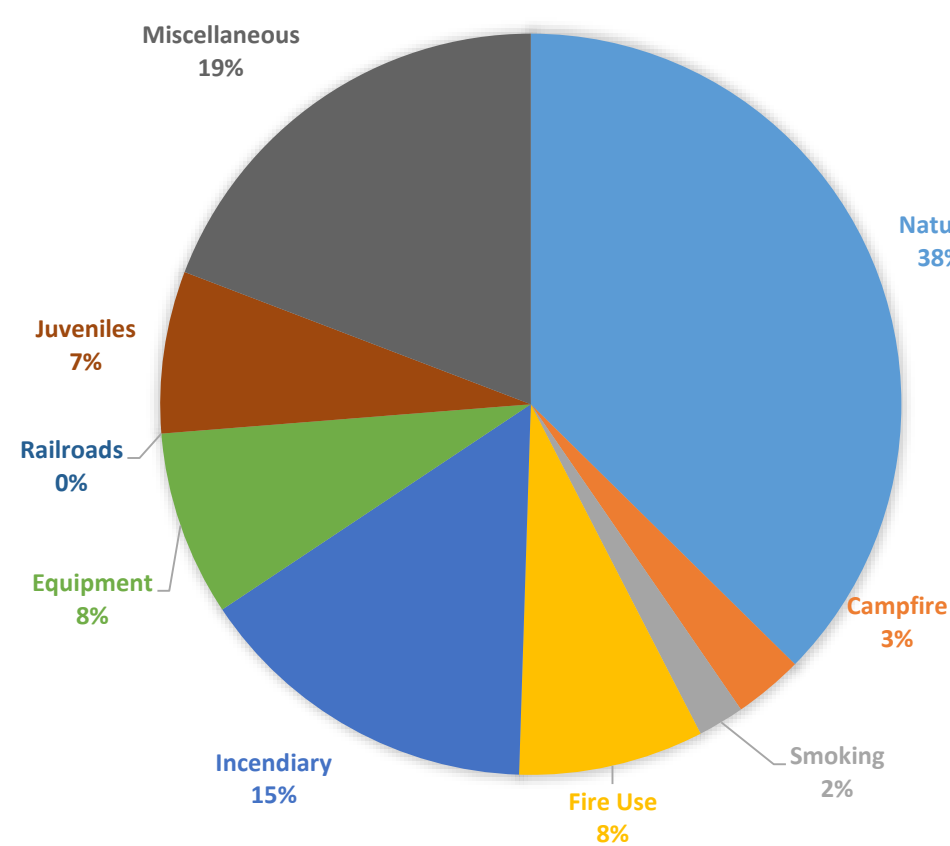
Natural	Lightning, volcanic
Campfire	Cooking or warming fires
Smoking	Smoking
Fire use	Trash burning, burning dump, field burning, land clearing, slash burning, right-of-way, resource management
Incendiary	Trash burning, field burning, grudge fire, recurrent, employment, blasting, fireworks
Equipment	Aircraft, vehicle, exhaust, brakes, blasting, power-line
Railroads	Exhaust, brakes
Juveniles	Recurrent, fireworks, ignition devices
Miscellaneous	Burning building, adult fireworks

Wildfire Interventions

Prevention
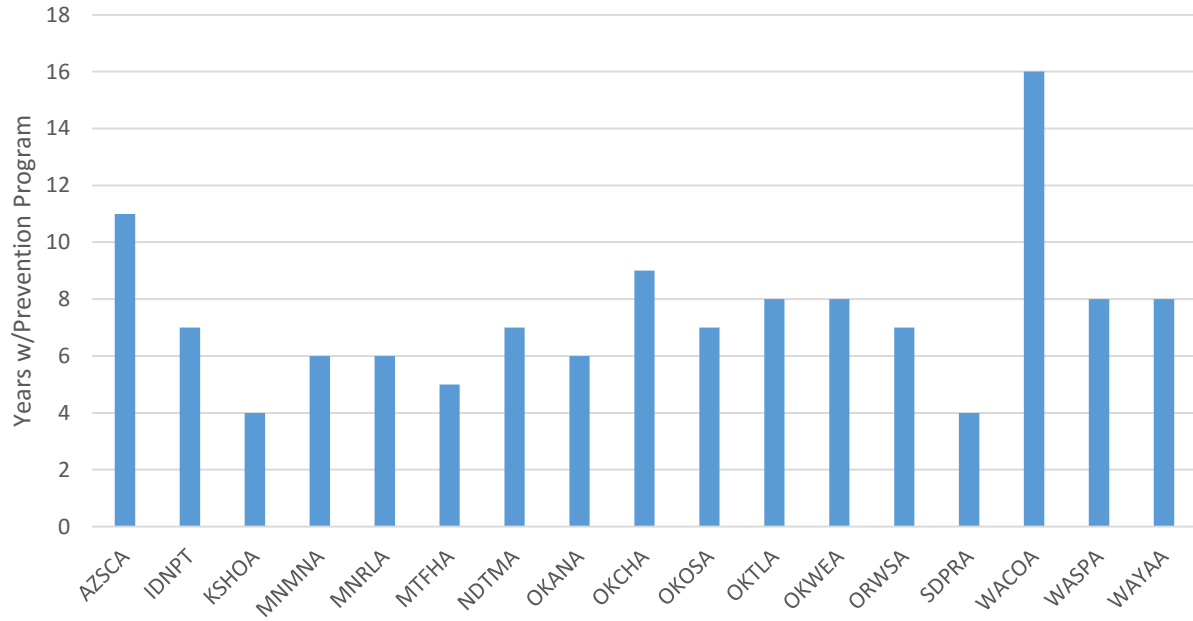
Law Enforcement
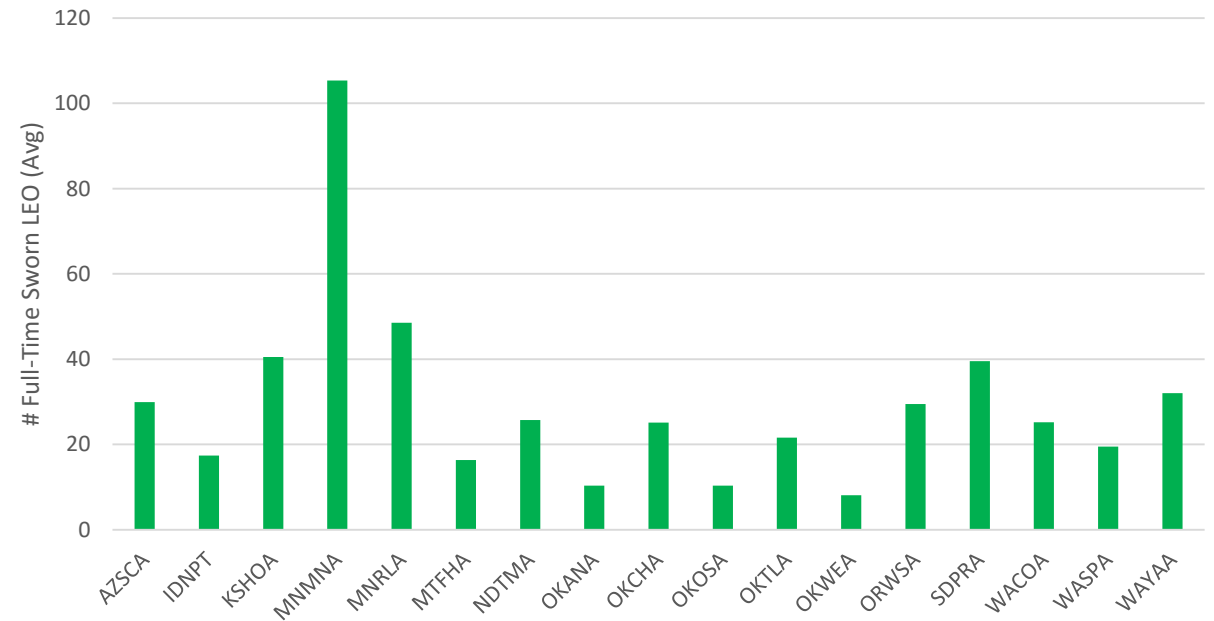
Model Framework (Six Count Models)

Seasonality

Annual Trends

Weather

Non-Specific Tribal Unit Effects

Law Enforcement
(# Sworn FT Officers)

Wildfire Prevention
(# Months of Program)

Previous Wildfire Activity

1. # Escaped Campfires
2. # Smoking Wildfires
3. # Escaped Fire-Use
4. # Juvenile-Set Wildfires
5. # Incendiary Wildfires
6. # Equipment-Set Wildfires
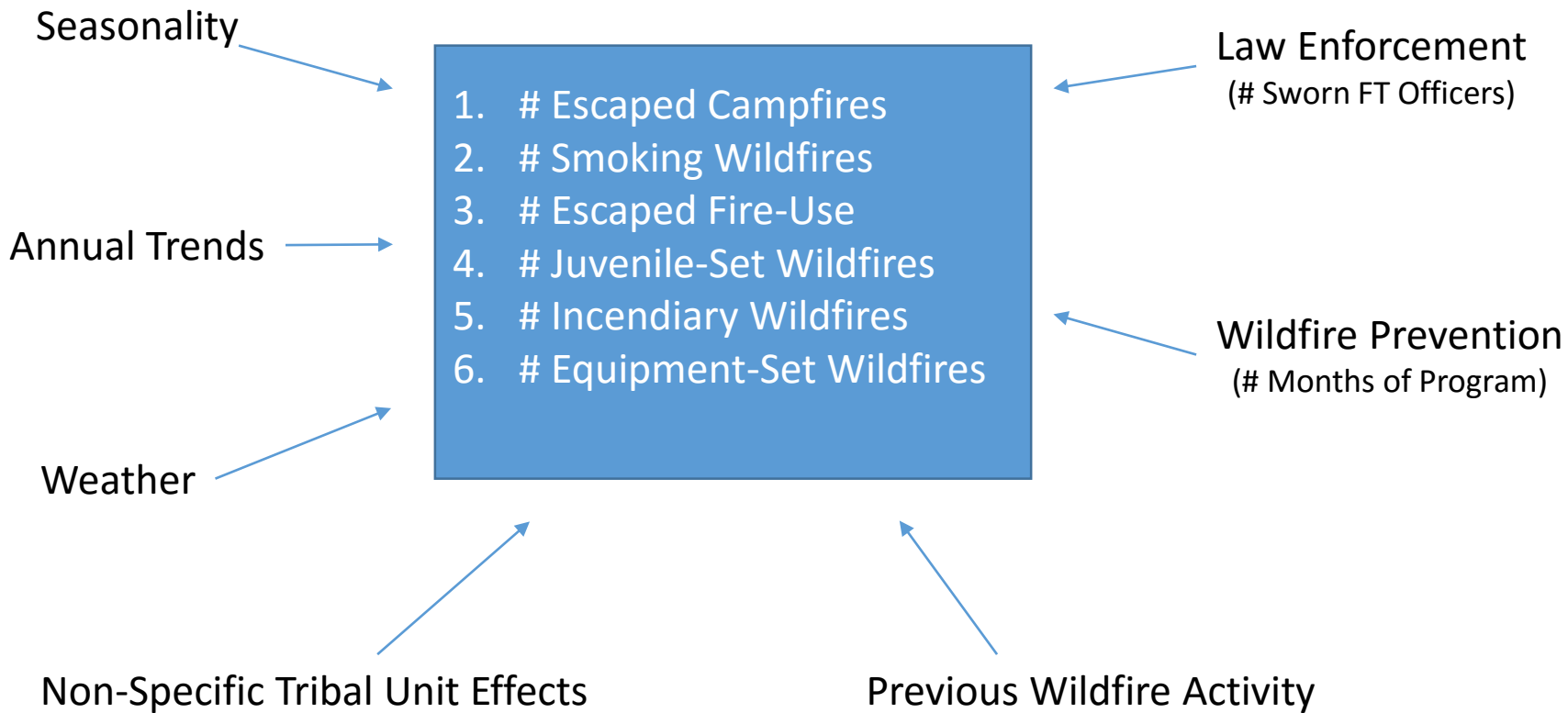
Table 3. Descriptive statistics for the dependent and continuous explanatory variables ($n = 2901$)

KBDI, Keetch–Byram drought index; FWI, Fire Weather index

Variable	Mean	s.d.	Min.	Max.
Campfire-caused wildfires	0.32	1.59	0.00	31.00
Smoking-caused wildfires	0.15	0.78	0.00	22.00
Fire-use-caused wildfires	2.22	9.14	0.00	225.00
Juvenile-caused wildfires	2.11	10.94	0.00	244.00
Incendiary-caused wildfires	2.53	10.83	0.00	194.00
Equipment-caused wildfires	0.64	1.63	0.00	32.00
Prevention duration	29.11	38.14	0.00	192.00
Full-time sworn law enforcement officers	30.56	23.23	3.00	110.00
Temperature (°C)	16.74	11.13	−14.71	39.82
Days with wind >24 km h^{-1}	5.37	4.08	0.00	25.00
Percentage relative humidity	40.07	12.79	9.51	72.14
Average monthly KBDI	146.12	164.02	0.00	731.50
Average monthly FWI	18.19	5.19	4.29	38.50
Days with precipitation	6.77	4.32	0.00	23.00
Days FWI high	12.03	4.57	0.00	26.00
Days FWI extreme	3.44	3.60	0.00	19.00
Area burned (10^3 ha)[A]				
Previous 1–12 months	2.81	5.65	–	50.11
Previous 13–24 months	2.80	5.60	–	50.11
Previous 25–36 months	2.80	5.58	–	50.11
Previous 37–48 months	2.65	5.50	–	50.11
Previous 49–60 months	2.44	5.37	–	50.11

[A]Note that the maximum and minimum span the entire dataset because of the cumulative lag – for example, the largest accumulation of 50.11×10^3 ha for 1 month in one unit is included in all five of the lag periods.

17 BIA Tribal Units / 1996 to 2011

Results: Statistical

Models →

Variables	Campfire	Smoking	Fire-Use	Juvenile	Incendiary	Equipment
Law Enforcement	X	X	X	X	−	−
Wildfire Prevention	−	X	−	−	X	−
Wildfire History	+	+	+, −	X	−	+
Tribal Unit Effects	+, −	+, −	+, −	+, −	+, −	+
Weather	+, −	−	−	+, −	+, −	+, −
Annual Trends	+	−	+	+	+, −	+
Seasonality	+	−	+, −	+, −	−	−

+ denotes positive statistical significance at the 5 % level

− denotes negative statistical significance at the 5% level

x denotes no statistical significance at the 5 % level

Marginal Effects of Interventions

Table 10. Marginal percentage reduction in the rate of wildfires, by ignition cause, per month of a wildfire prevention program and per sworn law enforcement officer

* denotes statistical significance at less than or equal to the 5% level

Ignition cause	Per month of prevention (%)		Per sworn law enforcement officer (%)	
Campfires	0.94	*	1.00	
Smoking	0.99		1.87	
Fire-use	1.98	*	0.40	
Juveniles	1.00	*	1.00	
Incendiary	0.43		3.13	*
Equipment	0.85	*	2.80	*

Avoided Wildfire Ignitions from Interventions

Table 11. **Observed and estimated avoided number of wildfires, by ignition cause, in total and per tribal unit month from prevention and law enforcement**

* denotes statistical significance at less than or equal to the 5% level

Ignition cause	Observed[A]	Observed per tribal month	Avoided by prevention[A,B]	Avoided by law enforcement	Avoided by prevention per tribal month	Avoided by law enforcement per tribal unit month
Campfire	925	0.3	488*		0.3	
Smoking	434	0.1				
Fire-use	6442	2.2	6588*		4.2	
Juveniles	6134	2.1	2925*		1.8	
Incendiary	7337	2.5	232*	249*		0.2
Equipment	1858	0.6	762*	32*	0.5	<0.01
Total	23 130	8.0	10 995	281	6.9	

[A]Computed for observations with a prevention program ($n = 1587$).
[B]Statistical significance was determined via bootstrapping.

Represents a 3 % (marginal) reduction in incendiary & equipment wildfires ('Last one hired')

Represents a 32 % reduction in all wildfires from prevention

Benefit-Cost Analysis: Prevention

Table 12. **Estimated partial benefit–cost ratios by region for prevention programs on 17 Bureau of Indian Affairs (BIA) tribal units using regional average expenditures per fire**

Region	Average annual prevention expenditures (2004–09)	Average suppression expenditures per fire[A] (2002–11)	Average annual suppression savings from prevention	Partial benefit–cost ratio
		2004 US dollars		
Eastern Oklahoma	51 326	3068	231 993	4.5
Great Plains	46 870	3093	233 870	5.0
Midwest	40 355	3683	278 547	6.9
North-west	47 111	23 949	1 811 063	38.4
Rocky Mountain	52 680	10 581	800 180	15.2
Western	43 609	17 416	1 317 047	30.2
Southern Plains	54 284	7549	570 837	10.5

[A]Data were unavailable for expenditures by fire cause or fire size, and thus this value represents the average cost per fire for all fire sizes and causes. To the extent that suppression expenditures differ by prevented cause, and by fire size, the benefit–cost ratio may over- or underestimate the true ratio.

Recent Wildfire Trend on BIA Lands

Number of Human-Caused Wildfires
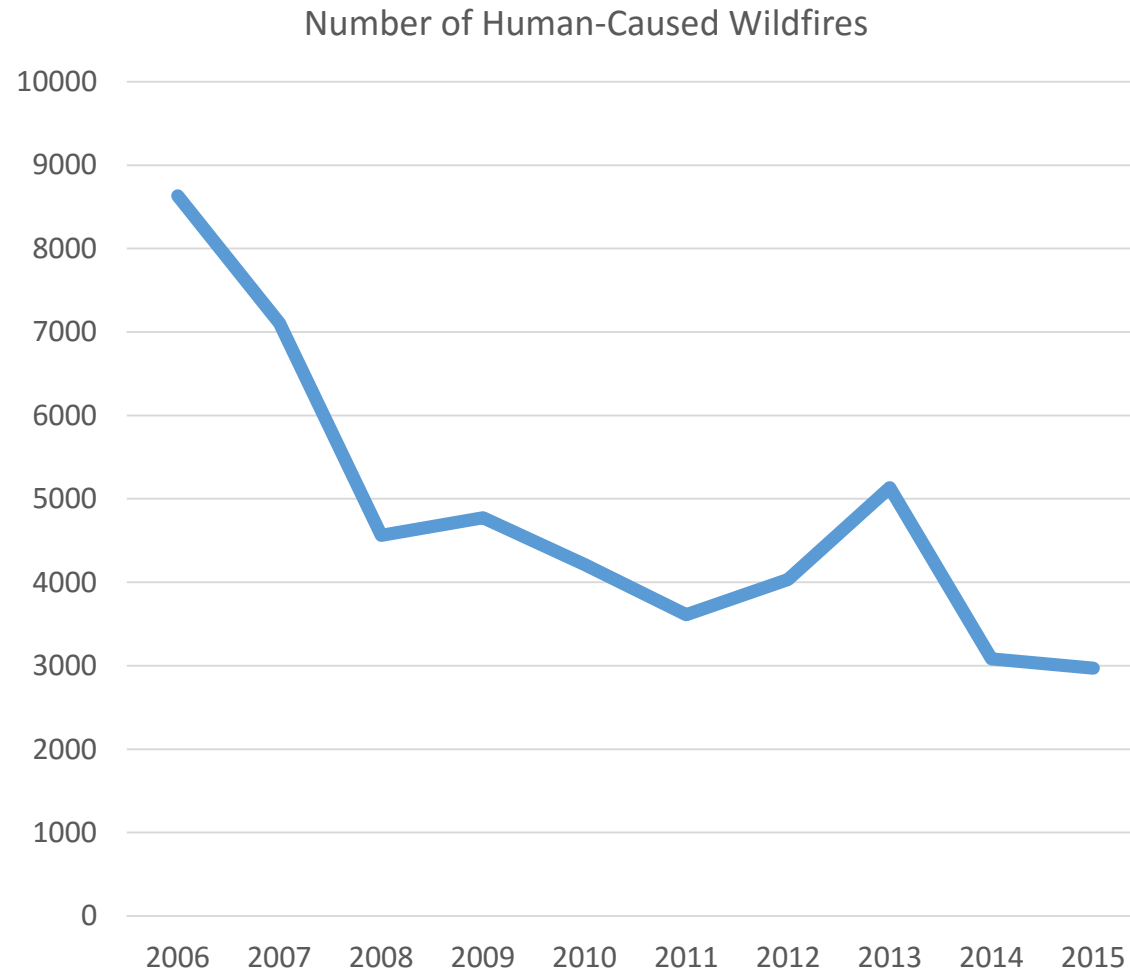
➢ 2015 ignitions represent a 66 % reduction since 2006

Key Takeaways

- Evidence that wildfire prevention programs reduce the numbers of human-caused wildland ignitions
  - More effective in areas with higher rates of escaped fire-use and juvenile fires
- Prevention programs were found to return $16 in avoided suppression costs for ever $1 spent, on average
- Areas with higher rates of incendiary fires appear to (only) respond to increased law enforcement activity
- More research is needed to identify the effectiveness of specific prevention activities (e.g., door-to-door outreach, public service announcements)

Contact Info

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Economic Perspectives and Research Ideas for the Fire Service

Andrew J. Wang, Ph.D.

Harvard Center for Green Buildings and Cities

What is economics?

- Economics is the study of allocation of resources under conditions of scarcity

- How much should we spend on fire protection?

- What should we spend fire protection dollars on?

- What is the return/benefit from spending on fire protection?

U.S. Local Government Expenditures
on Police and Fire Protection, 1977-2013
(per capita, in 2013 dollars)
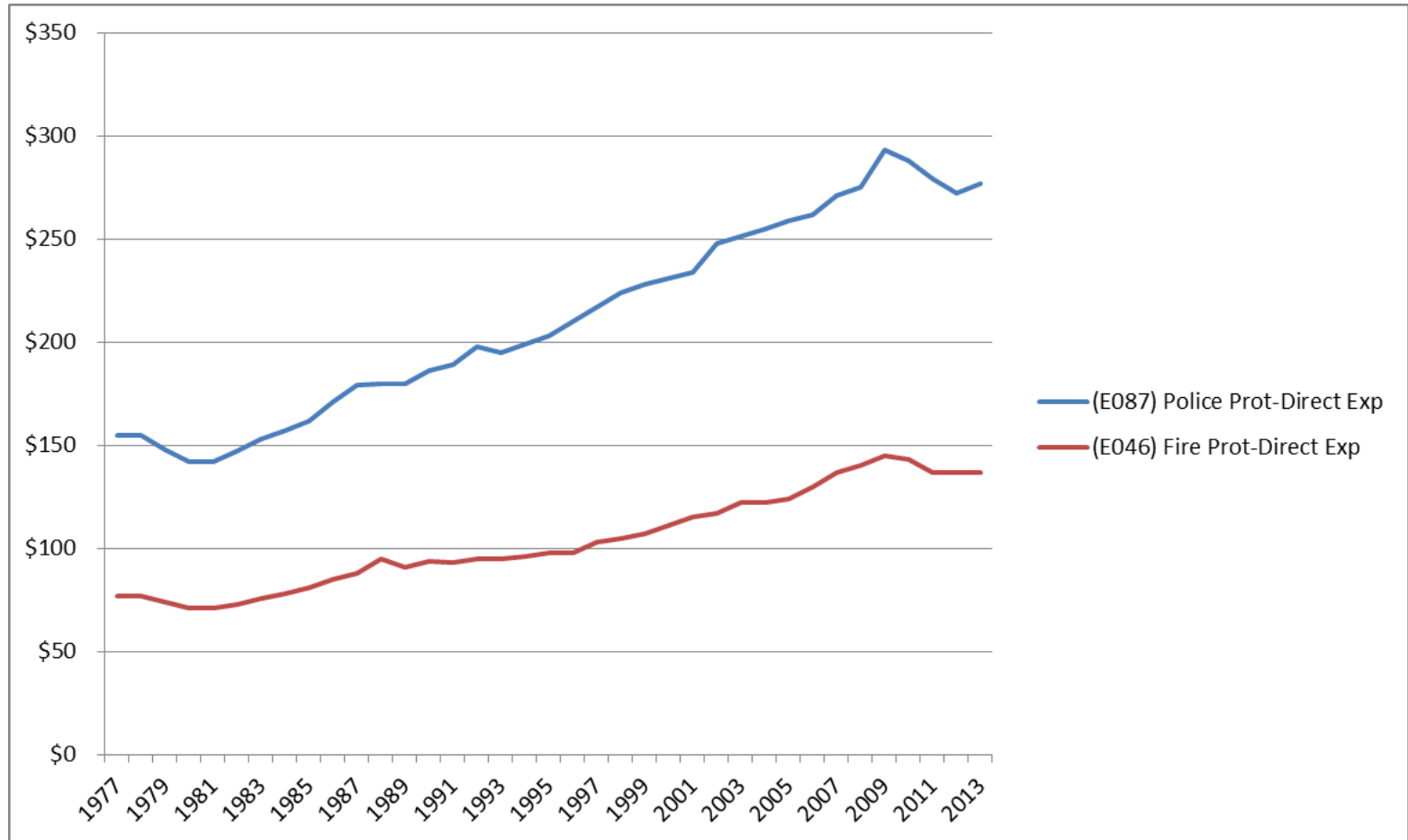
U.S. Local Government Expenditures
on Police and Fire Protection, 1977-2013
(share of total expenditures)
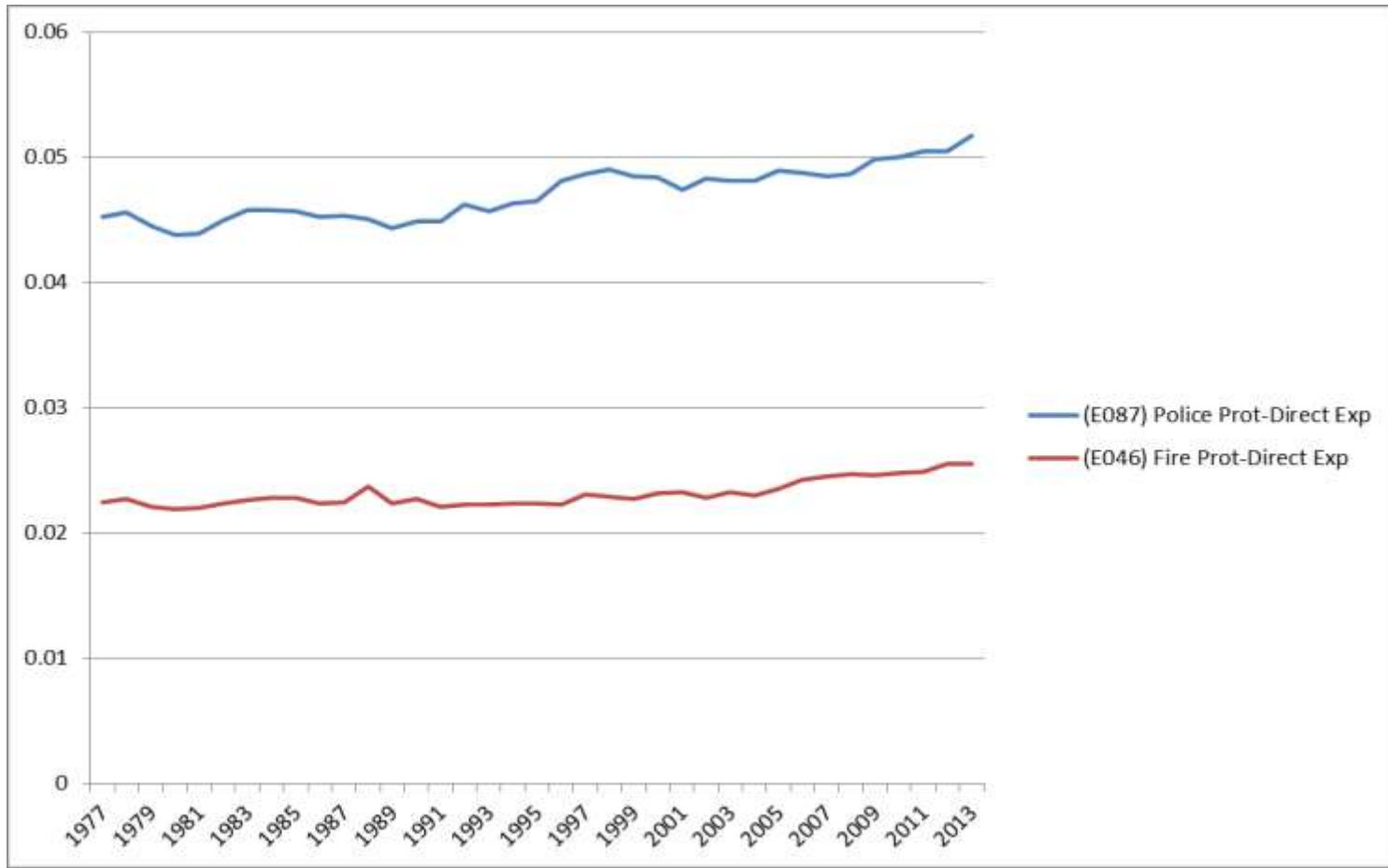
State & Local Government Finance Data Query System. The Urban Institute-Brookings Institution Tax Policy Center. Data from U.S. Census Bureau, Annual Survey of State and Local Government Finances, Government Finances, and Census of Governments.

U.S. Local Government Expenditures
on Police and Fire Protection, 1977-2013
(share of personal income)

U.S. Local Government Expenditures
on Police and Fire Protection, 2013
(by U.S. state)

Fire Incidents, 1977-2014

National Fire Protection Association, "Trends and Patterns of U.S. Fire Loss". February 2016.

Fire Incident Rate (per thousand population), 1977-2014
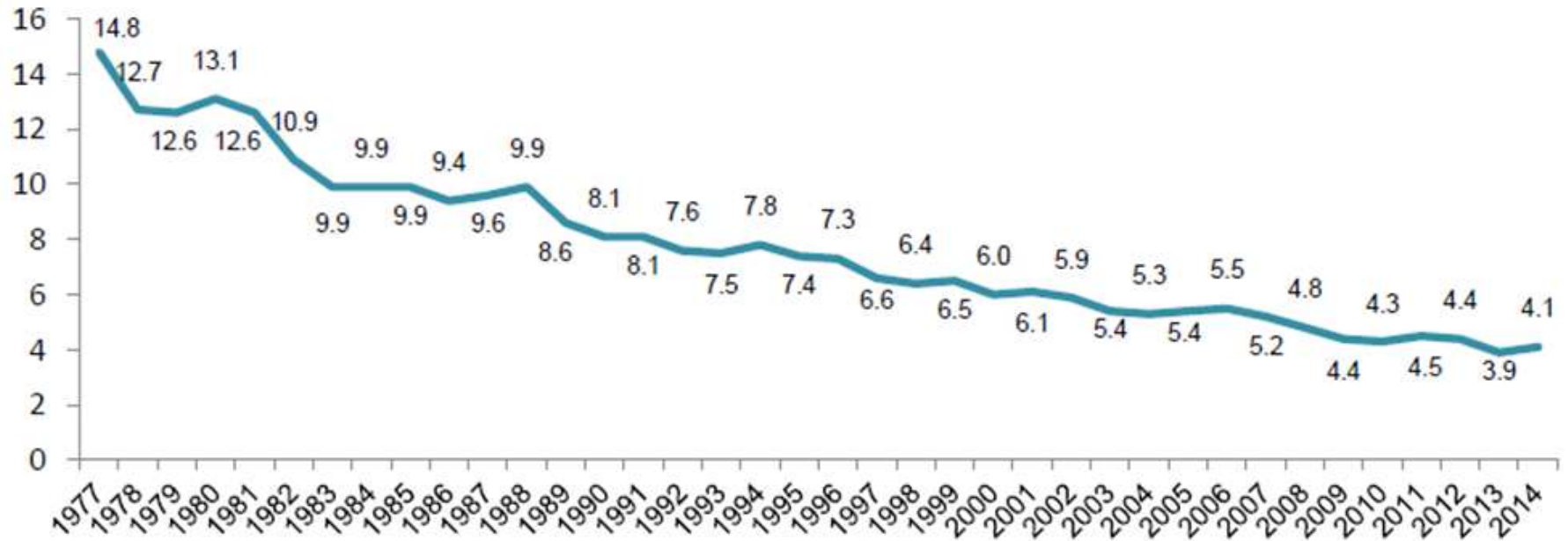
National Fire Protection Association, "Trends and Patterns of U.S. Fire Loss". February 2016.

Civilian Fire Death Rate (per million population), 1977-2014
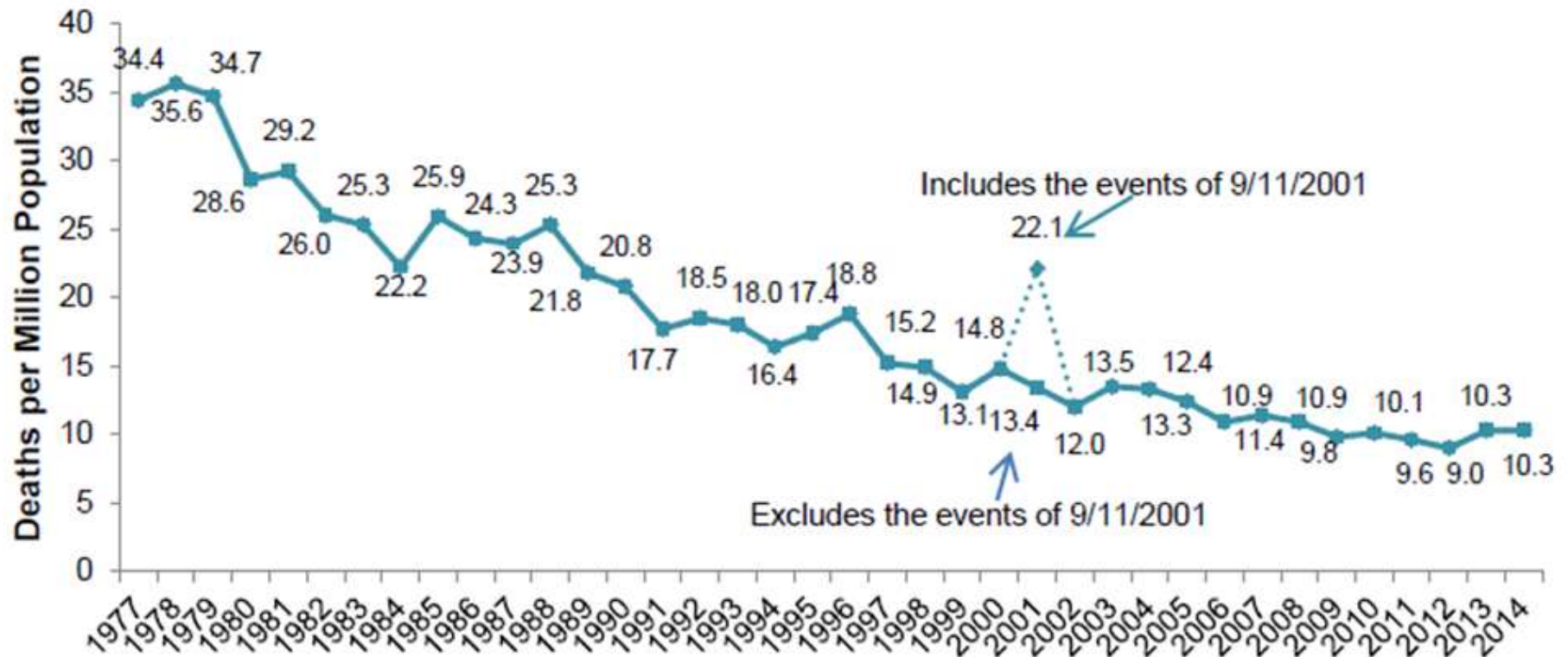
National Fire Protection Association, "Trends and Patterns of U.S. Fire Loss". February 2016.

Fire Loss and Fire Protection, 2011 (in billions)

- Economic Loss $14.9
  - Direct property loss $13.3
    - Reported fires $11.7
    - Unreported fires $1.6
  - Indirect income loss $1.7
- Human Loss $31.7
  - Deaths
  - Injuries

- Local fire department expenditures $42.3

National Fire Protection Association, "The Total Cost of Fire in the United States". March 2014.

How to measure economic impact of the fire service?

- Economic production function
  - Output Y
  - Inputs
    - capital K
    - labor L
    - intermediate inputs M (energy, materials, services)
  - Production function $Y = f(K, L, M)$

What is the *output* of the fire service?

- It is hard to measure output in the services sector, and especially government services
  - Auto repair (parts replaced, car performance)
  - Health care (doctor visits, lab tests, health outcomes)
  - Education (classroom hours, student outcomes)
- Performance measurement
  - Activities (training, planning)
  - Outputs (incident responses, fires suppressed)
  - Outcomes (fire deaths and injuries, property loss)

Modeling fire risk and loss

- Output
  - Risk of fire incident
  - Risk of fire injury or death
  - Expected value of property damage
- Input
  - Capital (fire stations, vehicles, equipment)
  - Labor (personnel, training)
  - Intermediate inputs (energy, materials, services)
- Environmental factors
  - Characteristics of buildings and cities
  - Demographic and socioeconomic characteristics

Empirical implementation – neighborhood level

- National Fire Incident Reporting System (NFIRS)
  - Incident level data reported by fire departments
- Geocode fire incidents to Census block group or tract
  - block group contains 600 to 3000 people
  - tract contains 1200 to 8000 people; optimal size is 4000
- Match in Census data on population and housing characteristics at the block group or tract level
- Match in local fire department expenditures at the block group or tract level
- Estimate the statistical relationship between fire incidence/loss and fire department expenditures
  - Benchmark for performance
  - Return on investment for fire protection expenditures

Empirical implementation – building level

- Building level data
  - NFIRS
    - size, type, height
    - detector, sprinkler
  - City government administrative data
    - year built
    - size, type
    - property tax assessment value
  - Insurance data?
    - building characteristics (e.g., size, type, detector, sprinkler)
    - occupant characteristics (e.g., age, smoker)
    - insurance coverage
    - claims, fire loss

Building characteristics and fire risk

- Building "quality"
  - design
  - building materials and furnishings (e.g., fire retardant)
  - systems (e.g., heating, cooking, fire sprinkler, smart home)
- Building vintage
  - year built
  - year renovated
  - applicable building code and standards

- Building level data enables empirical measurement of the impact of building "quality" on fire risk and loss

Big Data

- Microdata
  - more disaggregated, granular (e.g., building level)
  - more variables, detail (e.g., building and occupant characteristics)

- From univariate/bivariate to multivariate
  - univariate summary statistics, bivariate cross-tabulations
  - multivariate statistical analysis (e.g., regression)

Distribution of Fire Incidents and Losses, 2014

A. Fires
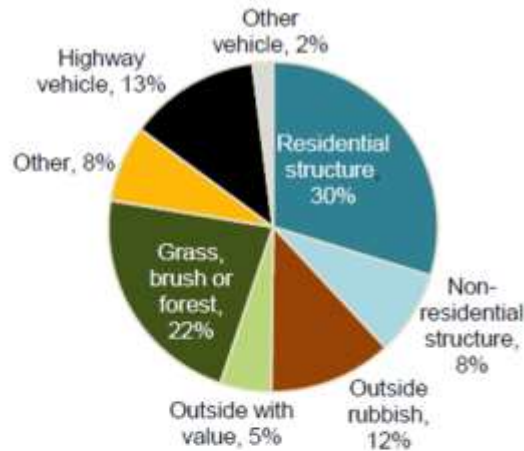
B. Civilian Deaths
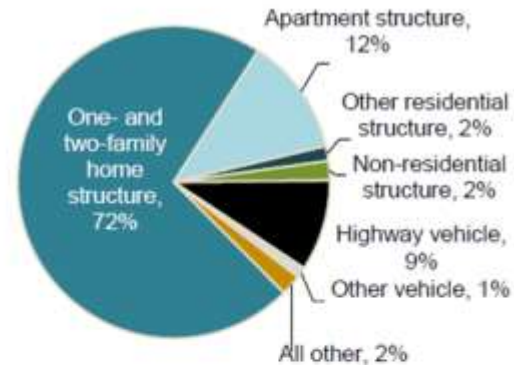
C. Civilian Injuries
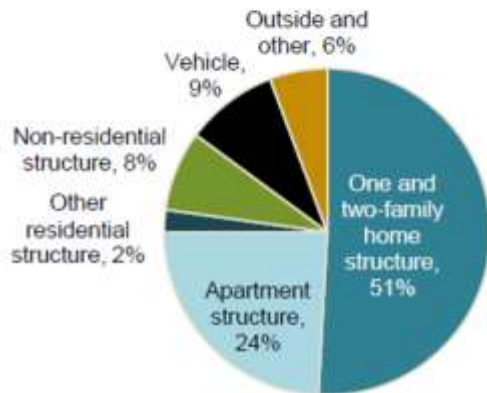
D. Direct Property Damage

National Fire Protection Association, "Trends and Patterns of U.S. Fire Loss". February 2016.
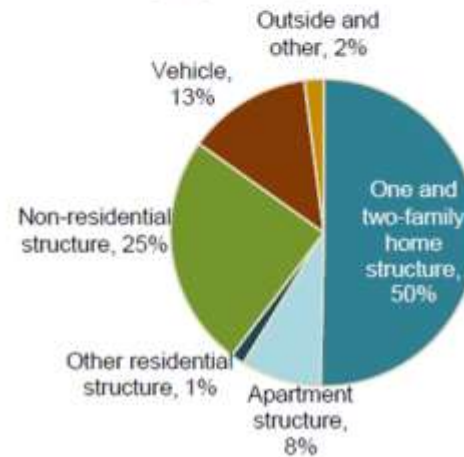
Beyond Fire

- What does the fire service do more broadly?
  - Fire & Rescue
    - emergency medical service (e.g., heart attack)
    - rescue (e.g., jaws of life, my child fell into a hole)
    - explosions, chemical spills, downed power lines
  - Community Resilience
    - first responder
    - natural disaster
    - public safety

Fire Department Responses by Incident Type, 2014
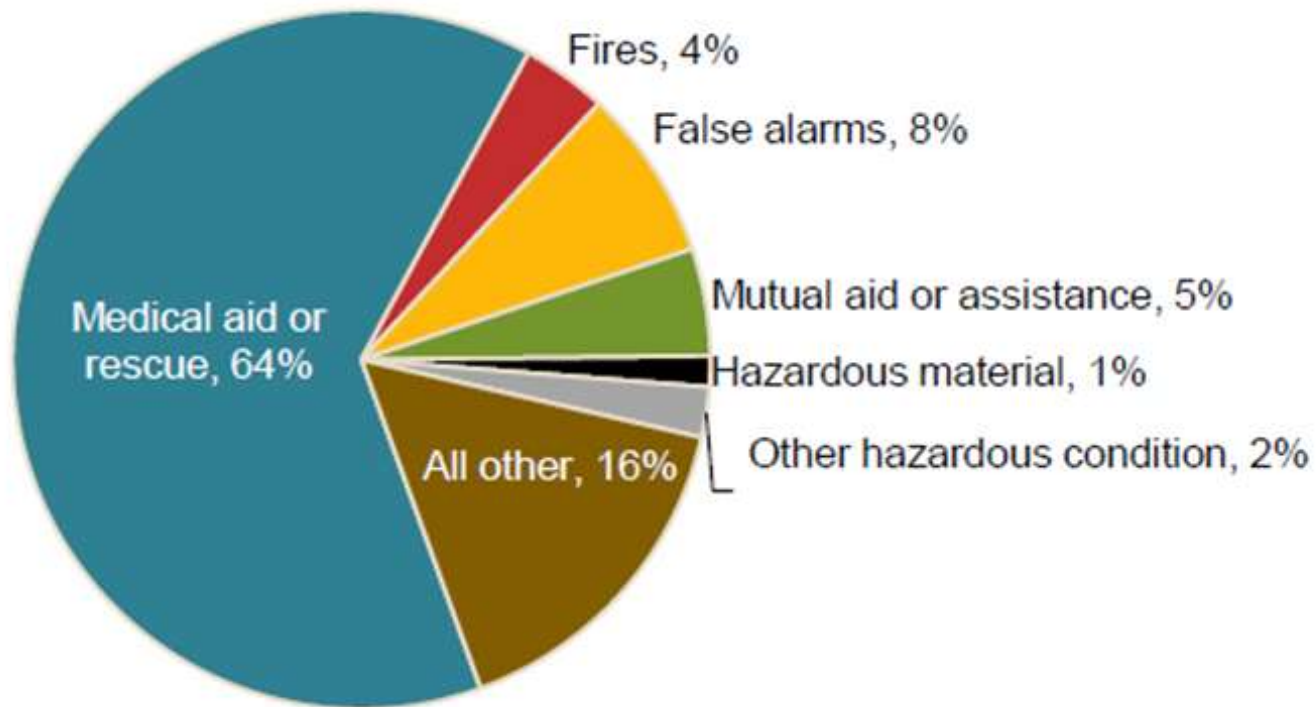
National Fire Protection Association, "Trends and Patterns of U.S. Fire Loss". February 2016.

Beyond the Fire Service

- What industries are engaged in fire protection?

- What is total economic output and investment for fire protection?

- What are new technologies and innovations that improve fire protection and fire safety?

Economic impact of standards

- Empirical measurement of the impact of building codes/standards on fire risk and loss
  - Do changes in codes/standards affect fire risk?

- What industry sectors are impacted by building codes/standards?
  - What companies are users of standards?
  - What companies participate in standards setting?
  - How do standards affect industry performance?

Optimal resource allocation for fire protection

- How much will an additional dollar of fire protection expenditure return in benefits, i.e., lives saved, fewer injuries, reduced property damage? How does this compare to expenditures and investments in other areas?

- Are total fire protection expenditures optimally distributed across geography and types of spending?

- Data and empirical analysis are needed for evidence-based policy

Cost-benefit analysis of fire protection resource allocation in the United States: Models and a 1980-2011 case study

Dr. Jun Zhuang,
Adam Behrendt, Vineet Madasseri Payyappalli

Department of Industrial and Systems Engineering
University at Buffalo, Buffalo NY

Introduction

- Fire related hazards - everyday phenomenon
- Firefighting in the United States is the collective effort of firefighters, fire departments, other organizations (administration, science, manufacturing, IT, etc.)
- However there is very little work done on:
  - Risk assessment and risk reduction models,
  - Cost-benefit analysis of investment, and
  - Resource allocation problems.
- Our work addresses this gap.

Cost of Fire in the United States in 2011[2]

Core Costs	Billion \$
Economic Loss	\$14.9
Local fire department expenditures	\$42.3
Net insurance (premium minus NFPA estimate of reported direct damages)	\$20.2
New building costs for fire protection	\$31.0
Total core costs	\$108.4
Other Costs	
Other economic cost	\$48.9
Cost of statistical deaths & injuries, civilian & firefighter	\$31.7
Cost of coverage by career firefighters of areas now protected by volunteer firefighters	\$139.8
Total	**\$328.7**

Demography of firefighting in US, 2014[1]:

- 1,134,400 firefighters (31% career and 69% volunteer)
- 29,980 fire departments

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[1] The United States Fire Service Fact Sheet (NFPA, 2014)
[2] The Total Cost of Fire in the United States (NFPA, 2014)

Cost of Fire: Economic losses, Fire Department Expenditures, and Casualties[34]
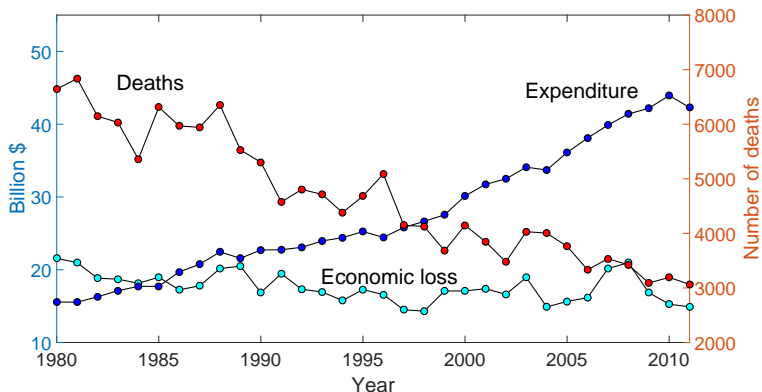
- ▶ Economic losses have decreased over the last three decades.
- ▶ Local fire department expenditures have increased.
- ▶ The total number of deaths have decreased.

[3] 2001 data does not include the events of 9/11 attacks.

[4] The Total Cost of Fire in the United States (NFPA, 2014)

Least Cost Model: Introduction

$$U_t = q_t + d_t$$

U_t: Total cost of fire, q_t: Cost of fire loss, d_t: Total expenditure

$$q_t = r_t + l_t V$$

r_t: Economic losses, l_t: Deaths due to fire, V: Value of life estimated at $9.1 million[5]

$$Q_t = R_t + L_t V$$

Q_t: Potential loss, R_t: U.S. GDP, L_t: U.S. Population[6]

---

[5] Applebaum, "As U.S. Agencies Put More Value of a Life, Bussinesses Fret" 2011

[6] GDP, Population. Sources: Bureau of Economic Analysis (BEA), U.S. Census

Vulnerability vs Investment
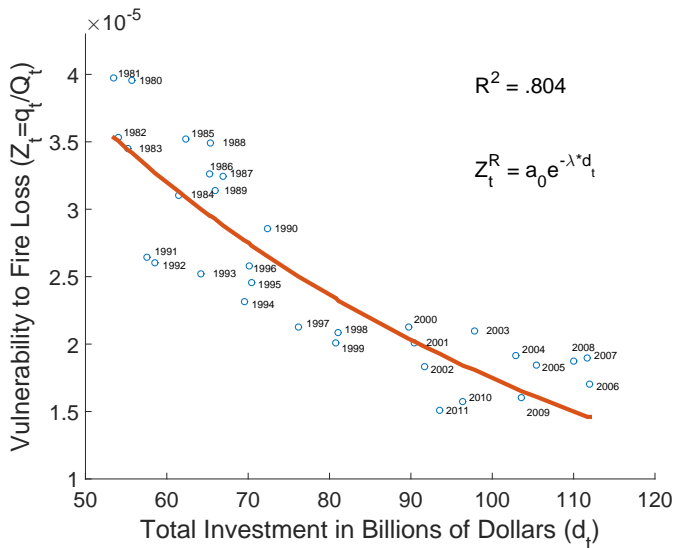
Vulnerability vs Investment
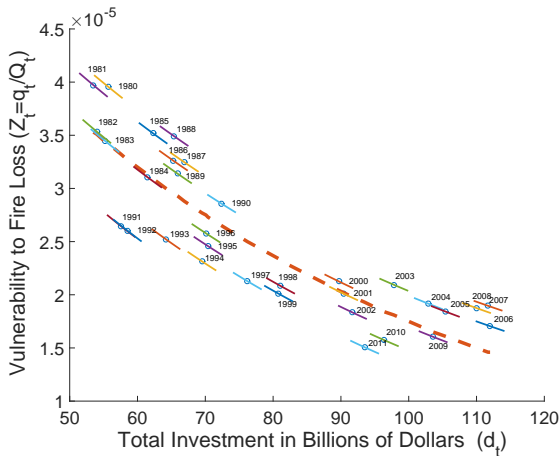
▶ We create individual best fit lines by defining the vulnerability with vector parameter values, changing each year: $Z_t^M = a_t e^{-\lambda_t d_t}$

Least Cost Model: Results

$$U_t = a_t e^{-\lambda_t d_t} Q_t + d_t$$

Total cost equation, U shaped with respect to investment

$$d_t^* = \frac{\ln\left(a_t \lambda_t Q_t\right)}{\lambda_t}$$

d_t^*: Optimal investment, increasing in a_t and Q_t and decreasing in λ_t

$$q_t^* = \frac{1}{\lambda_t}$$

q_t^*: Optimal loss, would be the inverse of λ_t

Formulation of a_t and λ_t
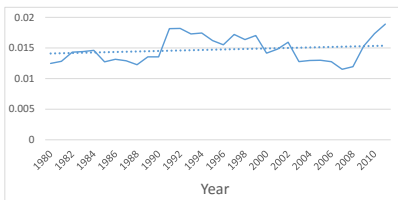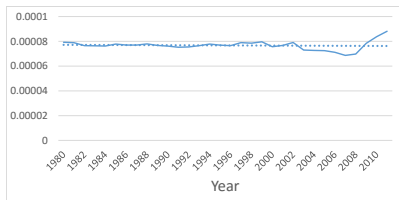
- $Z_t^M = a_t e^{-\lambda_t d_t}$ subject to: $\dfrac{\partial Z_t^R}{\partial d_t} = \dfrac{\partial Z_t^M}{\partial d_t}$

- With $Z_t^M = a_t e^{-\lambda_t d_t}$ and $\lambda_0 a_0 e^{-\lambda_0 \cdot d_t} = \lambda_t a_t e^{-\lambda_t \cdot d_t}$ we are able to solve for a_t and λ_t

- $a_t = Z_t \cdot e^{\frac{a_0 \cdot d_t \cdot \lambda_0 \cdot e^{-\lambda_0 \cdot d_t}}{Z_t}}$ and $\lambda_t = \frac{a_0 \cdot \lambda_0 \cdot e^{-\lambda_0 \cdot d_t}}{Z_t}$

Actual vs Optimal Total Cost, 2011
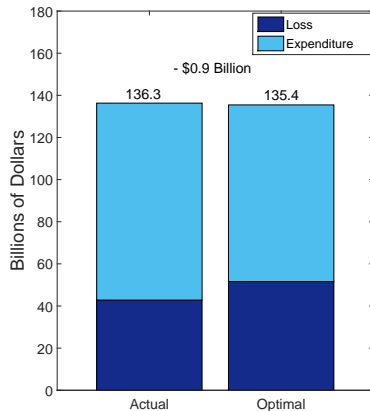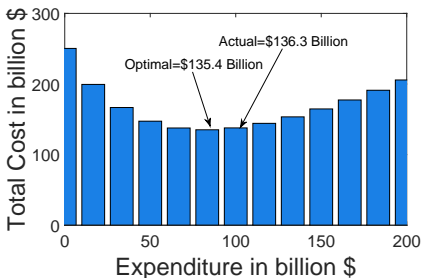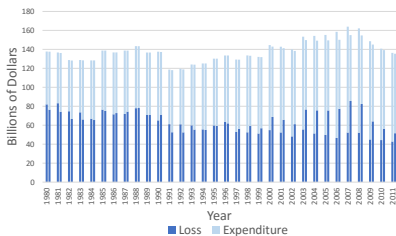
Investment, Loss and Total Cost vs Value of Life for 2011
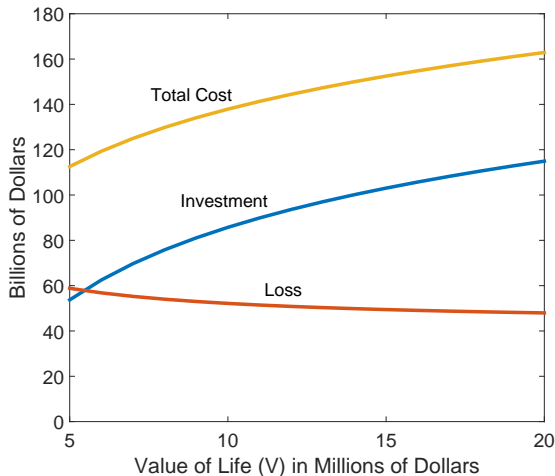
- ▶ Uses for policy makers and analysts in determining appropriate levels of investment for minimal total cost of fire
- ▶ Help in creating a value of life in a fire protection context to be used in future analyses and research

Optimal Resource Allocation Model: Introduction

- Optimal allocation of resources is a challenge for the government
  - This is due to the trade-off between efficiency and equity
- The loss function from the Least Cost Model is used
- We model the total economic loss in region i as:

$$L_i = G_i a_i e^{-\lambda_t d_t}$$

where

- L_i = loss,
- G_i = potential loss,
- d_i = investment,
- λ_i = coefficient of effectiveness, and
- a_i = initial vulnerability.

Optimal Resource Allocation Model: Considering Equity[7]

- Objective: Minimize total economic loss

$$\min_{d_i} \sum_{i=1}^{n} G_i a_i e^{-\lambda_i d_i}$$

- Subject to constraints:

$$\sum_{i=1}^{n} d_i \leq B$$

$$d_i \geq d_i^e \quad \forall i$$

where d_i^e = equity-based investment.

For e.g., $d_i^e = c_i \times r_e \times B$, where
  - r_e is the equity coefficient and
  - c_i is the equity fraction of region i.

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[7] Cost of equity in homeland security resource allocation in the face of a strategic attacker (Shan & Zhuang, 2013)

Equity based on GDP, population, and land area

Equity based on GDP
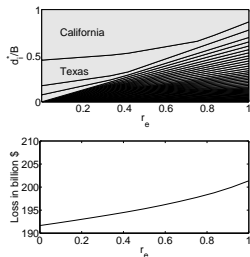
Equity based on population
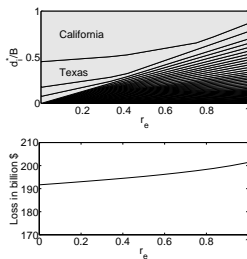
Equity based on land area
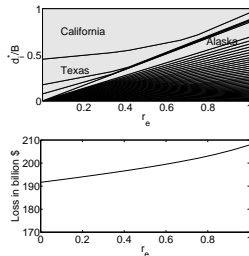
c_i is the equity fraction of region i based on GDP.

c_i is the equity fraction of region i based on population.

c_i is the equity fraction of region i based on land area.

In each case, c_i and r_e are used to calculate $d_i^e = c_i \times r_e \times B$.

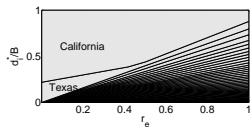# Equity based on population (different budget levels)

Budget = $50 billion
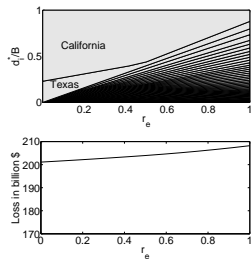
Budget = $125 billion
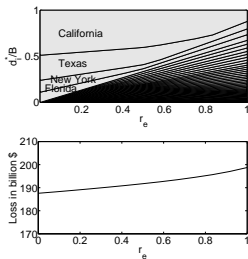
Budget = $200 billion
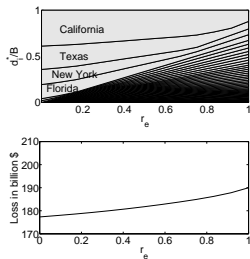
Equity based on population (different λ levels)
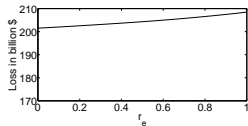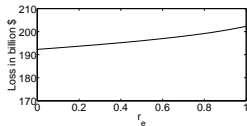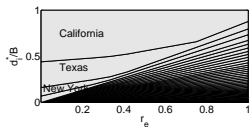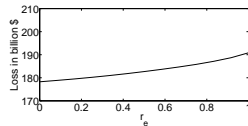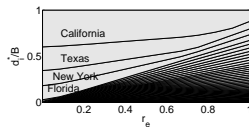
Cost of Equity (Based on Population)

3 levels of budget B
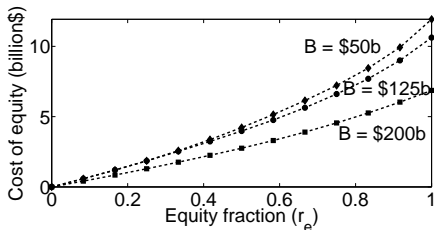
3 levels of effectiveness coefficient λ

Future Research Directions

Fire Employee Density Per Million Population

Fire Station Density Per Million Population

- ▶ Currently there is a drastic difference between the resource distribution in different states.
- ▶ For e.g., North & South Dakota have about twice as many employees and four times as many fire stations as Texas and California.
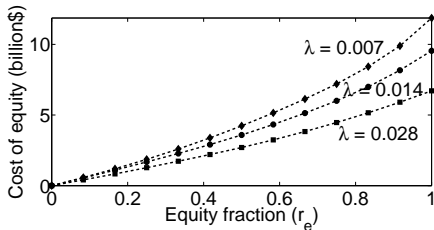
Fire Station Density: ZIP Code Level[8]

Number of fire departments
per thousand population

0
[0.0108 to 0.0644)
[0.0644 to 0.2040)
[0.2040 to 0.4859)
[0.4859 to 1.2285)
[1.2285 to 1,000.0000]
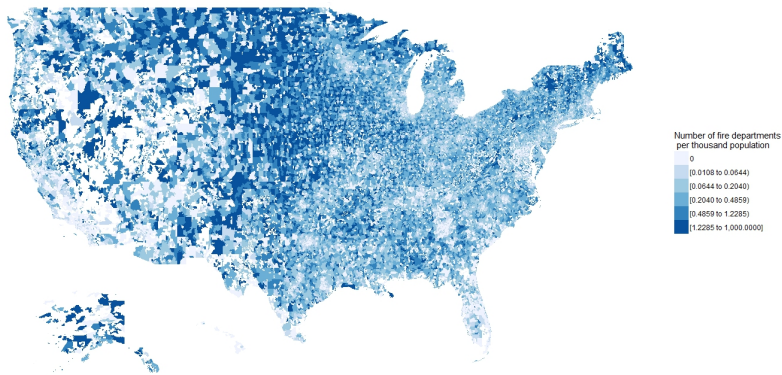
Based on ZIP Code Tabulation Areas (ZCTA) defined in US Census (2010).

Thank you for your time!!
Any questions/comments?

Collaborations are welcome!

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