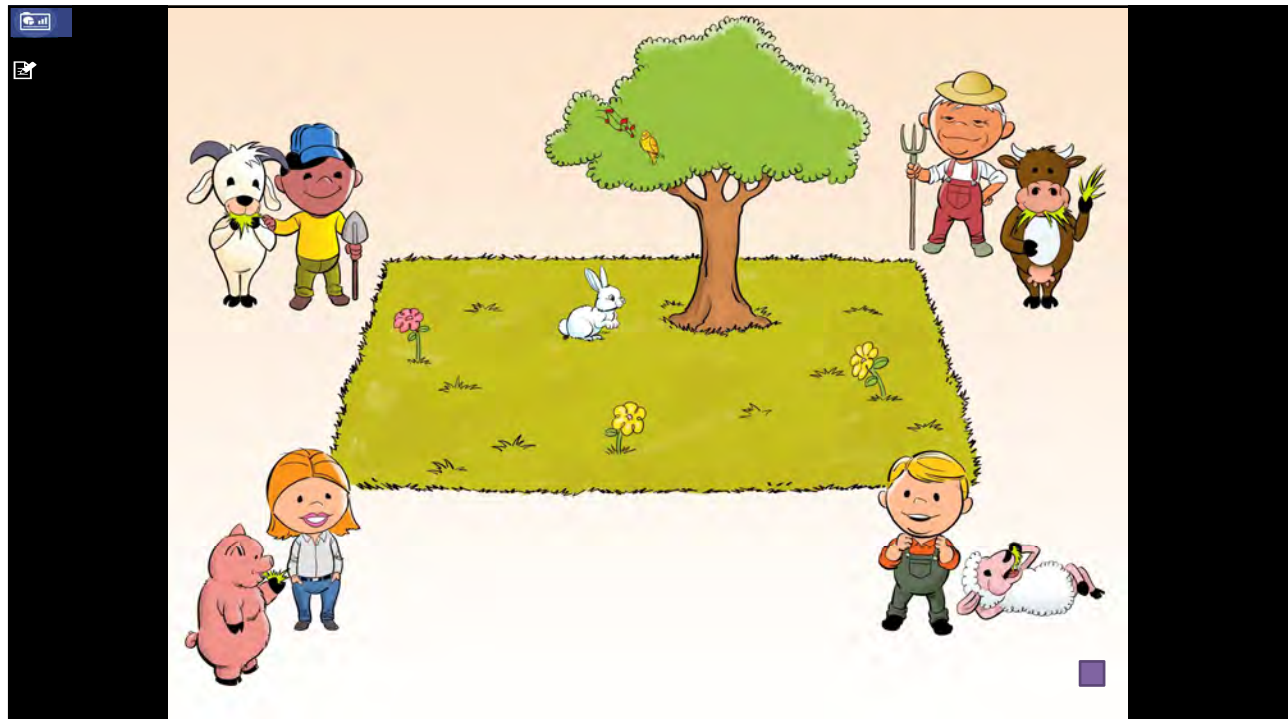


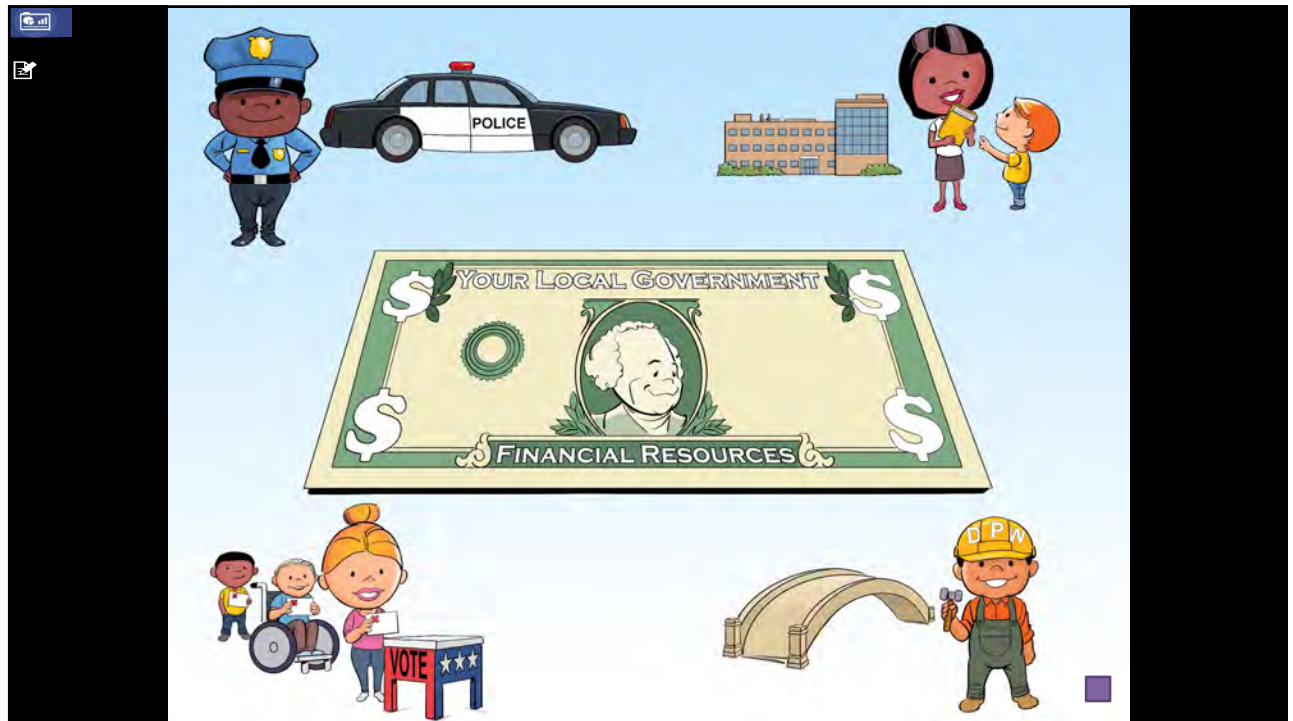
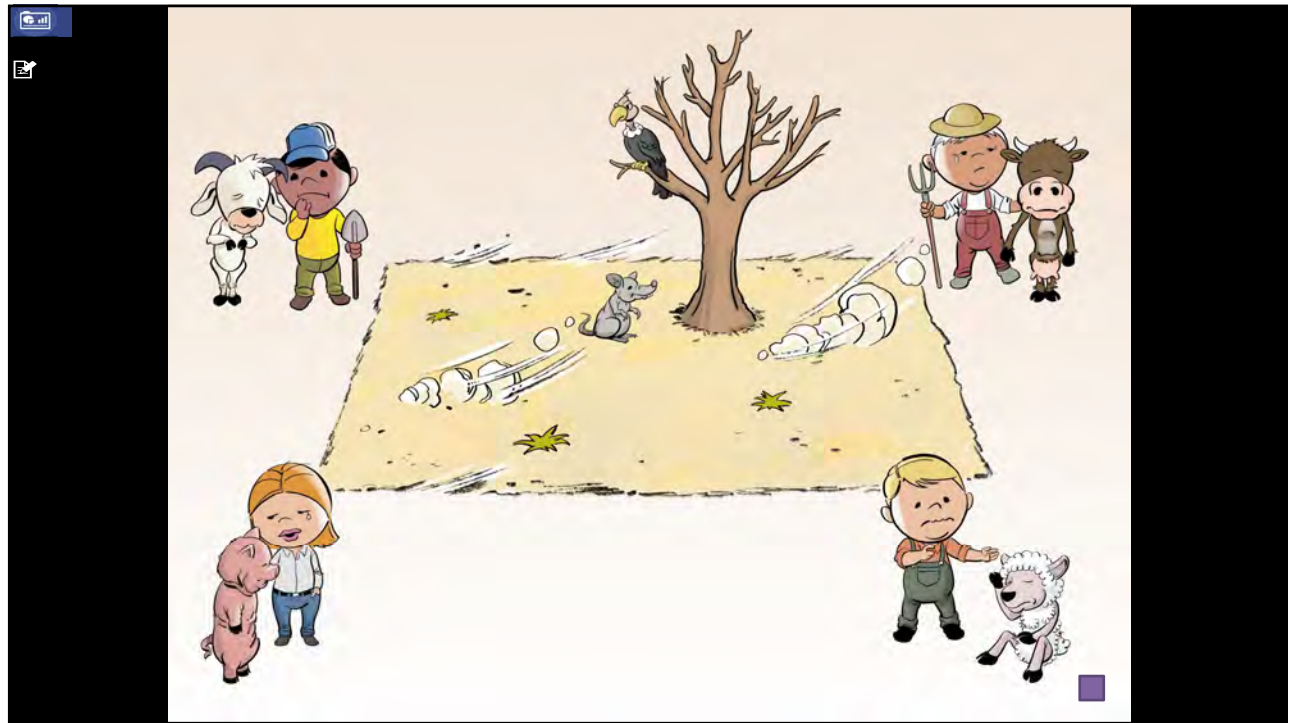
# Reserves

## *How Much is Enough?*

Finding the Right Amount for  
your Community

California Municipal League, December 2018

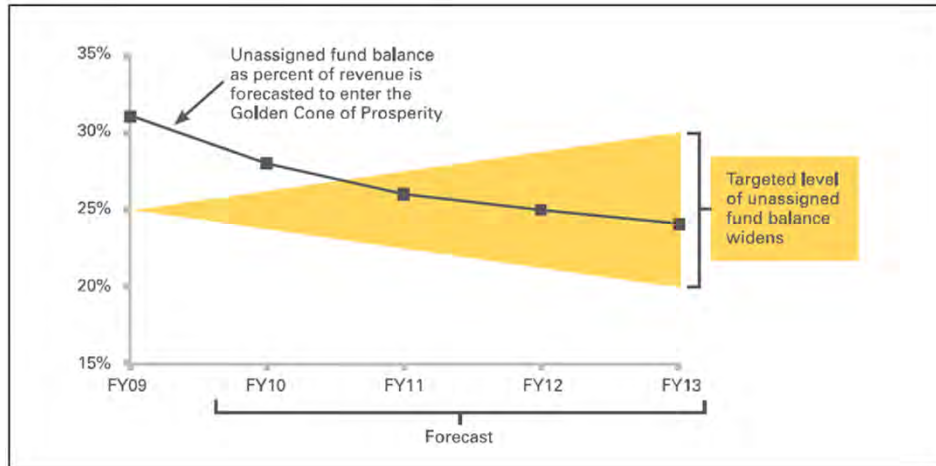








## The Golden Cone of Prosperity



## A Reserve is a Hedge Against Risk

***But how much is enough?***





## A Complete Definition of Risk\*

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**The probability and magnitude of a loss, disaster, or other undesirable event**

\*Definitions on this and previous slide from Doug Hubbard in *The Failure of Risk Management*



## Why We Need Probabilities

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“Without numbers, there are no odds and no **probabilities**; without odds and **probabilities**, the only way to deal with risk is to appeal to the gods and the fates. Without numbers, risk is wholly a matter of gut.”

-Peter Bernstein, *Against the Gods: The Remarkable Story of Risk*





## Why Not Go With the Gut?

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What will the next color be?



vs.



## Cognitive Biases

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- **Overconfidence bias.** We are overconfident in our predictions and underestimate uncertainty. Research shows we usually underestimate uncertainty by around 50%.
- **Availability bias.** Details that are more easily recalled are overweighed when assessing risk.
  - Example: Flood insurance
- **Confirmation bias.** Random patterns will be taken as evidence if they match an expectation.

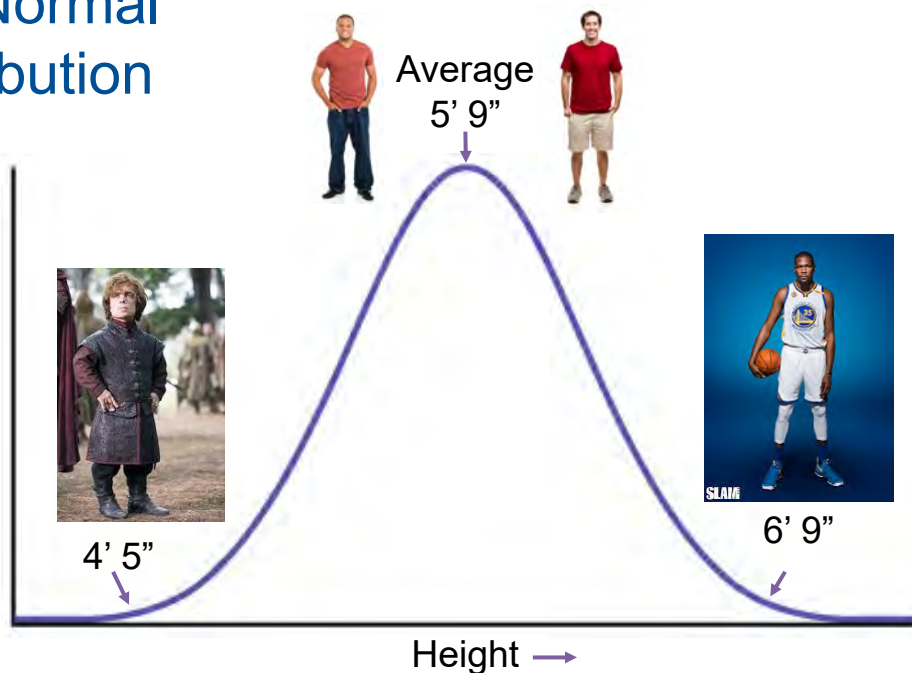


## Beware the “Flaw of Averages”\*

- Averages condense down a range of possibilities into a “convenient” single number
- This obscures the variation you are subject to
- Variation is a source of uncertainty
- Understanding uncertainty is key to understanding risk

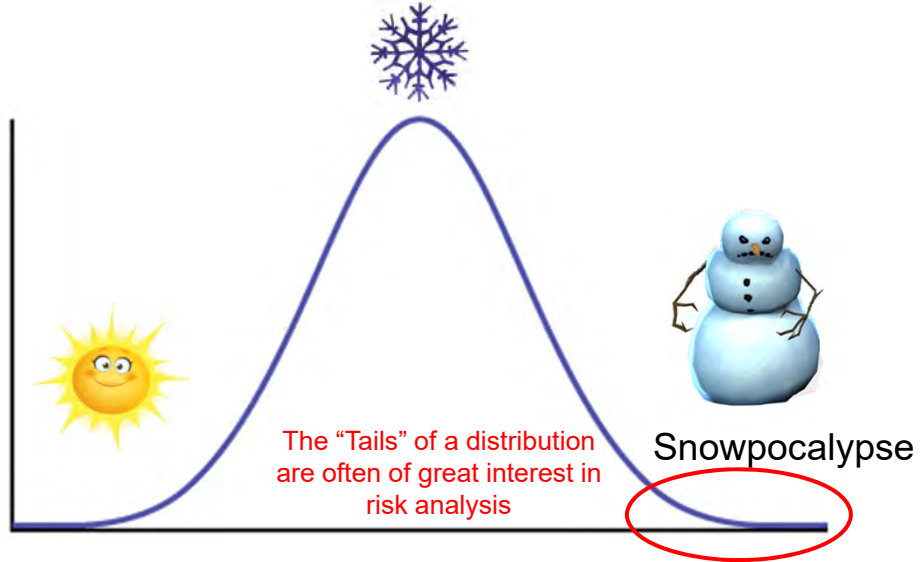
\*See Sam Savage, *The Flaw of Averages*, 2009

## The Normal Distribution

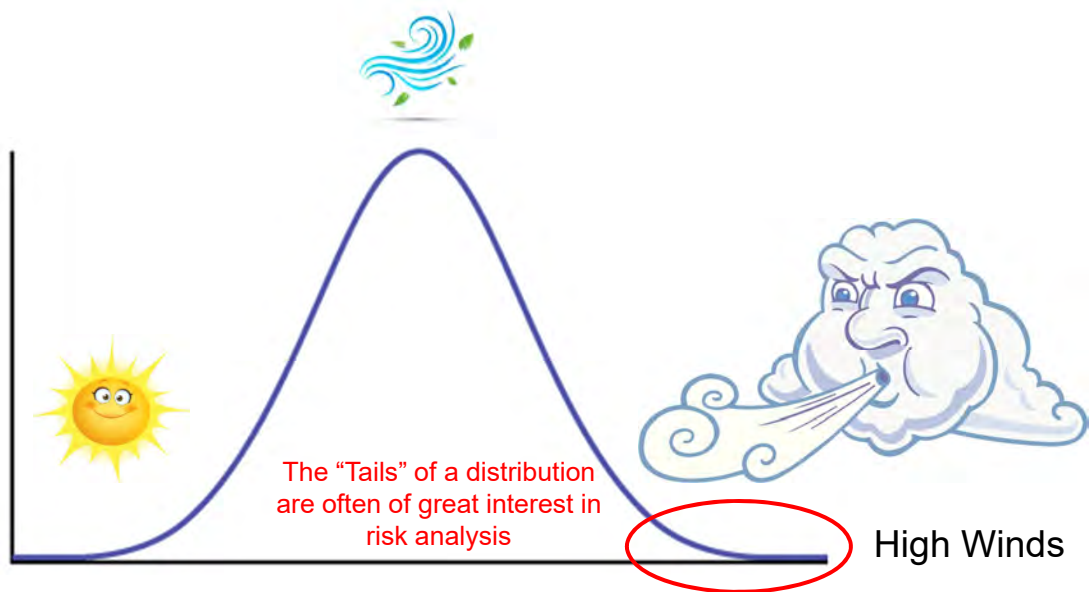




## Normal Distribution in Cities



## Normal Distribution in Cities

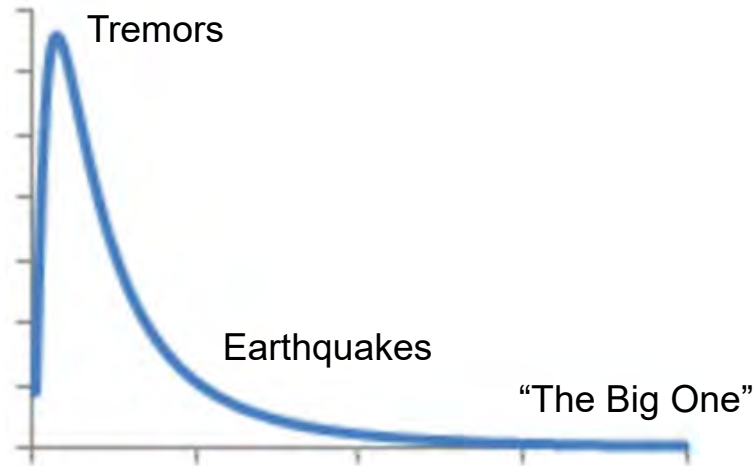




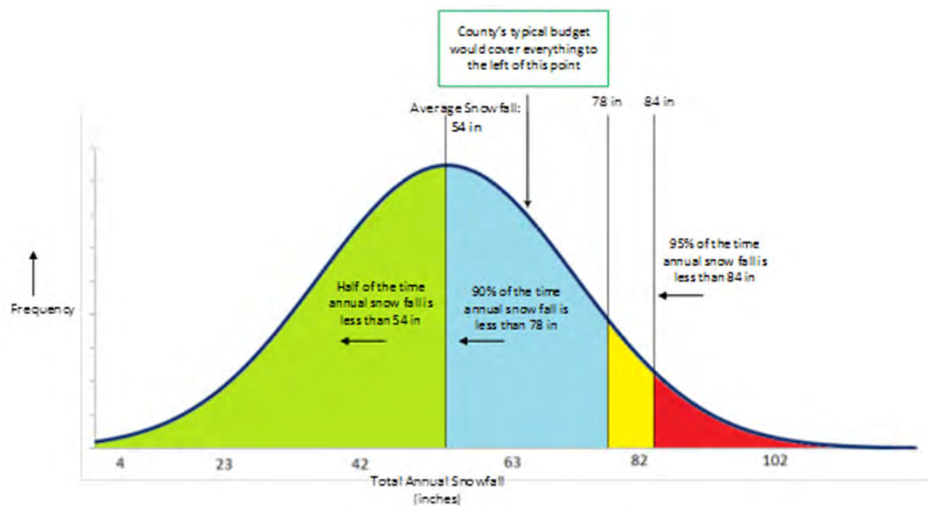


# Asymmetrical Distribution

## Earthquakes



# "Subway" Uncertainty\*

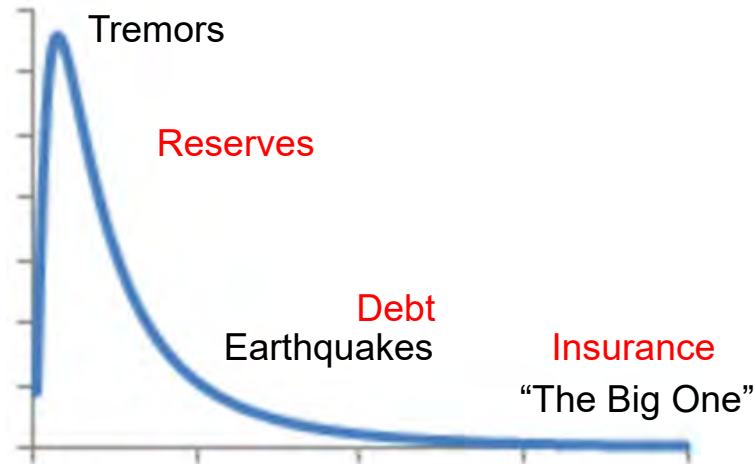


\*Terminology from Spyros Mikridakis, et al. *Dance with Chance*



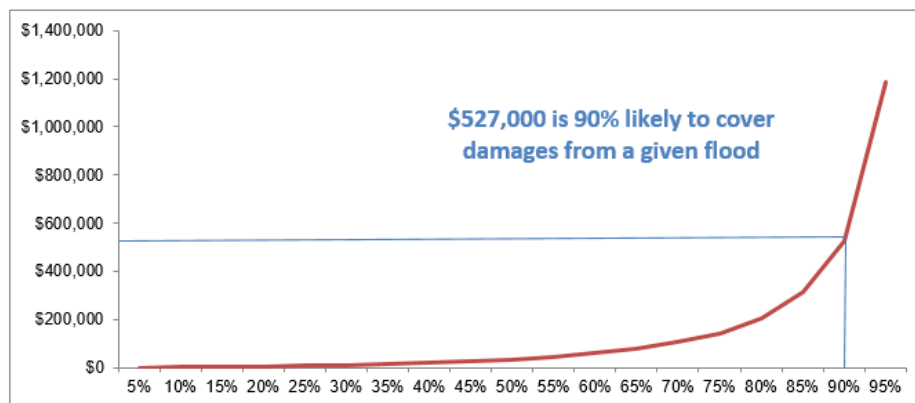
# “Meteorite” Uncertainty

## Earthquakes



# Cumulative Probability Chart

## Floods





# Risks aren't Additive

Likelihood of covering the extreme event	Hazardous Materials	Wildfires	Total (New Distribution of Total Risk)	Total (Simple Sum of Individual Risks)
90%	\$3.1 million	\$2.5 million	\$4.7 million	\$5.6 million
95%	\$3.5 million	\$2.8 million	\$5.2 million	\$6.3 million
99%	\$4.1 million	\$3.2 million	\$6.1 million	\$7.3 million



# Probability of Extreme Events over Various Time Horizons

## Poisson Distribution

		Time Horizon				
		1 year	2 Years	3 Years	4 Years	5 Years
Number of Extreme Events that Occur	0	81.9%	67.0%	54.9%	44.9%	36.8%
	1	16.4%	26.8%	32.9%	35.9%	36.8%
	2	1.6%	5.4%	9.9%	14.4%	18.4%
	3	0.1%	0.7%	2.0%	3.8%	6.1%
	4	0.0%	0.1%	0.3%	0.8%	1.5%
	5	0.0%	0.0%	0.0%	0.1%	0.3%

# The Method



## Triple-A Approach to Uncertainty

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- **Accept**
  - Uncertainty is inevitable
- **Assess**
  - Find potential impact, using reference cases – historical or analogues
- **Augment**
  - Uncertainty will usually be underestimated!



## Probability Management

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- Open-source standard for probabilistic analysis
- Works in 100% native Microsoft Excel
  - Free set of tools gives you shortcuts
- Makes “Monte Carlo” analysis more accessible than ever before

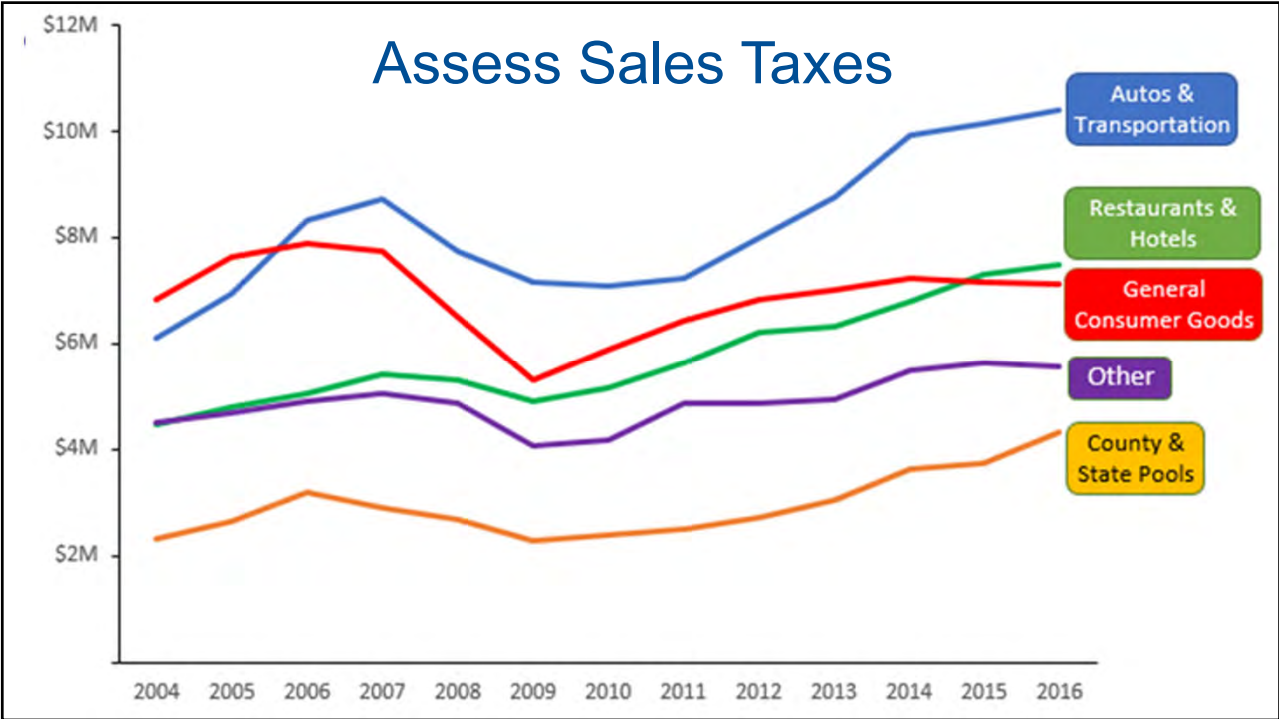
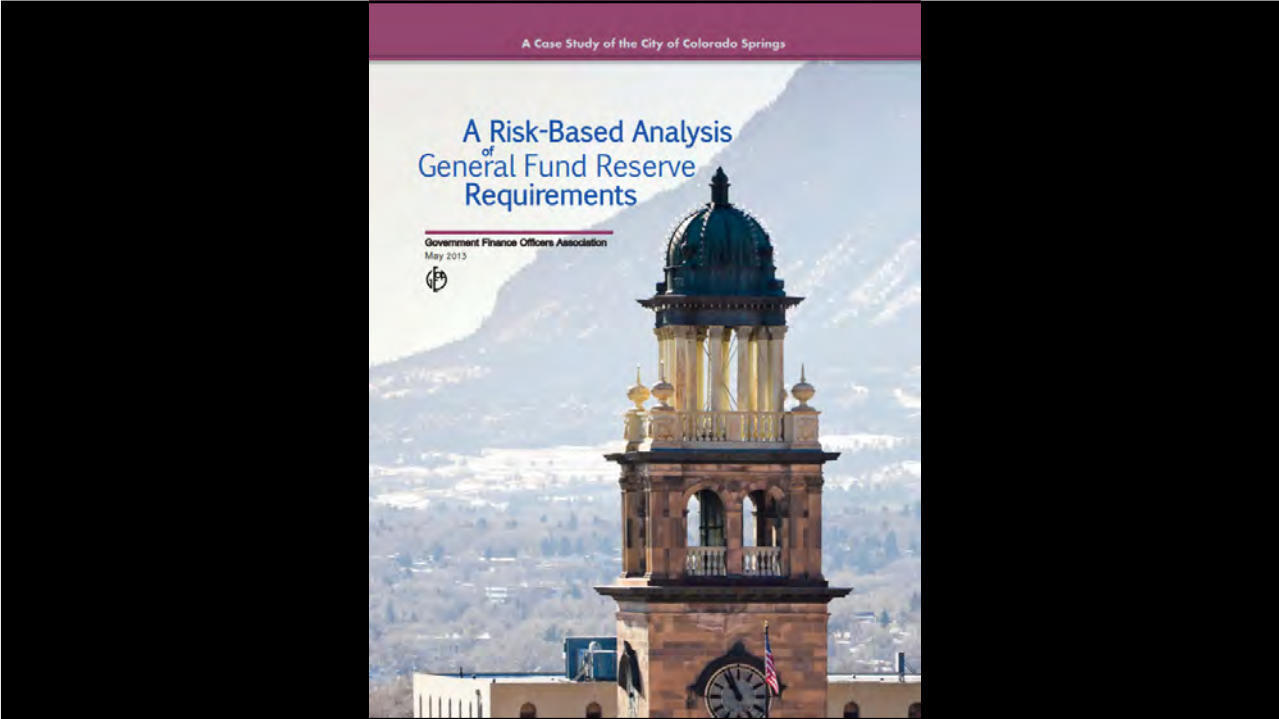


## Monte Carlo Analysis

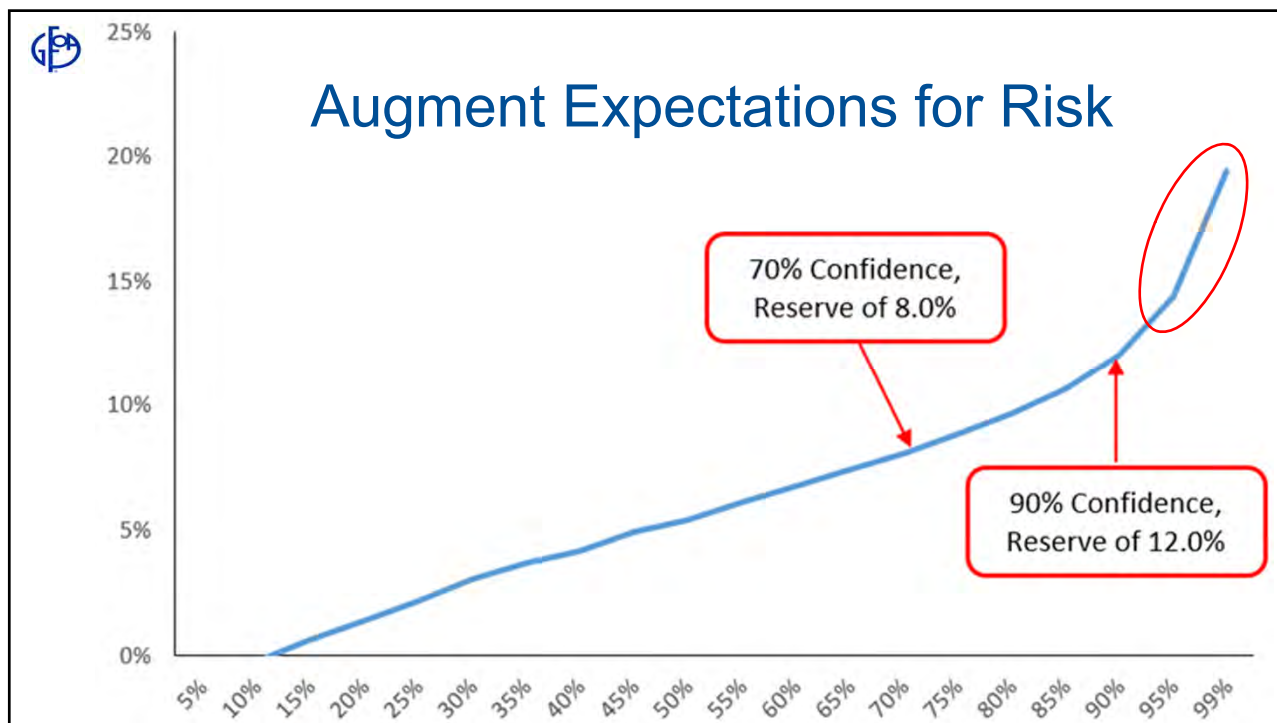
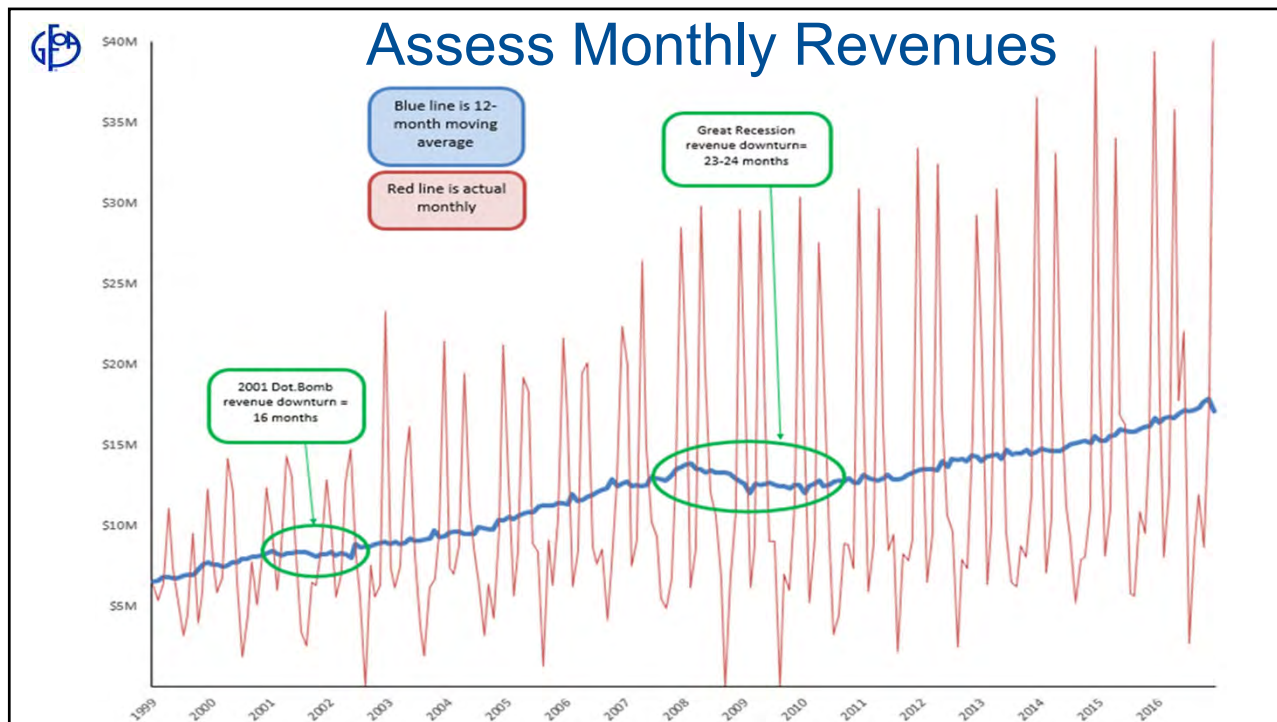
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- Computerized equivalent of developing your own custom set of dice to represent the likelihood of an undesirable event, and then rolling them thousands of times to see what happens









# The Model

