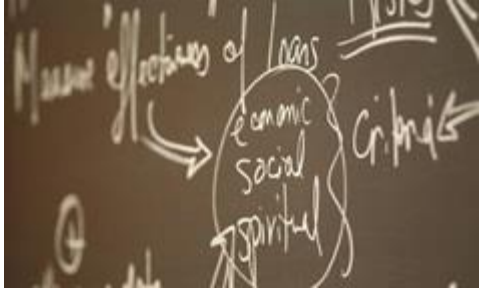


HARVARD | BUSINESS | SCHOOL

Investing in Resilience: Probability, Structures, and Capital

Interactive Discussion

Prof. John Macomber
Finance Unit, Harvard Business School
August 8, 2019

TAMPA BAY REGIONAL PLANNING COUNCIL

The Nature Conservancy

Investing in Resilience

Objectives

- Introduce analytical tools for attracting finance toward resilience
- Practice several situations
- Have an interactive discussion Harvard Business School Case Method style
- (This is not a lecture: YOU are the leaders)
- Draw out your experience

Agenda

- Context
- Mary, Nancy, and The Bank
- Investing in Resilience
- Probability, Expected Value, When to do what? - Techniques
- Sources of Funds; Techniques
- Revisit Sources Toolkit; discuss

Mexico Beach, Florida, Oct 10th, 2018 (AP)

The New York Times

March 28, 2019

25 States Are at Risk of Serious Flooding This Spring, U.S. Forecast Says

Flooding in Hamburg, Iowa, on Monday. Tim Gruber for The New York Times

Menu | The Boston Globe | Business | **Breaking:** Slowdowns affect highways

Report offers ideas for a Boston beset by rising seas

Envisions canals, fortifications

Sea rise could bring a Clarendon Canal and other flood controls. (Michael Wang, Arlen Stawasz, and Dennis Carlberg)

Santa Rosa, CA Wildfires 2018 (AP)

The Boston Globe

Exxon suffers a big setback in climate-change case involving its Everett oil terminal

JOHN TLUMACKI/GLOBE STAFF/FILE

The Conservation Law Foundation says ExxonMobil hasn't adequately protected its Everett petroleum terminal (above) from potential floods caused by storms and rising sea waters that could sweep pollutants off the site.

Boston
March 30, 2019

Dismissing the risks of climate change didn't turn out to be as easy as Exxon-Mobil lawyers had hoped.

CLF's lawsuit, A lawsuit filed by the Conservation Law Foundation… among other things, accuses Exxon of failing to adequately protect the property from potential floods caused by storms and rising sea waters that could sweep pollutants off the site.

The closely-watched lawsuit could have ripple effects that influence the broader oil industry and how it prepares for future storms.

Consider a simple setup: Small shop owner whose building is self insured. Bank which retains mortgages.

- Mary thinks her building is worth $600,000 (mortgage = $500,000)
- One year probability of event that destroys it = 1% (1/100)
- Redrawn Base Flood Elevations (BFE) indicate much higher exposure than was previously believed…
- Now that probability is 5% (1/20)
- On EV and NPV basis, this means she is now in violation of LTV clause.
- Should Mary move, sell, "harden" the building, or do nothing?
- Hardening costs $50,000 for 100% certainty

- Nancy's bank holds the mortgage on Mary's store building
- Mary is now violation of BFE rider… and also LTV covenant on an EV NPV basis (no insurance in this simple story).
- Should Nancy foreclose?
- When Mary's note comes due in two years, should Nancy refinance? With what terms?
- OR should Nancy's bank offer a new financial product that loans Mary the $50,000 for resilience work?

What would cash flow look like for an investment in “resilience?”

Investing in Resilience: "Compared to what other choice?"
Think of "vulnerable" cash flows in three simple scenarios:
A) baseline, B) unprotected, and C) with "investment in resilience."

Scenario "A": No resilience investment, no bad event						
Year	0	1	2	3	4	Total
Baseline Investment	(20)					(20)
Additional Resilience Investment	0					0
Cash Flow from Operations		20	20	20	20	80
Stress Event: Cost		0	0	0	0	0
Net Cash Flow						**60**

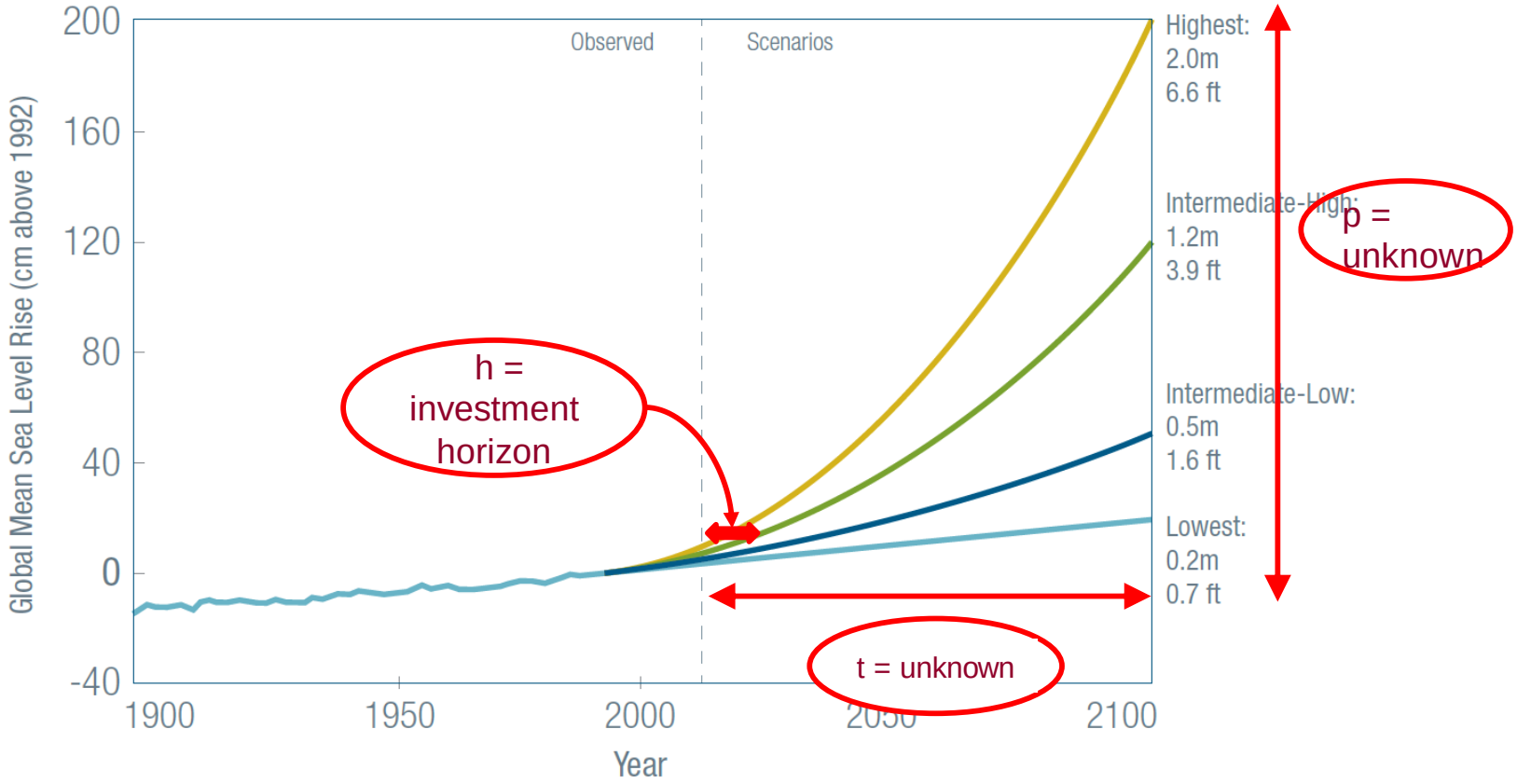
Scenario "B": No resilience investment, a bad event						
Year	0	1	2	3	4	Total
Baseline Investment	(20)					(20)
Additional Resilience Investment	0					0
Cash Flow from Operations		20	20	**10**	**10**	60
Stress Event: Cost		0	0	**(30)**	**0**	(30)
Net Cash Flow						**10**

Scenario "C": Investment up front in resilience/adaptation, a bad event						
Year	*0*	*1*	*2*	*3*	*4*	*Total*
Baseline Investment	(20)					(20)
Additional Resilience Investment	**(10)**					(10)
Cash Flow from Operations		20	20	**20**	20	80
Stress Event: Cost		0	0	**(10)**	0	(10)
						40

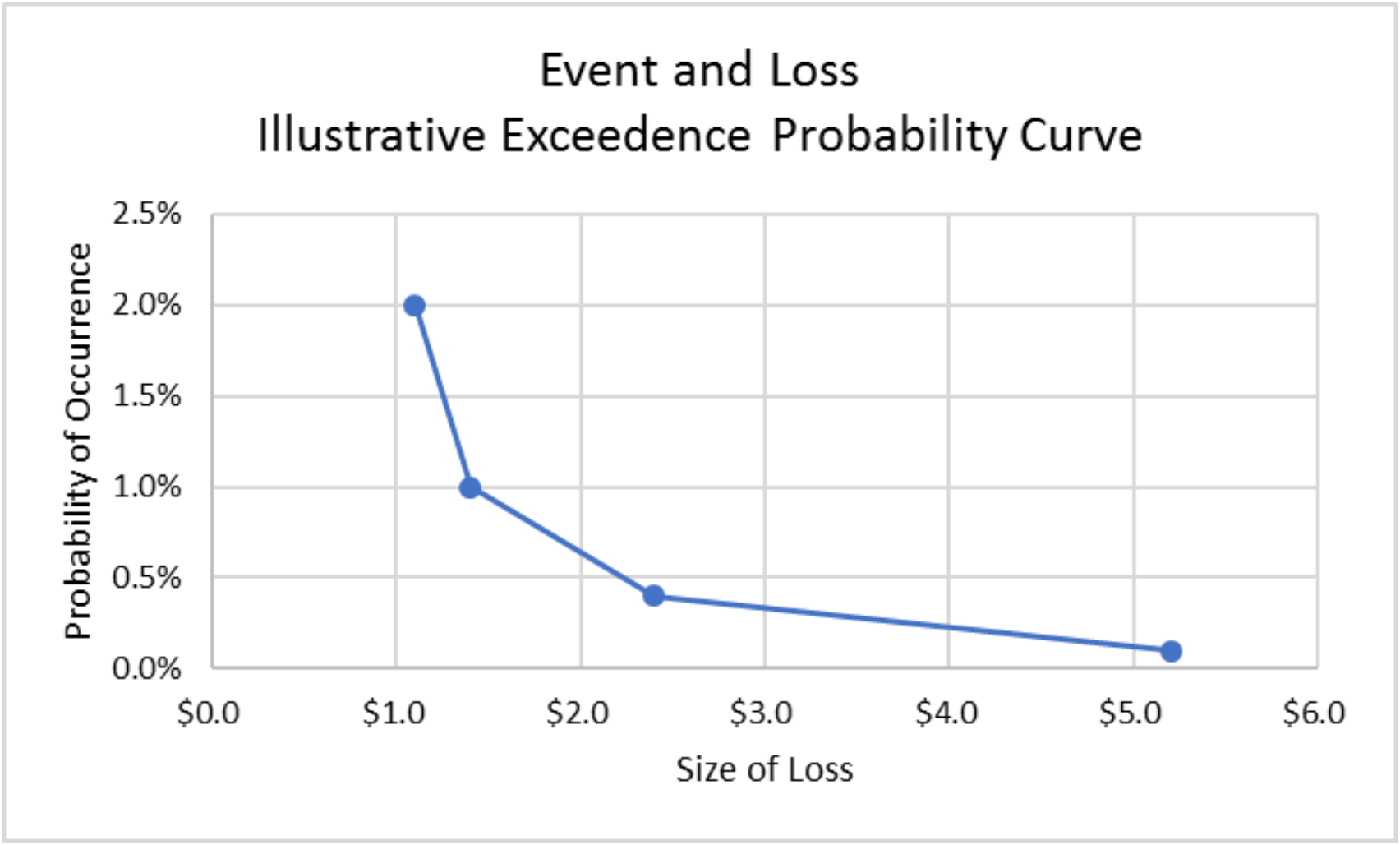
But…
Cost. Uncertainty. Time.

We don't know the future.
Everything (in resilience finance) is a matter of probabilities.
There are many scenarios, and they vary by location.

From ULI Boston Living with Water: Projections of sea level rise from 2010 to 2100,based on US National Climate Assessment 2012.7



Think like an insurance company.
"What might happen and how bad could it be?"



What if “we” could calculate benefit/cost ratio, and when to *invest to shift the exceedance curve*?

For example, would a more resilient design:

a) reduce the amount of the loss and/or

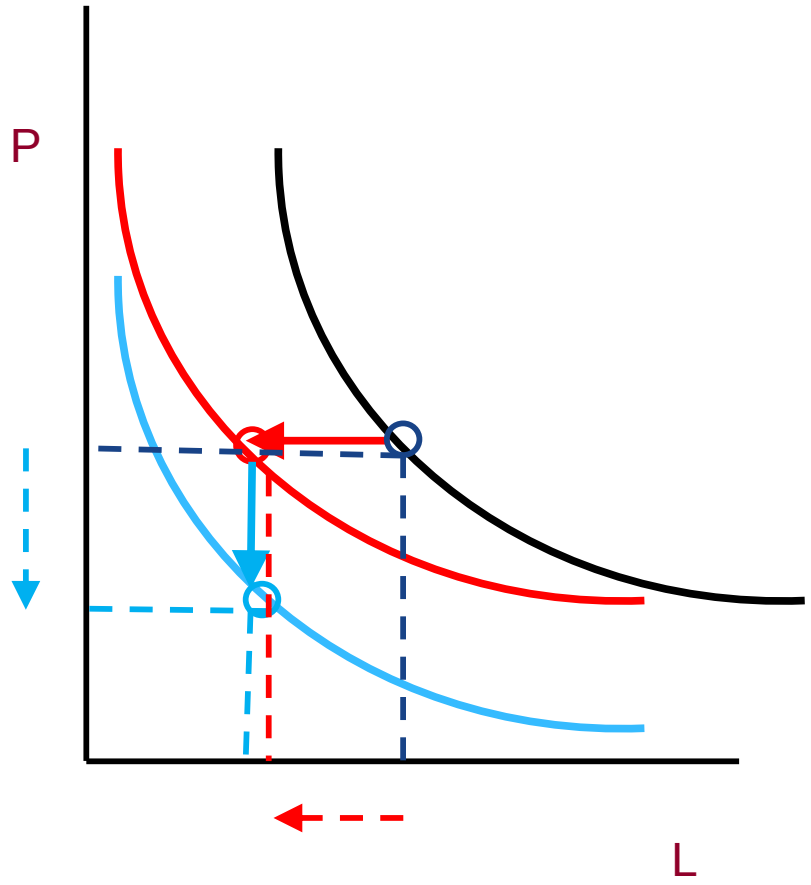
b) reduce the probability of loss?

Would investors be attracted to a less vulnerable asset if the **incremental investments** and outcomes were **expressed monetarily**?

Can the **favorable cash flow** stream related to **avoided cost** be monetized?

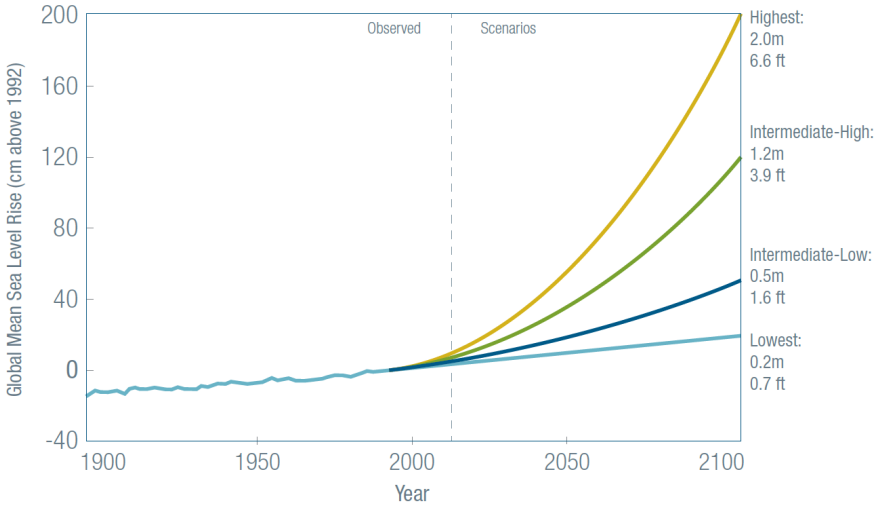
Can these be done **asset by asset** (cash flow by cash flow)?

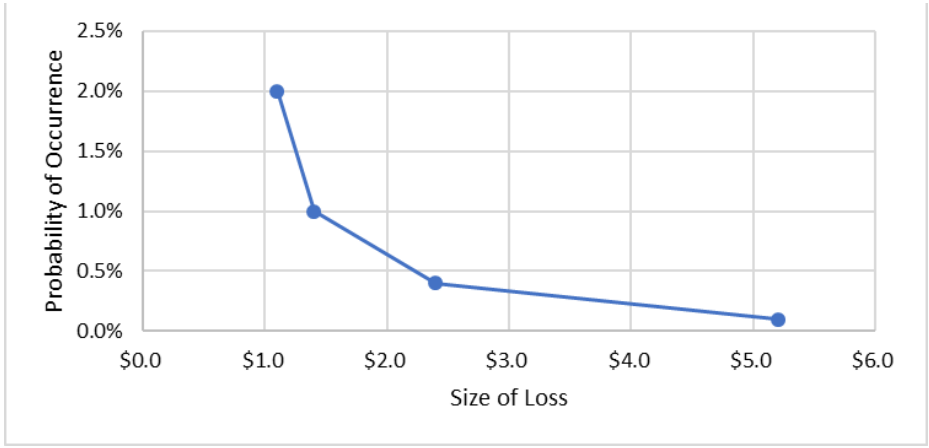
Should/will **rating agencies** look at climate vulnerability in addition to debt service coverage ratio and loan to value ratio?



Using climate models…

…an exceedance curve can be generated for any of the points on the IPCC sea level rise curve and any location.





Example of…

….three waste treatment plants in Miami. These plants also are facing a required environmental upgrade. Should they be reinforced, moved, or nothing?

HARVARD Kennedy School
JOHN F. KENNEDY SCHOOL OF GOVERNMENT

KS1212

Case Number 2084.0

Miami-Dade County and Sea Rise

In April 2013, Miami-Dade County Mayor, Carlos Gimenez was at the center of a controversial battle between the County government and environment advocates.

After months of work, Gimenez was on the verge of successfully negotiating a complex 1.5 billion dollar agreement with federal and state governments to upgrade and improve the county's aging sewerage system that was prone to flooding from storm surges.

In recent years, the pipes and pumps carrying raw sewage and the facilities that treated the county's waste had corroded and decayed to such an extent that Miami-Dade illegally discharged waste more than 260 times between 2006 and 2012,[1] violating the US Clean Water Act (CWA). In late 2012, facing fines and court action from both the State of Florida and the US Environmental Protection Agency (EPA), the County government and its Water and Sewage Department (WASD) entered into negotiations with state and federal officials on the scope and content of a consent decree under which the County would agree to fix and upgrade its sewerage system.

Illustrative Infrastructure: Miami, FL
Virginia Key WWTF is one of three plants in question

Three plants all have need for environmental upgrades in the billions of $$ even before considering possible flooding.

Good money after bad to do the upgrades in situ?

Move all three inland where not exposed, and also do the upgrades? Also a several billion $$ choice.

Baseline Capex assumptions (engineering) and potential losses (recovery costs) (economics)

	A	B	C	D	E	F
1	Miami-Dade County and Sea Rise					
2	Financial Supplement and Insurance Worksheet					
3	Billions of dollars					
4			Capex Inputs:		Losses: Recovery Costs	
5			Required	Optional		
6			Environment	Climate		
7			Upgrade	Resiliency	Direct	Related
8	Do Nothing		5.0	0.0	10.0	15.0
9	Build Minor Defenses		6.0	2.0	8.0	10.0
10	Relocate Plants		3.0	10.0	0.0	3.0
11						

Probabilities for one point on an illustrative probability curve

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Miami-Dade County and Sea Rise													4/2/2017
2	Financial Supplement and Insurance Worksheet													
3	Billions of dollars													
4			Capex Inputs:		Losses: Recovery Costs			Probabilities					(Note that insurance coverages are most effective in the face of extreme events. South Florida is also exposed to slow moving "sunny day" sea level rise that is harder to insure against).	
5			Required	Optional				Probability of Event, Annual:			2.0%			
6			Environment	Climate				Duration of Analysis, Years:			25			
7			Upgrade	Resiliency	Direct	Related								
8	Do Nothing		5.0	0.0	10.0	15.0		Insurance						
9	Build Minor Defenses		6.0	2.0	8.0	10.0		Coverage as % of Exposure			80.0%			
10	Relocate Plants		3.0	10.0	0.0	3.0		Ins Co Markup on Probability			1.0%			
11														

Three engineering and investment choices.
One year expected value of each choice
(We are looking for low expected values, these are costs)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Miami-Dade County and Sea Rise													4/2/2017
2	Financial Supplement and Insurance Worksheet													
3	Billions of dollars													
4			Capex Inputs:		Losses: Recovery Costs			Probabilities					(Note that insurance	
5			Required	Optional				Probability of Event, Annual:			2.0%		coverages are most	
6			Environment	Climate				Duration of Analysis, Years:			25		effective in the face of	
7			Upgrade	Resiliency	Direct	Related							extreme events. South	
8	Do Nothing		5.0	0.0	10.0	15.0		Insurance					Florida is also exposed to	
9	Build Minor Defenses		6.0	2.0	8.0	10.0		Coverage as % of Exposure			80.0%		slow moving "sunny day"	
10	Relocate Plants		3.0	10.0	0.0	3.0		Ins Co Markup on Probability			1.0%		sea level rise that is harder	
11													to insure against).	
12	A: ONE YEAR		Climate	Required	Added				Direct	Related	Total	1 year		1 year EV
13	NO INSURANCE		Investment	Environ.	Climate		Total	Event??	Recovery	Disaster	Cost	Event Prob	(Extend	Expected
14			***Choice***	Investment	Investment		Investment		Cost	Costs	Exposure	2%	Math)	Value
15			Do	5.0	0.0		5.0	yes	10.0	15.0	**30.0**	2%	0.6	
16			Nothing					no	0.0	0.0	**5.0**	98%	4.9	5.5
17														
18	Starting		Minor	6.0	2.0		8.0	yes	8.0	10.0	**26.0**	2%	0.5	
19	Value		Defenses					no	0.0	0.0	**8.0**	98%	7.8	8.4
20	1.0													
21			Relocate	3.0	10.0		13.0	yes	0.0	3.0	**16.0**	2%	0.3	
22								no	0.0	0.0	**13.0**	98%	12.7	13.1

What should Mayor Giminez do?

Same three engineering and investment choices to make today.
MULTI-year expected value of each choice.
(We are looking for low expected values, these are costs)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Miami-Dade County and Sea Rise													4/2/2017
2	Financial Supplement and Insurance Worksheet													
3	Billions of dollars													
4			Capex Inputs:		Losses: Recovery Costs			Probabilities						
5			Required	Optional				Probability of Event, Annual:			2.0%			
6			Environment	Climate				Duration of Analysis, Years:			25			
7			Upgrade	Resiliency	Direct	Related								
8	Do Nothing		5.0	0.0	10.0	15.0		Insurance						
9	Build Minor Defenses		6.0	2.0	8.0	10.0		Coverage as % of Exposure			80.0%			
10	Relocate Plants		3.0	10.0	0.0	3.0		Ins Co Markup on Probability			1.0%			
11														
23														
24	B: MULTI YEAR		Years =	25.0										
25	NO INSURANCE		Cumul Prob =	39.65%	(without discounting for time)									
26			Climate	Required	Added				Direct	Related	Total	25		Multi Year
27			Investment	Environ.	Climate		Total	Event??	Recovery	Disaster	Cost	Multi Year	(Extend	Expect Val
28			***Choice***	Investment	Investment		Investment		Cost	Costs	Exposure	Event Prob	Math)	("per year")
29												39.65%		
30			Do	5.0	0.0		5.0	yes	10.0	15.0	**30.0**	40%	11.9	
31			Nothing					no	0.0	0.0	**5.0**	60%	3.0	14.9
32	Starting													
33	Value		Minor	6.0	2.0		8.0	yes	8.0	10.0	**26.0**	40%	10.3	
34	1.0		Defenses					no	0.0	0.0	**8.0**	60%	4.8	15.1
35														
36			Relocate	3.0	10.0		13.0	yes	0.0	3.0	**16.0**	40%	6.3	
37								no	0.0	0.0	**13.0**	60%	7.8	14.2

What should Mayor Giminez do?

What if:
Probability of an event goes up (IPCC curve)
Cost of the resilience investment goes down (clever engineering)

Miami-Dade County and Sea Rise — 4/2/2017
Financial Supplement and Insurance Worksheet
Billions of dollars

	Capex Inputs: Required Environment Upgrade	Capex Inputs: Optional Climate Resiliency	Losses: Recovery Costs Direct	Losses: Recovery Costs Related
Do Nothing	5.0	0.0		15.0
Build Minor Defenses	6.0	2.0		
Relocate Plants	3.0	8.0		

Probabilities	
Probability of Event, Annual:	4.0%
Duration of Analysis, Years:	25
Insurance	
Coverage as % of Exposure	80.0%
Ins Co Markup on Probability	1.0%

Was 2.0%

Was 10.0

B: MULTI YEAR — Years = 25.0
NO INSURANCE — Cumul Prob = 63.96% (without discounting for time)

Starting Value	Climate Investment Choice	Required Environ. Investment	Added Climate Investment	Total Investment	Event??	Direct Recovery Cost	Related Disaster Costs	Total Cost Exposure	25 Multi Year Event Prob	(Extend Math)	Multi Year Expect Val ("per year")
									63.96%		
	Do	5.0	0.0	5.0	yes	10.0	15.0	30.0	64%	19.2	
	Nothing				no	0.0	0.0	5.0	36%	1.8	21.0
1.0	Minor	6.0	2.0	8.0	yes	8.0	10.0	26.0	64%	16.6	
	Defenses				no	0.0	0.0	8.0	36%	2.9	19.5
	Relocate	3.0	8.0	11.0	yes	0.0	3.0	14.0	64%	9.0	
					no	0.0	0.0	11.0	36%	4.0	12.9

Now what should Mayor Giminez do?

Downtown Miami Waterfront

CITY OF MIAMI, FLORIDA

ULI ADVISORY SERVICES

JUNE 7, 2019

Design Introduction

- What does resilient mean in a design context? Resilience is complex, contradictory, it evolves over time. There's no one single answer.
- One Waterfront. The panel's goal for the Bay Walk and River Walk is to develop a cohesive strategy to address the different needs of these two distinct stretches of waterfront.
- Resilient design knows no boundaries. The waterfront isn't the only place where design matters for a resilient city. The high ground also plays a critical role.

But what about investment choices, probabilities, time frame, and range of damage impacts?

In this illustration, there are three courses of action with respect to investing in resilience:

1. Do nothing

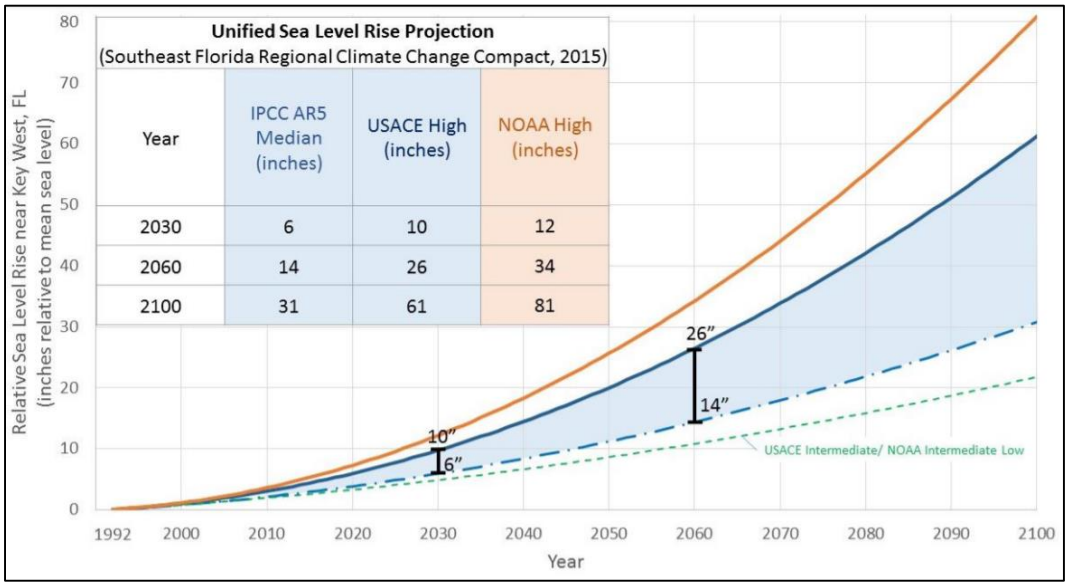
2. Invest at one level

(in the order of magnitude of $50-100 million for the level of protection indicated in the Baywalk design

3. Invest at a higher level

(in the order of magnitude of $500 million to $1billion in robust defenses like a tidal gate at the river and high wing walls).

(For all of these investments there are multiple sources of funds ranging from USACE to city to private landowners to philanthropy, as will be presented subsequently).



Source: MDDA, courtesy Southeast Florida Regional Climate Change Compact

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Illustration of a probability - adjusted model of three investment levels and three types of floods/storms.

Assumptions:

(Millions of dollars)

Resilience Investment	**Cost Budget Midrange**	**Event Damages Exposure: *Uninsured* Losses with this defense:**		
		No Event	High tides, Cat 1	Cat 5 at King Tide
Nothing	0	0	500	5,000
Medium (Baywalk)	50	0	250	4,000
Robust (Tidal Barrier)	500	0	100	500

	No Event	High tides, Cat 1	Cat 5 at King Tide
Event Probability (Annual)	94.0%	5.0%	1.00%
Length of Study (Years)	25	25	25
Event Probability (In study period)	100.0%	72.3%	22.2%

Downtown Miami:
Illustration of a probability - adjusted model of three investment levels and three types of floods/storms.

Expected Value Math:

Protection Choice:	Investment	Event?	Long Run Probability	Losses	Prop Wtd Extend	Expected Value ***Cost*** This Choice (Millions)
		Big	22.2%	5,000	1,111	
1. Do Nothing	0	Med	72.3%	500	361	$1,472
		Small	100.0%	0	0	
		Big	22.2%	4,000	889	
2. Midrange	50	Med	72.3%	250	181	$1,219
		Small	100.0%	100	100	
		Big	22.2%	500	111	
3. Robust	500	Med	72.3%	100	72	$683
		Small	100.0%	0	0	

Underpinning: The Weather and the Losses (supporting the prior slide)

What could happen?

For the sake of argument, assume for simplicity that three basic weather scenarios could unfold over the next 25 years:

- No important weather events
- A series of king tides, rain bombs, low grade hurricanes
- A big hurricane during a king tide

These all have different probabilities of occurring.

What would the damages be for each investment choice in each storm situation?

Economic costs from uninsured losses would include **direct costs of rebuilding, indirect costs of being out of business or displaced from home, and human costs like job loss and public health problems**. The vulnerability is largely inland along the Miami River. These impacts are hard to gauge but *for a big hurricane during a king tide*, history shows that uninsured losses could be in these ranges:

Investment 1 (nothing), these would be huge - probably on the order of $5 -7 billion in the study area. Consider the market values and economic values discussed above; this is a big deal and the exposure is real.

Investment 2 (something) these would still be huge.

Investment 3 (robust), there is a high level of protection and uninsured losses would be much less.

Outside forces 1:

THE WALL STREET JOURNAL.

Climate Change Could Swamp Your Muni-Bond Portfolio

California localities warn of disaster when suing oil companies. So how come they don't tell investors?

San Francisco in 2015. PHOTO: DAVID PAUL MORRIS/BLOOMBERG NEWS

By Jay Newman

Feb. 2, 2018 6:20 p.m. ET

176 COMMENTS

By the end of this century Oakland, Calif., will be experiencing a "100-year flood" every week. At least that's what the Oakland city government argued last year, when it filed a lawsuit against several oil companies for contributing to climate change. The city forecasts that rising water levels in the San Francisco Bay will threaten the sewer system and other property "with a total replacement cost of between $22 billion and $38 billion."

Suppose you hold some of Oakland's municipal bonds. This climate apocalypse sounds like a serious risk, right? Yet a recent prospectus for Oakland's general-obligation bonds shrugs off the threat. "The City is unable to predict when seismic events, fires or other natural events, such as sea rise or other impacts of climate change or flooding from a major storm, could occur," the prospectus states. And even if such events occur, the city can't be sure "whether they will have a material adverse effect on the business operations or financial condition of the City or the local economy."

Urban Land Institute

Outside forces 2:

Bloomberg

Climate-Changed

Moody's Warns Cities to Address Climate Risks or Face Downgrades

By Christopher Flavelle
November 29, 2017, 4:00 AM EST

- Communities in Texas, Florida, other coastal states at risk
- Credit rating agency says it's adding climate to credit risks

Coastal communities from Maine to California have been put on notice from one of the top credit rating agencies: Start preparing for climate change or risk losing access to cheap credit.

In a report to its clients Tuesday, Moody's Investors Service Inc. explained how it incorporates climate change into its credit ratings for state and local bonds. If cities and states don't deal with risks from surging seas or intense storms, they are at greater risk of default.

"What we want people to realize is: If you're exposed, we know that. We're going to ask questions about what you're doing to mitigate that exposure," Lenny Jones, a managing director at Moody's, said in a phone interview. "That's taken into your credit ratings."

In its report, Moody's lists six indicators it uses "to assess the exposure and overall susceptibility of U.S. states to the physical effects of climate change." They include the share of economic activity that comes from coastal areas, hurricane and extreme-weather damage as a share of the economy, and the share of homes in a flood plain.

Based on those overall risks, Texas, Florida, Georgia and Mississippi are among the states most at risk from climate change. Moody's didn't identify which cities or municipalities were most exposed.

Read More: Rising Seas May Wipe Out Jersey Towns and Millions in AAA Bonds <https://www.bloomberg.com/news/articles/2017-05-25/investors-say-it-s-time-to-price-climate-into-cities-bond-risks>

Bond rating agencies such as Moody's are important both for bond issuers and buyers, as they assign ratings that are used to judge the risk of default. The greater the risk, the higher the interest rate municipalities pay.

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Revisit Toolkit items: Sources of funds?

Sea Level Rise and Potential Real Estate Values Losses by 2045 (Union of Concerned Scientists from Zillow 2018)

Community	Homes at Risk	Value at Risk	Property Tax at Risk
Miami Beach	12,095	$6,443,424,737	$91,013,636
Miami	5,718	$2,115,800,018	$28,542,062
Upper Keys	3,514	$1,838,699,914	$16,273,796
Bradenton	4,368	$1,837,661,024	$21,225,539
Key West	3,709	$1,675,527,450	$14,684,991
Lower Keys	3,415	$1,398,112,163	$12,975,389
West Palm Beach	771	$1,210,159,069	$17,281,943

Creation of Intergovernmental Entities to Fund Resilience

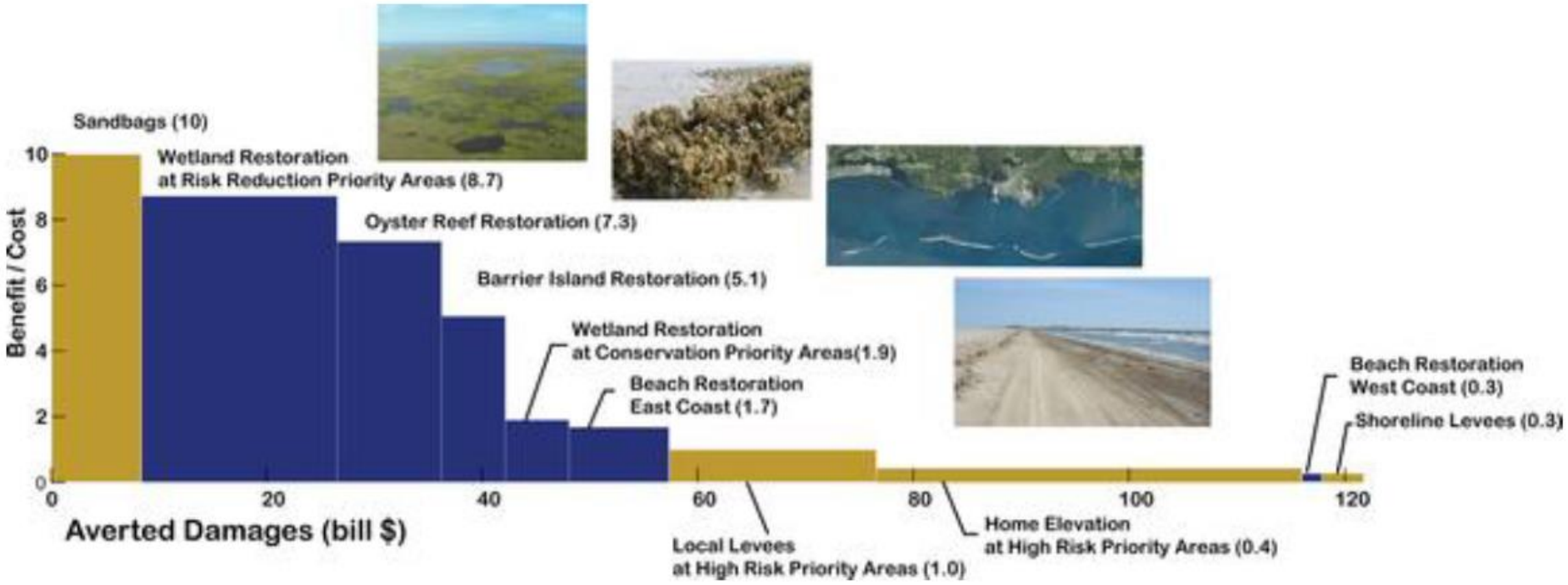
- The Florida Interlocal Cooperation Act of 1969, Section 163.01, F.S., authorizes local governments to enter interlocal agreements that allow them to exercise certain governmental powers, including "any power, privilege, or authority which such agencies share in common and which each might exercise separately."
- Entities have the power to issue bonds, issue contracts etc.
- Gulf Consortium example—Established to administer distribution of Deepwater Horizon settlement dollars.

The Nature Conservancy
Protecting nature. Preserving life.™

Infrastructure Sales Surtax

- Local option sales surtax levied by counties at rate of ½ to 1 cent to fund capital projects, acquire and restore land for conservation & recreation purposes.
- Resilience examples—Tallahassee Cascades Park used to fund downtown redevelopment project that addresses stormwater management problems. Proposal by Alachua County to fund deployment of solar on county land with use of proceeds.
- Equity issues of regressive sales tax.

Natural Climate Solutions Discussion



Coastal Flooding & Storms: Vulnerability and Resilience Taxonomy

Primary Choices in Policy and for Businesses, Investors, and Citizens
= ∫ (demographics, geography, engineering, economic value)

1. ***Rebuild***
   Funding: Insurance, Government, Self?
2. ***Reinforce (Hardening)***
   Equity, Debt, PPP < Investable
3. ***Rebound (bounce back)***
   Equity, Debt, PPP < Investable

1. ***Restrict***
   You can't live here…(because "we" know better…)
   (? So what is my asset worth now?)
2. ***Retreat***
   Voluntary, orderly, compensated < Investable
   Forced, involuntary, unplanned, unfunded
3. ***Nothing*** *(by far the main strategy at present)*

Also consider:

- Property rights
- Protection of the public
- Race
- Class
- Prevention: How implement? Everyone knows it's cheaper than recovery after.
- What is present value of a future loss event that might or might not occur?
- Market pricing, market failures
- Socialized costs (who pays when "the government" pays)?

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