



# Data-rich, information-poor: First steps toward 10-year targets

Network-level analysis work by early adopters of TAM Plans

Paul D. Thompson

# Background on TAM Plans

- Mandated by MAP-21 for pavements and bridges
- Among the required ingredients are:
  - Life cycle cost analysis
  - Risk analysis
  - Investment plan
- FHWA is developing guidance
  - About 15 states are early adopters
  - Some of them don't have fully-functional management systems



# Life cycle cost and Return on investment

8  
10  
12

# Life cycle cost analysis – Input data

- Quantity by condition state
- Deterioration rates
- Routine maintenance costs
- Corrective action application, costs, and effects
- Replacement cost



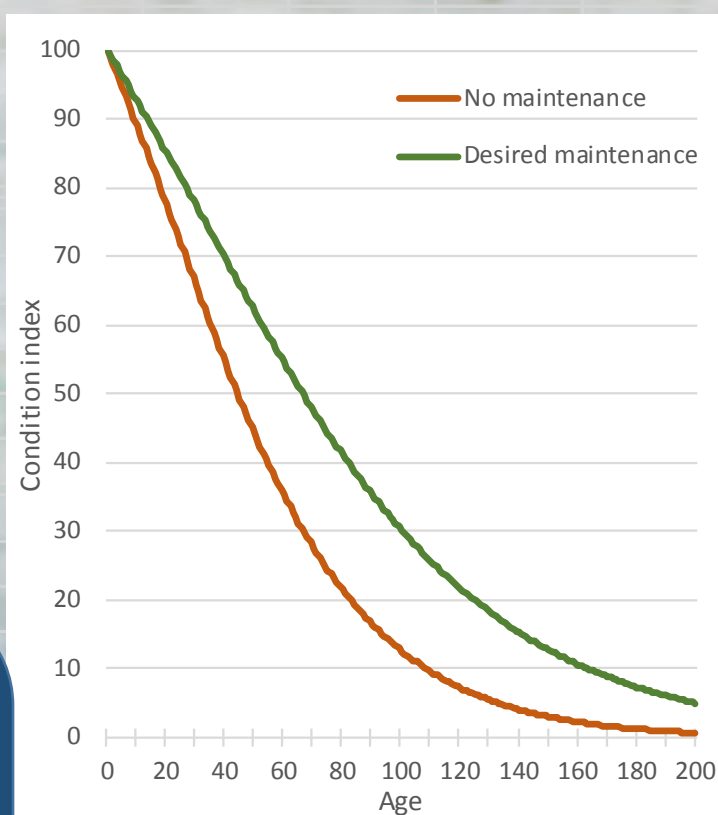
- Use NPRM definitions of Good and Poor for federal requirements
- Use element condition states for management

# General appraisal

General	Good	Satis	Fair	Poor	Total	
Number of bridges:	8542	4316	1335	434	14627	Deck area: 70,743,216 sq.feet
Condition index wt:	100	80	50	0		Indirect cost factor: 50%

Deterioration model	With no maint	Desired maint	Reality ✓
			Estimated life
Good (9 to 7):	12	18	No maintenance
Satisfactory (6):	23	35	61 years
Fair (5):	12	18	Desired maint
Poor (4 to 0):	--	--	91 years

Routine maintenance (cyclic or repair)	Units	\$/bridge	% bridges acted upon in a year				Reality ✓	Interval
Treatment			Good	Satis	Fair	Poor	(\$M/yr)	(years)
Cleaning								20
Sealing								



Effectiveness - State probability after action				
Good	Satis	Fair	Poor	Sum
40%	50%	10%		100%
50%	40%	10%		100%
				0%
				0%
				0%
100%				100%

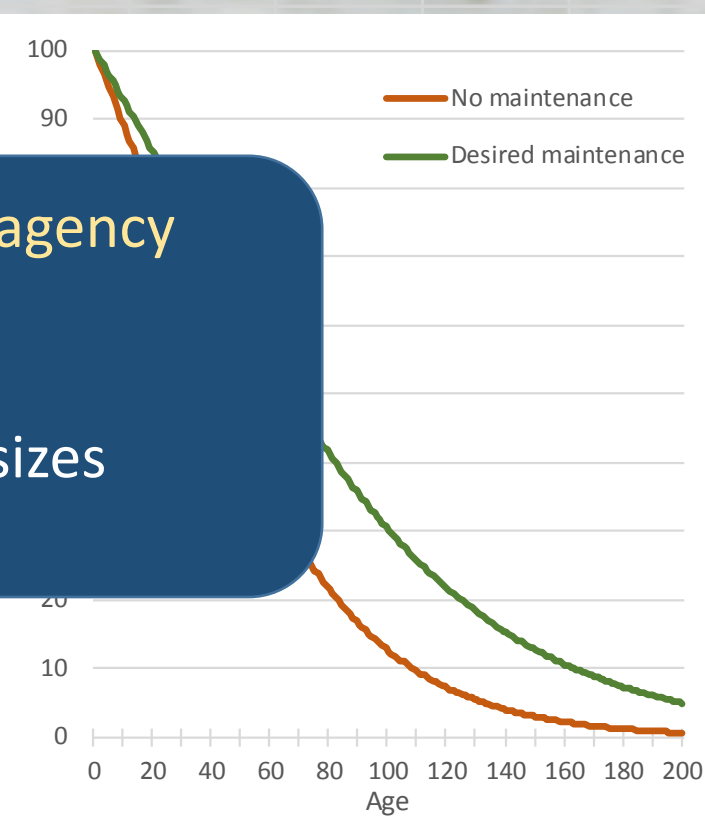
**Deterioration expressed as median transition times**

- Expert judgment informed by research
- Research often not in a form easily used for this purpose
- Element-level condition and deterioration would produce more reliable results

Corrective action	Units	\$/bridge	Good	Satis	Fair	Poor	Reality ✓
Concrete patching							
Steel repair							
Other							
Other							
Other							
Bridge replacement							
Total percent							
Annual cost per bridge			0	725	7255	4353	34.99

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**Actions and costs based on agency estimation practice**

- Indirect costs included
- Based on typical project sizes

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Good (9 to 7):	12	18
Satisfactory (6):	23	35
Fair (5):	12	18
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Routine maintenance (cyclic or reactive)		Units per									
Treatment	Units	\$/unit	bridge	\$/bridge	Good						
Cleaning	bridge	1500.00	1	1,500	50%	50%	50%	50%	10.97	2.0	
Sealing	sq.feet	1.46	4836	7,061	10%	10%	10%	10%	10.33	10.0	
Annual cost per bridge					2184	2184	2184	2184	21.30		

Corrective action and replacement		Units per	% bridges acted upon in a year				Reality ✓	Interval	Effectiveness - State probability after action						
Treatment	Units	\$/unit	bridge	\$/bridge	Good	Satis	Fair	Poor	(\$M/yr)	(years)	Good	Satis	Fair	Poor	Sum
Concrete patching	sq.feet	10.00	4836	48,365		1%	5%	3%	5.95	119.0	40%	50%	10%		100%
Steel repairs	sq.feet	10.00	4836	48,365			5%	3%	3.86	183.4	50%	40%	10%		100%
Other	bridge			0					0.00						0%
Other	bridge			0					0.00						0%
Other	sq.feet			0					0.00						0%
Bridge replacement	sq.feet	400	4836	1,934,593				3%	25.19	1123.4	100%				100%
Total percent acted upon					0%	1%	10%	9%		67.8					
Annual cost per bridge					0	725	7255	4353	34.99						

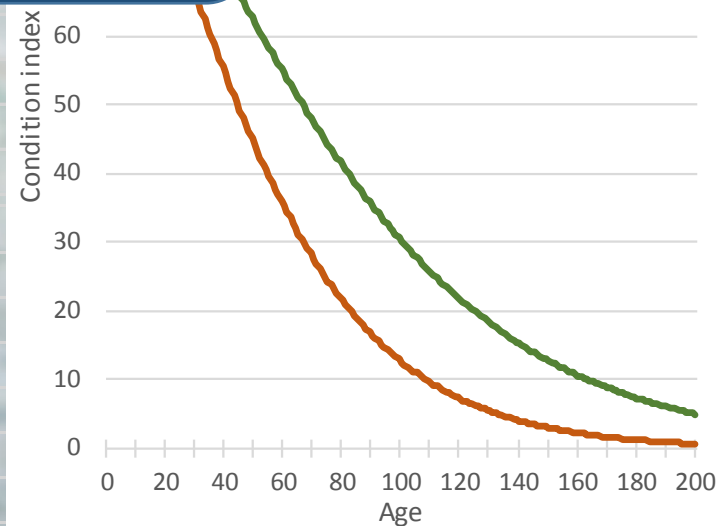
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Application rates reflect current agency expenditures and conditions

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No maintenance	61 years
Desired maint	91 years



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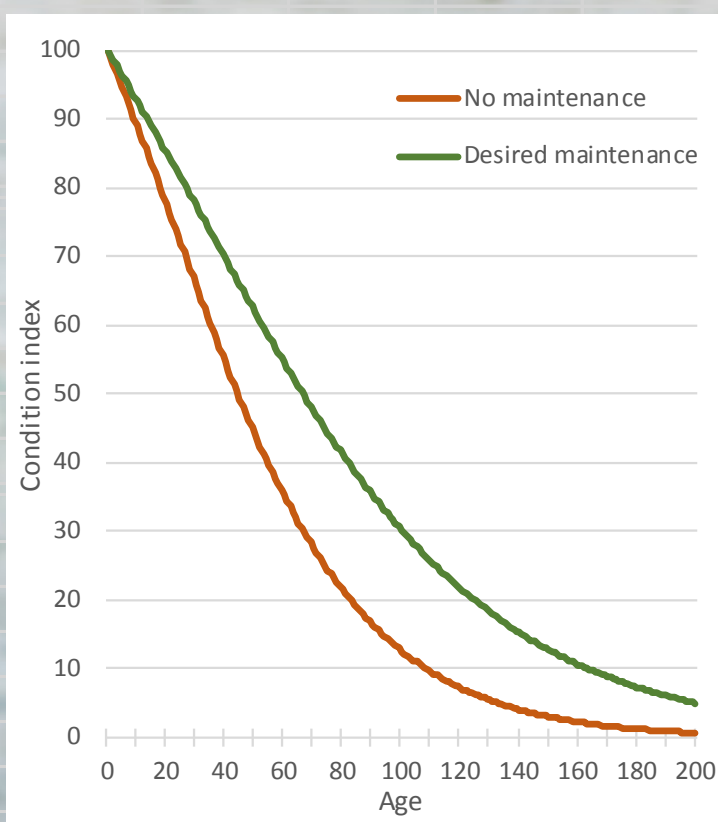
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Annual cost per bridge

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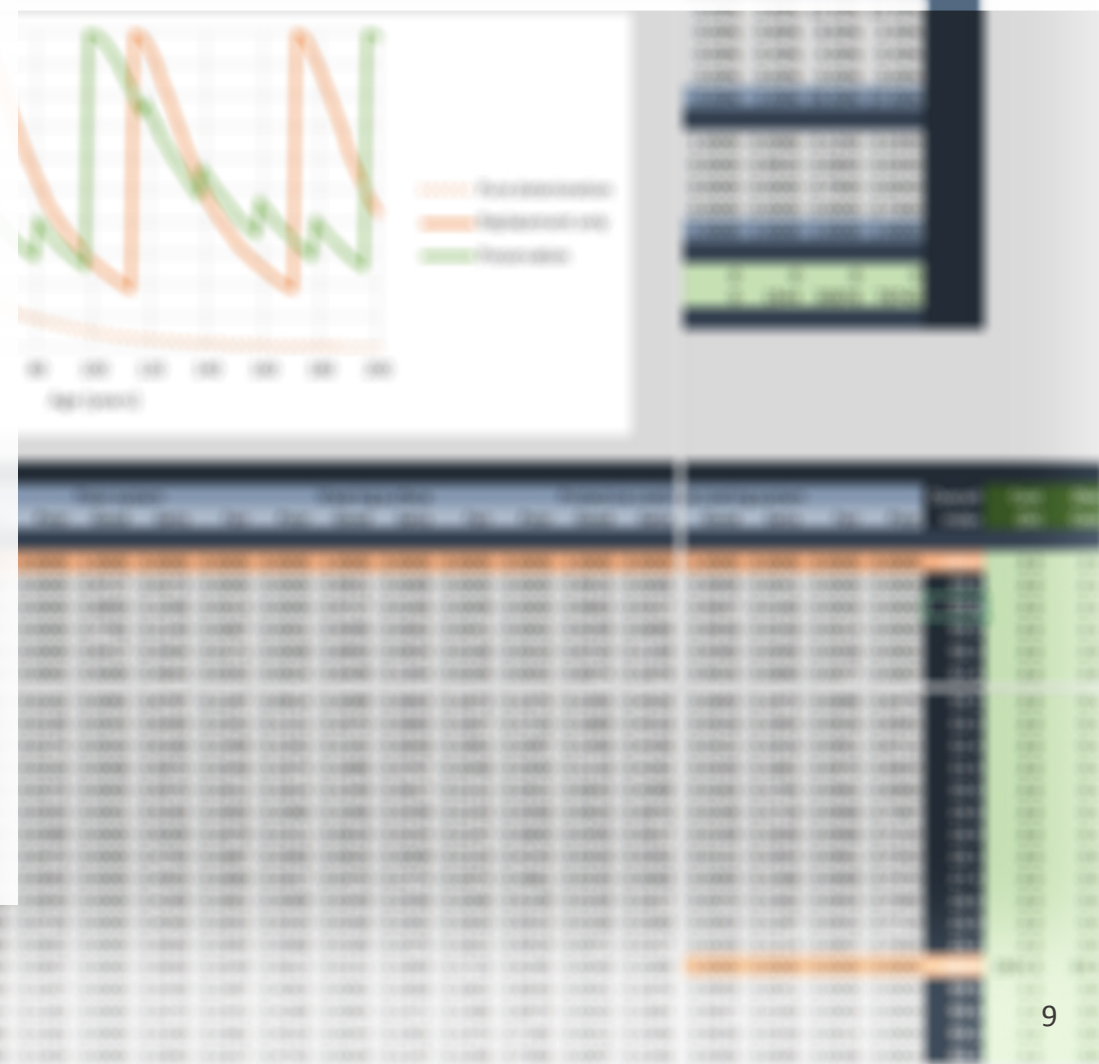
Effectiveness based on expert judgment



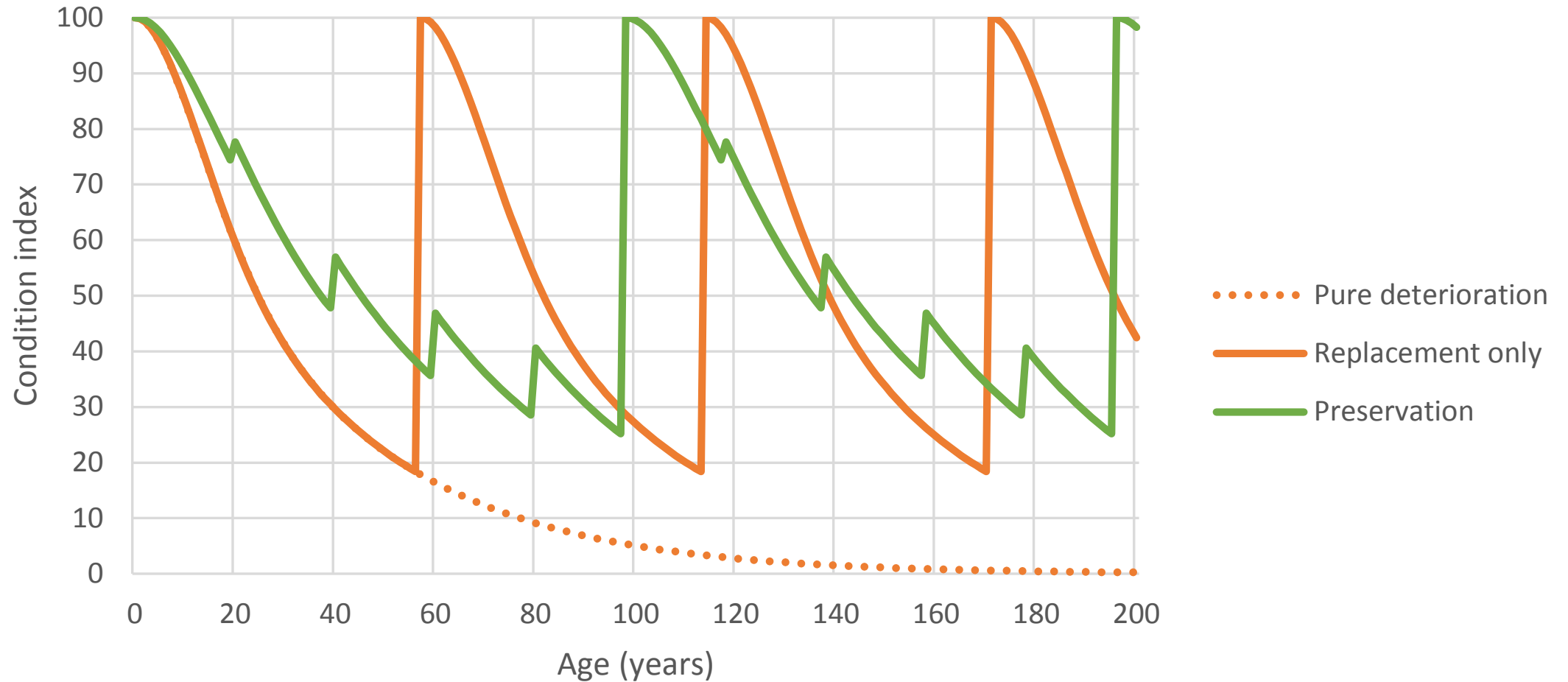


# Bridge LCCA – Life cycle activity profile

- Compares preservation strategy with replacement-only, for a typical bridge over its life cycle
- Pro-forma analysis to show life extension benefit of preservation
- A bridge management system would be able to do this routinely as a decision support tool
- **In Ohio, for example, Replacement-only found to cost 1.47 times as much as preservation**



# Bridge LCCA – Life cycle activity profile



# Development of unit costs

## Total by treatment (all in 2015 dollars)

	Cost (\$)	Average annual \$	Report count	Cost per report	Compare with
Routine	12,153,084	3,238,126	4557	2,842	
Deck repair	2,858,845	761,724	176	17,312	25,122 MN
Rail repair	964,937	257,102	145	7,092	23,800 TX
Joint repair	1,541,495	410,723	310	5,300	5,590 TX
Super repair	2,493,739	664,444	204	13,028	40,000 MN
Bearing repair	1,145,145	305,118	136	8,974	40,000 NV
Sub repair	1,069,709	285,018	270	4,222	20,637 TX
Slope repair	748,419	199,412	122	6,538	5,300 TX
Culvert repair	576,243	153,537	44	13,958	12,100 MN

Painting costs from other states:

TxDOT had about 300,000/bridge for painting

Ohio had about 200,000/bridge

MnDOT had 377,500/bridge

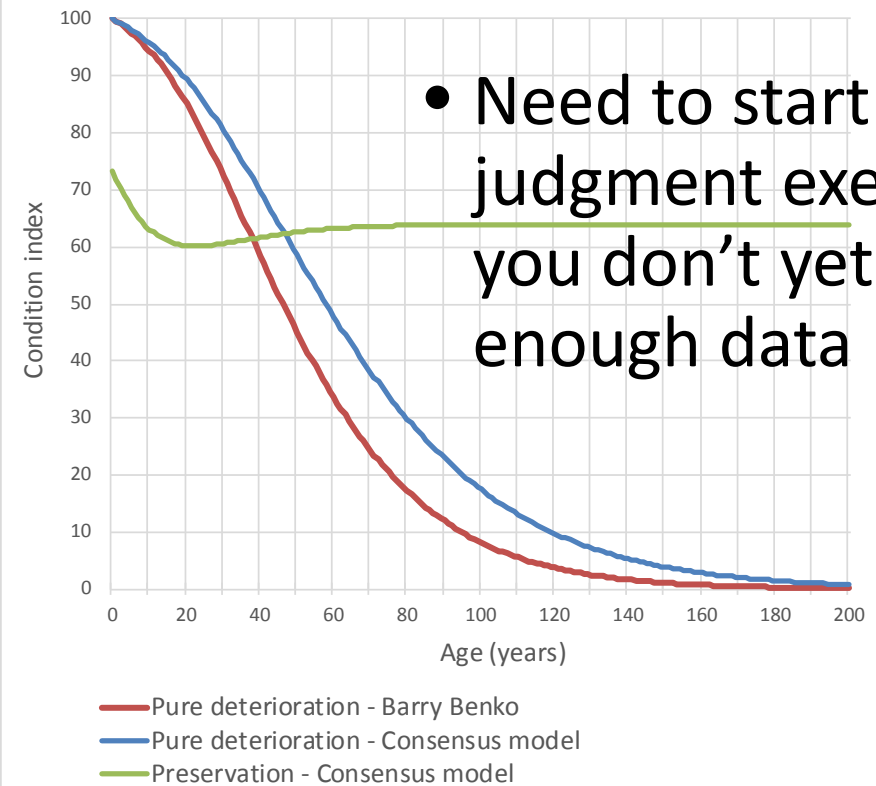
- The exercise quickly shows strengths, weaknesses of cost information

# Deterioration modeling

## Deterioration model - Soil slopes

Current conditions							
	State 1	State 2	State 3	State 4	State 5	Sum	
Sq.ft by state	55,987	19,342	186,467	93,161	46,229	354,957	
Transition time - median years to the next state							
	State 1	State 2	State 3	State 4		Life	
Consensus model	19.3	15.5	10.3	6.3		69	
Darren Beckstrand	20.0	15.0	10.0	5.0		67	
Barry Benko	15.0	12.0	9.0	5.0		55	
Bob Kimmerling	20.0	17.0	9.0	7.0		71	
Aine Mines	15.0	15.0	12.0	7.0		66	
Paul Thompson	25.0	20.0	15.0	10.0		94	
Mark Vessely	21.0	14.0	7.0	4.0		61	
Other							
Other							
Other							
Treatment frequency and cost						\$/sq.ft	OH%
Unit cost per state improved:						1328	50%
% acted upon per year						Cost	Cost
Treatment	State 1	State 2	State 3	State 4	State 5	\$/sq.ft	\$k/year
Maintain same state						0	0.0
Improve by 1 state			0.50%			1328	1238.1
Improve by 2 states			1.00%	1.50%	0.50%	2656	9278.0
Improve by 3 states				1.50%	1.00%	3984	7409.1
Improve by 4 states					1.00%	5312	2455.7
Total acted upon	0.00%	0.00%	1.50%	3.00%	2.50%		20380.9

## Comparison of deterioration models - Barry Benko



Preservation model starts with current condition; others with new condition

A photograph of a large steel truss bridge spanning a river. The bridge's intricate steel structure is visible, including the main trusses and the deck. The sky is overcast. In the foreground, a concrete barrier with black floats is visible along the riverbank. The text "Investment analysis" is overlaid in a large, yellow, sans-serif font on the lower-left portion of the image.

# Investment analysis

# Additional inputs for investment analysis

- Fiscal forecast
- Inflation rate
- Real growth rate
- Recapitalization rate
- Primary source: Agency revenue forecasts and pro-forma financial statements

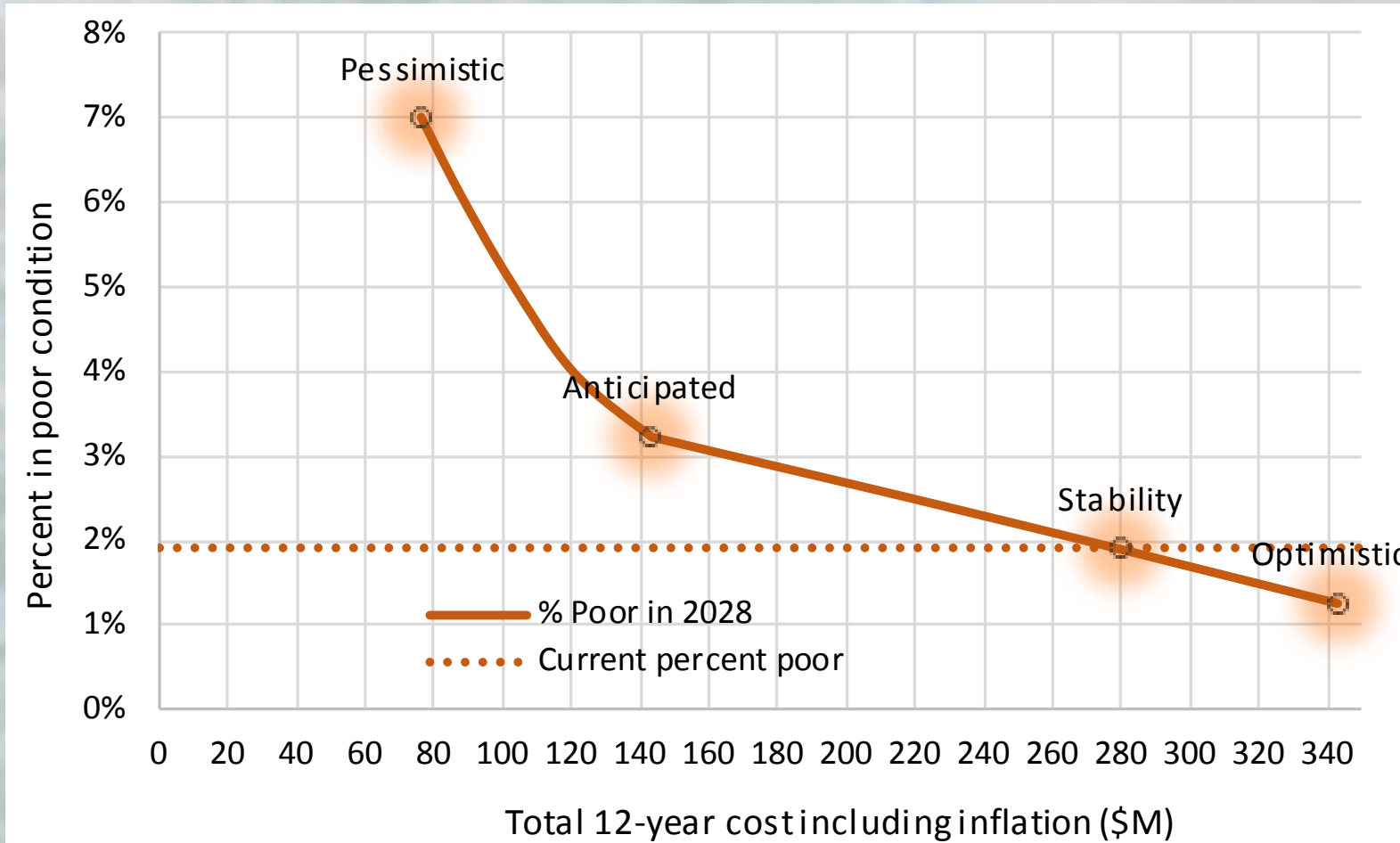
TRANSPORTATION FUNDING AND PROGRAM FORECAST (in Millions)										
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
<b>State Revenue</b>										
State General Fund	1,200	1,250	1,300	1,350	1,400	1,450	1,500	1,550	1,600	1,650
State Lottery	100	100	100	100	100	100	100	100	100	100
State Sales Tax	500	500	500	500	500	500	500	500	500	500
State Income Tax	200	200	200	200	200	200	200	200	200	200
State Property Tax	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
<b>Total State Revenue</b>	<b>2,000</b>	<b>2,050</b>	<b>2,100</b>	<b>2,150</b>	<b>2,200</b>	<b>2,250</b>	<b>2,300</b>	<b>2,350</b>	<b>2,400</b>	<b>2,450</b>
<b>Federal Revenue</b>										
Federal Highway Trust Funds	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Federal Airport and Airway Trust Funds	100	100	100	100	100	100	100	100	100	100
Federal Mass Transit Account	50	50	50	50	50	50	50	50	50	50
Federal Other	50	50	50	50	50	50	50	50	50	50
<b>Total Federal Revenue</b>	<b>1,200</b>	<b>1,200</b>	<b>1,200</b>	<b>1,200</b>	<b>1,200</b>	<b>1,200</b>	<b>1,200</b>	<b>1,200</b>	<b>1,200</b>	<b>1,200</b>
<b>Local Revenue</b>										
Local Property Tax	500	500	500	500	500	500	500	500	500	500
Local Sales Tax	200	200	200	200	200	200	200	200	200	200
Local Income Tax	100	100	100	100	100	100	100	100	100	100
Local Other	500	500	500	500	500	500	500	500	500	500
<b>Total Local Revenue</b>	<b>1,300</b>	<b>1,300</b>	<b>1,300</b>	<b>1,300</b>	<b>1,300</b>	<b>1,300</b>	<b>1,300</b>	<b>1,300</b>	<b>1,300</b>	<b>1,300</b>
<b>Total Revenue</b>										
<b>Total Revenue</b>	<b>4,500</b>	<b>4,550</b>	<b>4,600</b>	<b>4,650</b>	<b>4,700</b>	<b>4,750</b>	<b>4,800</b>	<b>4,850</b>	<b>4,900</b>	<b>4,950</b>
<b>Program Expenditures</b>										
Transportation Program	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Other Programs	500	500	500	500	500	500	500	500	500	500
<b>Total Program Expenditures</b>	<b>1,500</b>	<b>1,500</b>	<b>1,500</b>	<b>1,500</b>	<b>1,500</b>	<b>1,500</b>	<b>1,500</b>	<b>1,500</b>	<b>1,500</b>	<b>1,500</b>
<b>Net Change</b>										
<b>Net Change</b>	<b>3,000</b>	<b>3,050</b>	<b>3,100</b>	<b>3,150</b>	<b>3,200</b>	<b>3,250</b>	<b>3,300</b>	<b>3,350</b>	<b>3,400</b>	<b>3,450</b>

# Alternative fiscal scenarios

- For minimum scenario, we used either current funding or agency conservative forecast (for Ohio, **\$351 million/year for bridges**)
- For maximum scenario, we used a typical recapitalization rate
  - $\text{Recapitalization rate} = \text{annual expenditure} \div \text{replacement cost}$
  - Both in current dollars, assuming no backlog and optimal preservation
  - Includes replacement in-kind and all indirect costs
  - Typically 0.5% to 1.5% depending on climate
- For ODOT on-system bridges this works out to **\$424.5M** for the maximum scenario

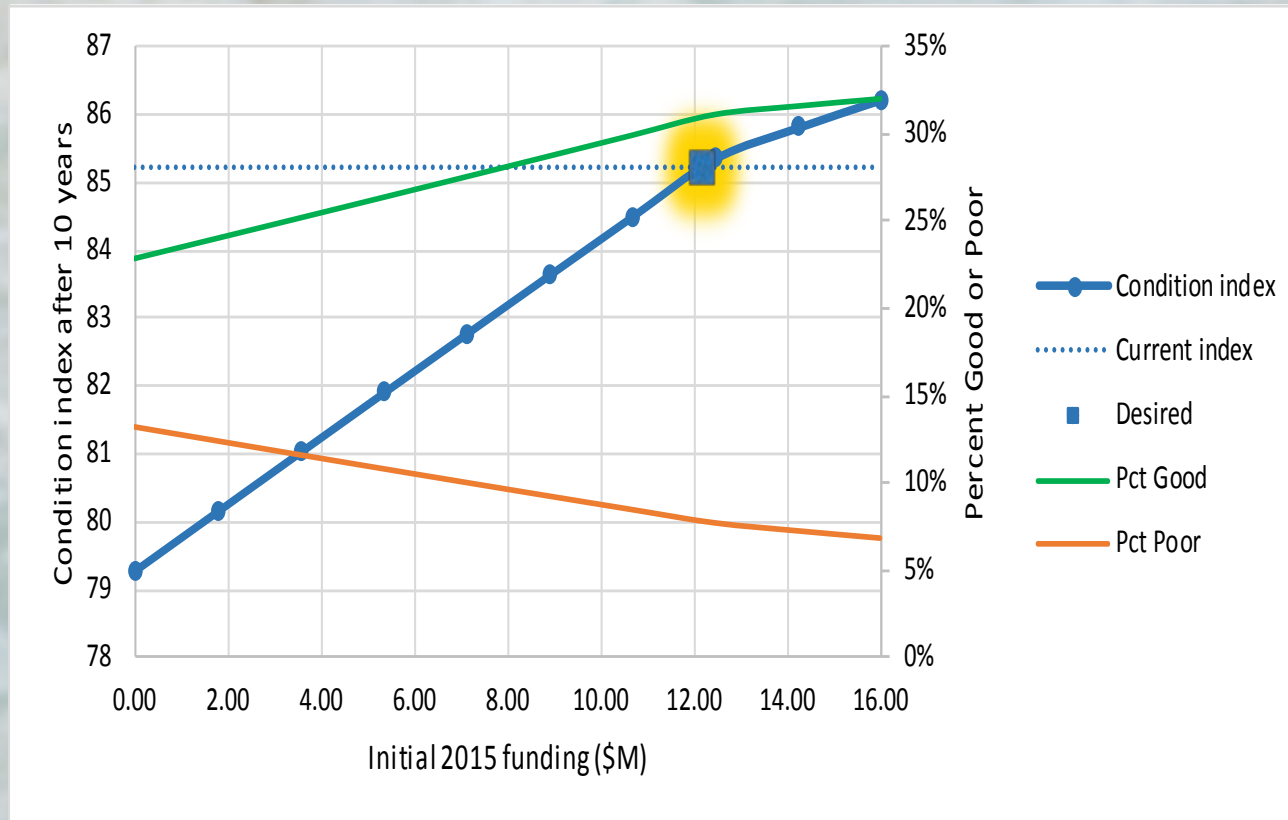


# Funding vs condition – bridge example





# Funding vs condition - slopes



This works for many asset classes:

- Pavements & bridges
- Culverts
- Geotechnical – slopes, embankments, walls
- Signals and ITS
- Signs
- Sidewalks, bikeways

# Conclusions

- Simplified spreadsheet methods can help you get started with analysis
- Not a substitute for good systems in the long run
- Can help you prioritize system improvements

# Conclusions

A photograph of a construction site. In the foreground, a grid of green-coated steel rebar is laid out on a wooden formwork. Two workers in safety gear are visible in the background. One worker in the foreground wears a yellow hard hat and a green safety vest. Another worker in the background wears an orange hard hat and a yellow safety vest. A large bundle of rebar is suspended in the air in the upper left. The background shows a dense line of green trees.

*All models are wrong;  
Some models are useful*

Thank you!