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

Life cycle cost analysis – Input data

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

General appraisal

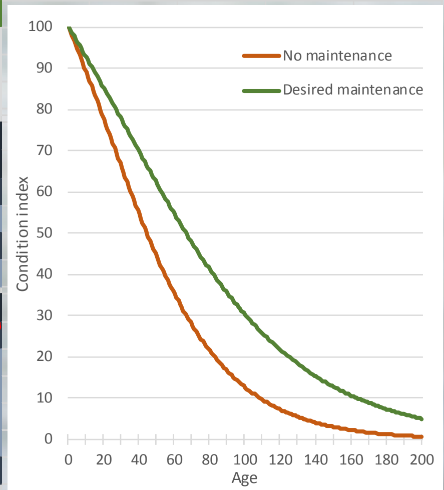
General	Good	Satis	Fair	Poor	Total		
Number of bridges:	8542	4316	1335	434	14627	Deck area:	70,743,216 sq.feet
Condition index wt:	100	80	50	0		Indirect cost factor:	50%

Deterioration model	With no maint	Desired maint
Good (9 to 7):	12	18
Satisfactory (6):	23	35
Fair (5):	12	18
Poor (4 to 0):	--	--

Reality ✓ Estimated life	
No maintenance	61 years
Desired maint	91 years

Routine maintenance (cyclic or reactive) Treatment	Units	$/unit	Units per bridge	$/bridge	% bridges acted upon in a year Good	Satis	Fair	Poor	Reality ✓ ($M/yr)	Interval (years)
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 Treatment	Units	$/unit	Units per bridge	$/bridge	% bridges acted upon in a year Good	Satis	Fair	Poor	Reality ✓ ($M/yr)	Interval (years)	Effectiveness - State probability after action 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						



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

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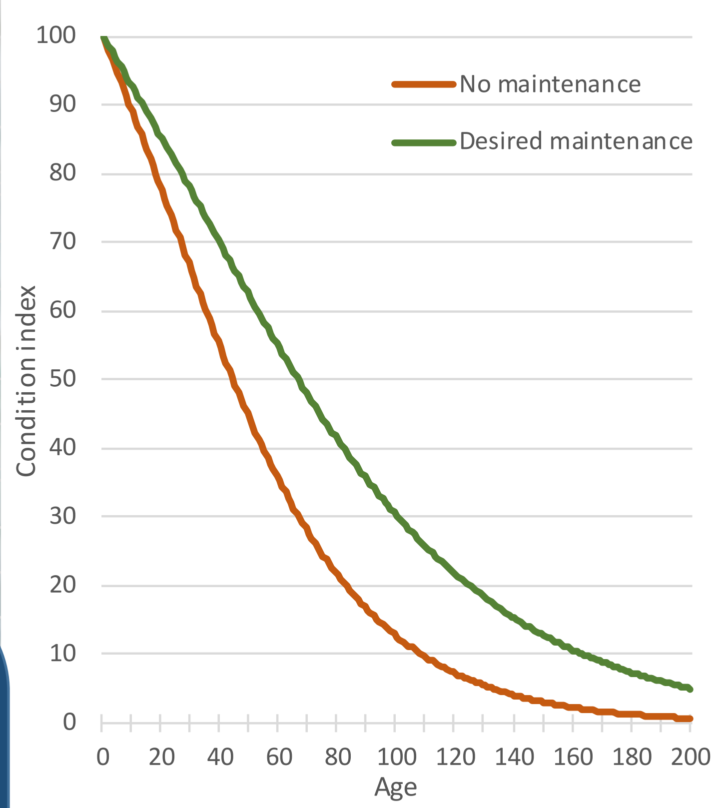
Routine maintenance (cyclic or re…		…per	% bridges acted upon in a year				Reality ✓	Interval
Treatment	Units	…$/bridge	Good	Satis	Fair	Poor	($M/yr)	(years)
Cleaning								
Sealing								
Annual cost								

Corrective a…	Effectiveness - State probability after action				
Treatment	Good	Satis	Fair	Poor	Sum
Concrete pa…	40%	50%	10%		100%
Steel repair…	50%	40%	10%		100%
Other					0%
Other					0%
Other					0%
Bridge repla…	100%				100%
Total percent …					
Annual cost per bridge	0	725	7255	4353	34.99



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

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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
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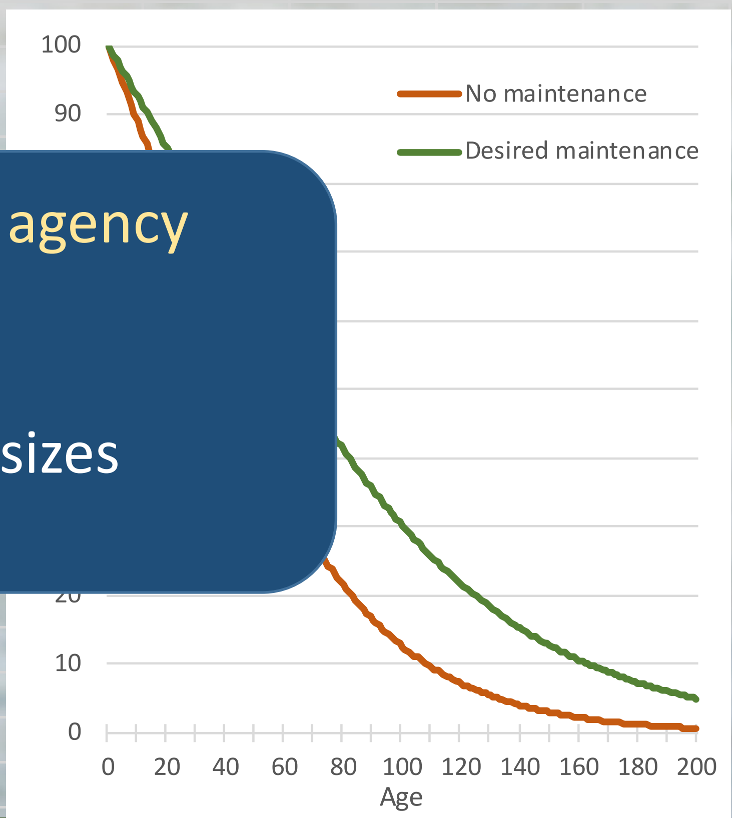
Actions and costs based on agency estimation practice

- Indirect costs included
- Based on typical project sizes



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Application rates reflect current agency expenditures and conditions

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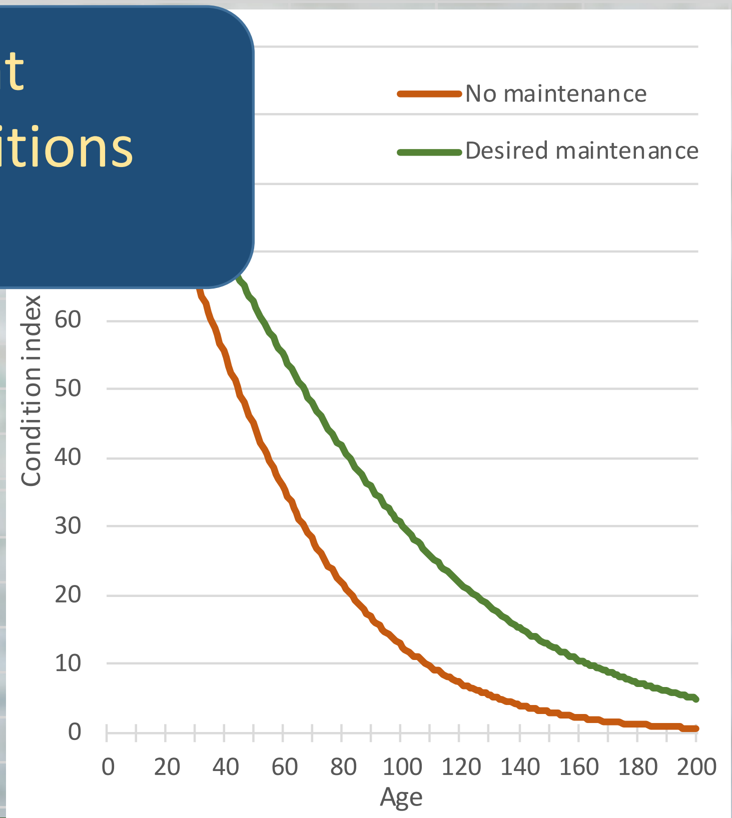

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Annual cost per bridge				…184	21.3…	

Effectiveness based on expert judgment

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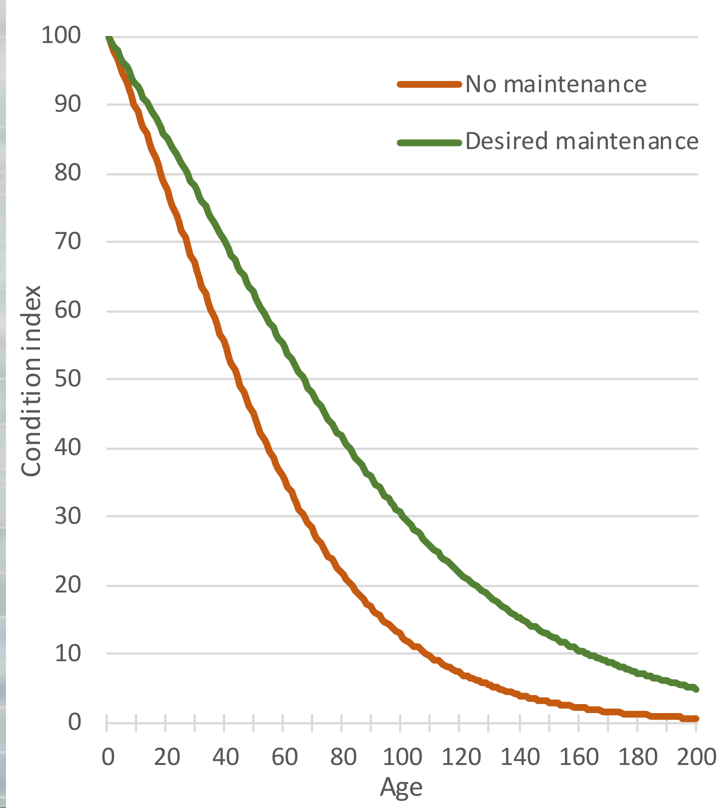
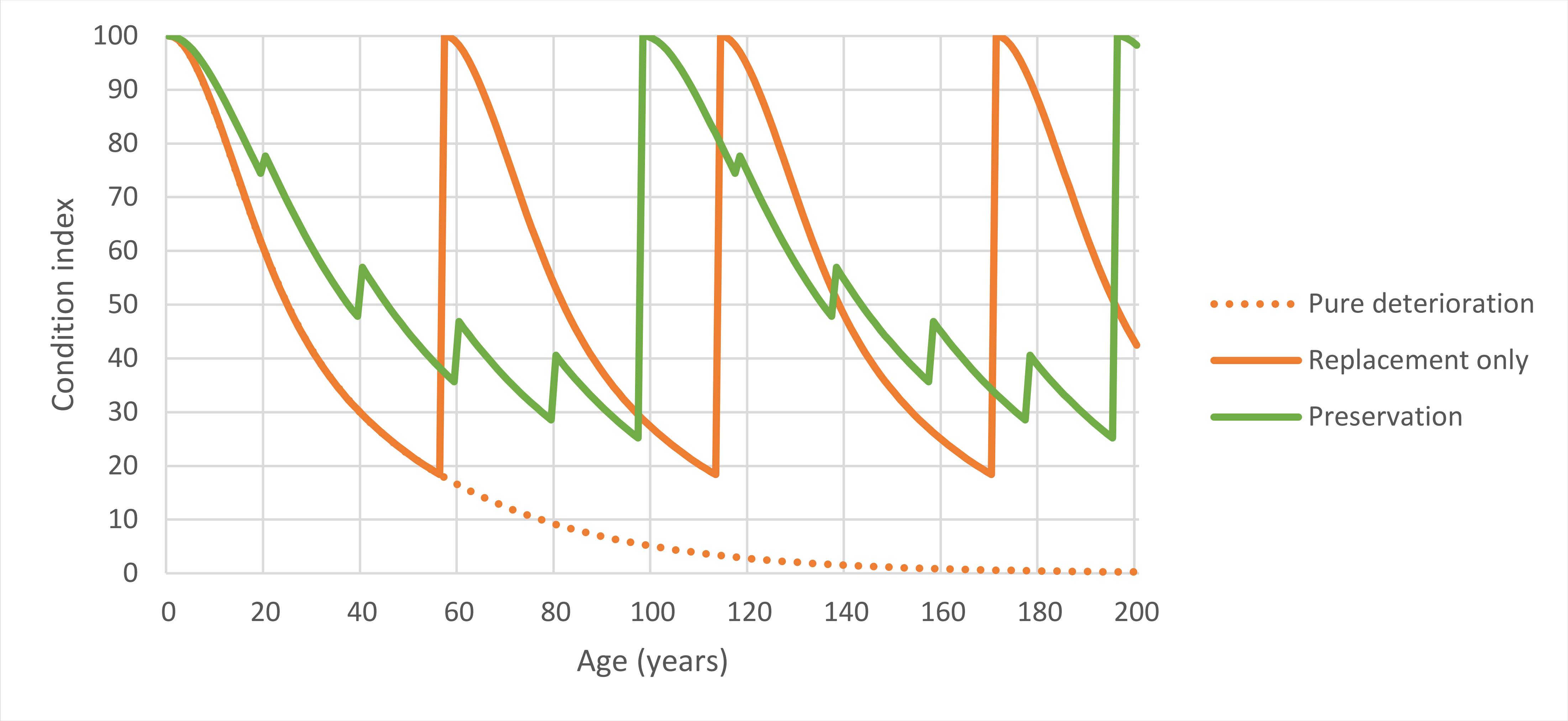


Bridge LCCA – Life cycle activity profile

- 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

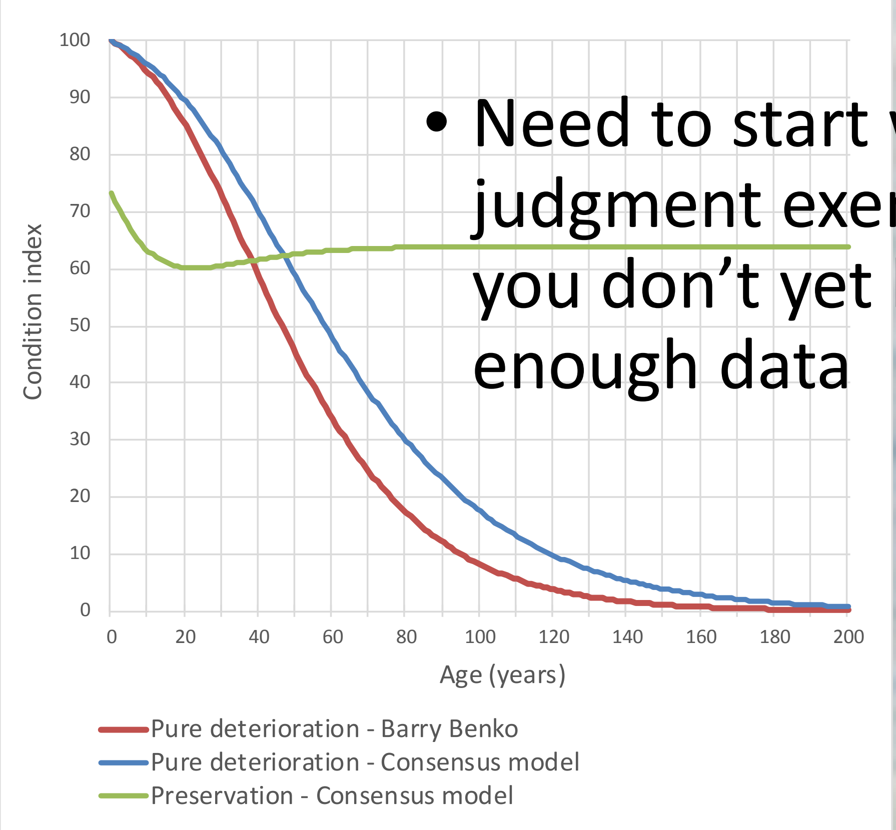
Deterioration model - Soil slopes

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



- Need to start with a judgment exercise if you don't yet have enough data

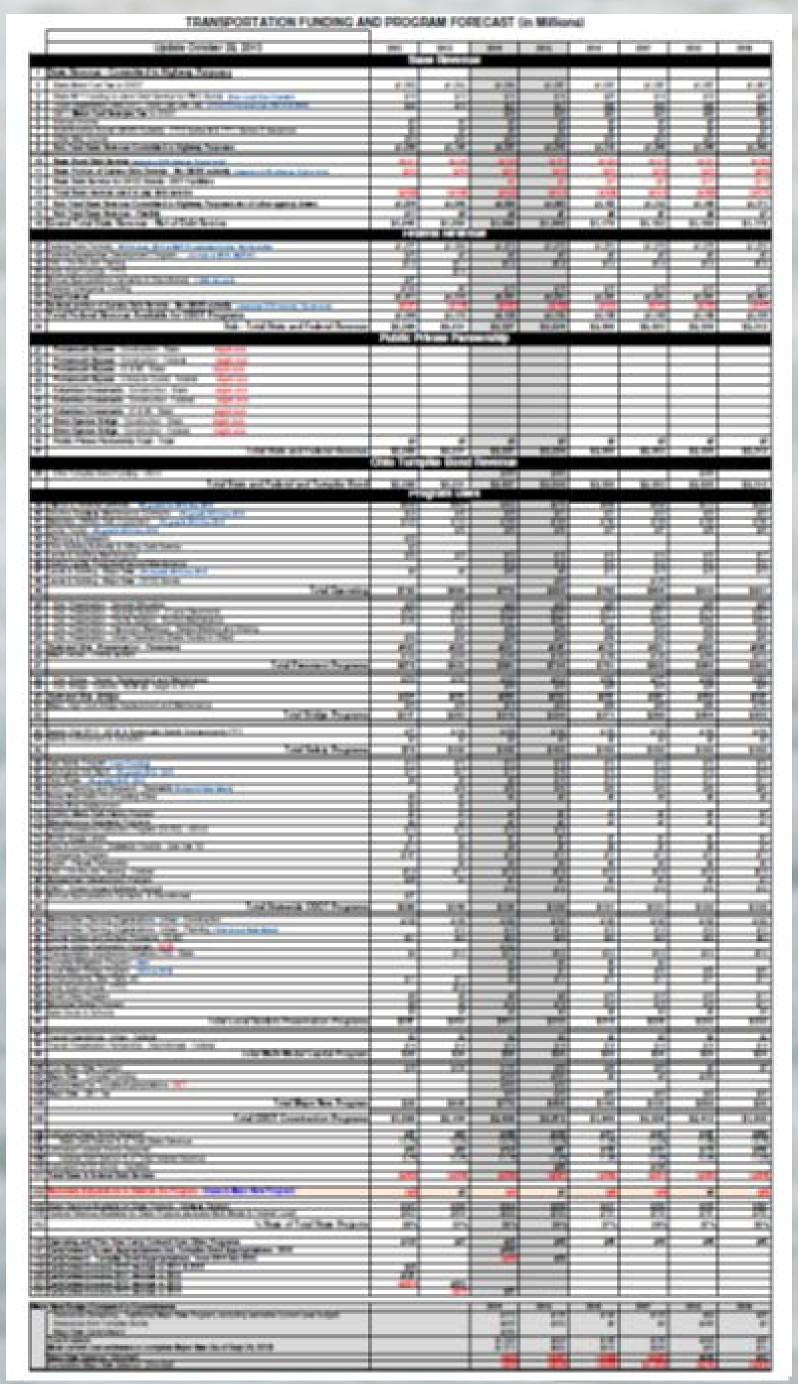
Preservation model starts with current condition; others with new condition

Investment analysis

Additional inputs for investment analysis

- Fiscal forecast
- Inflation rate
- Real growth rate
- Recapitalization rate

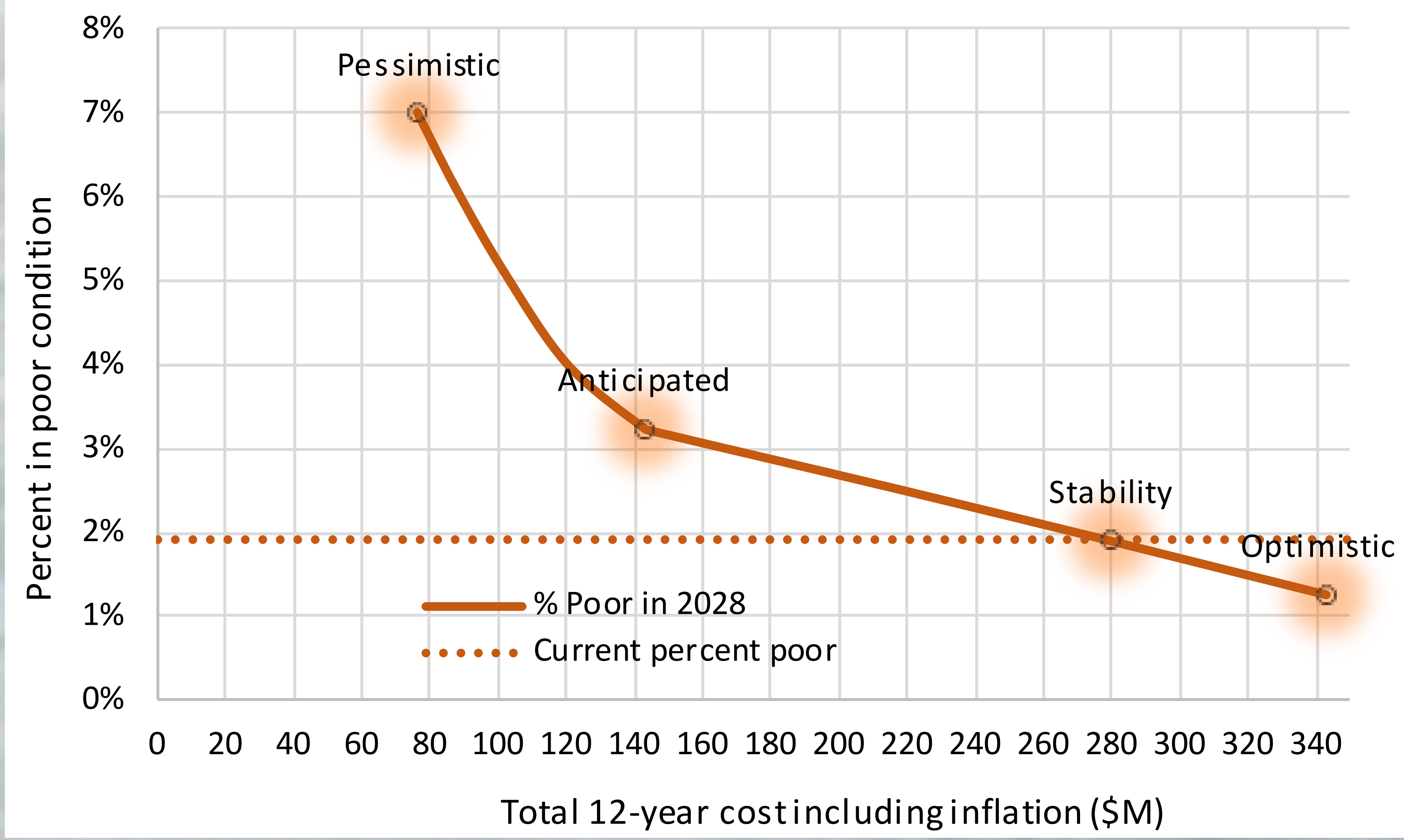
- Primary source: Agency revenue forecasts and pro-forma financial statements


TRANSPORTATION FUNDING AND PROGRAM FORECAST (in Millions)

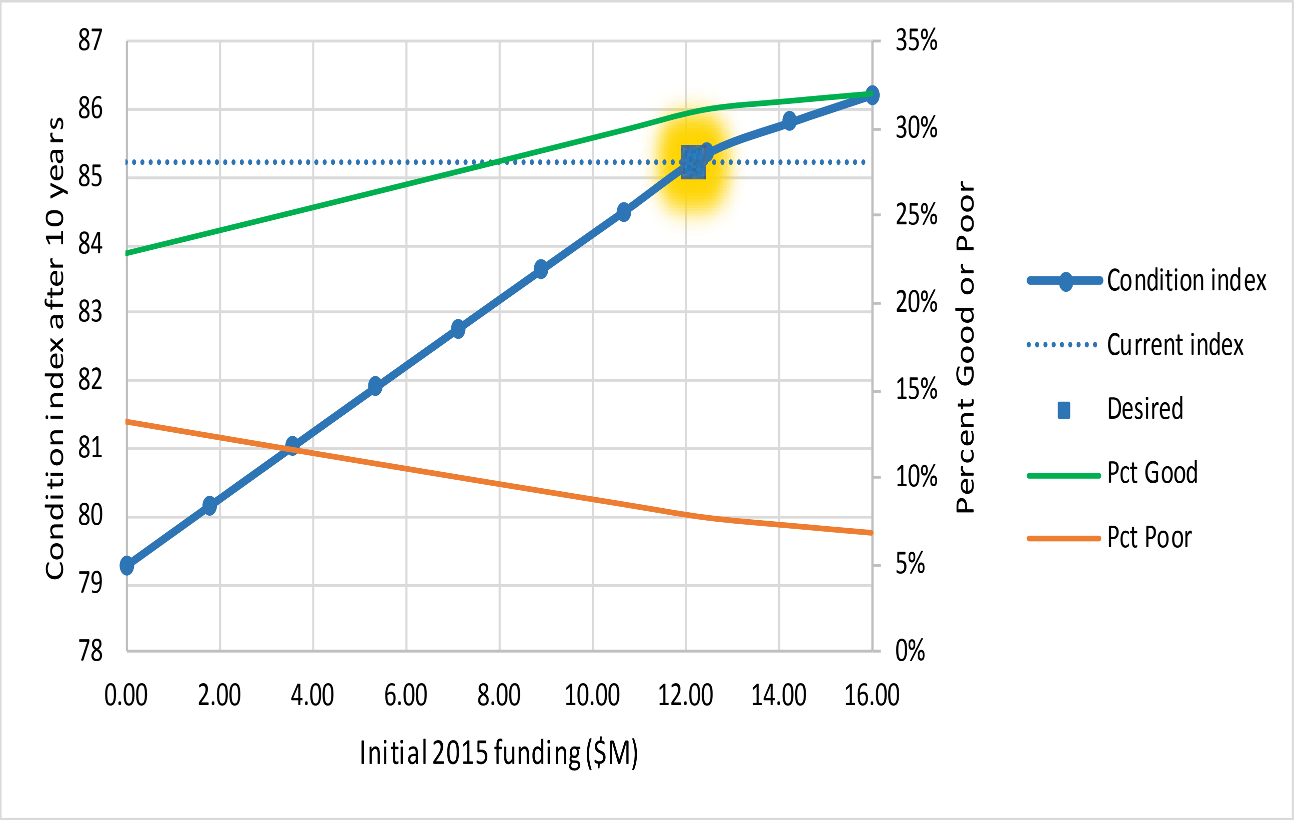
Alternative fiscal scenarios

- 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
  - Recapitalization rate = annual expenditure ÷ 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

All models are wrong;
Some models are useful

Thank you!