Long Term Cost Benefit Considerations at Road Stream Crossings

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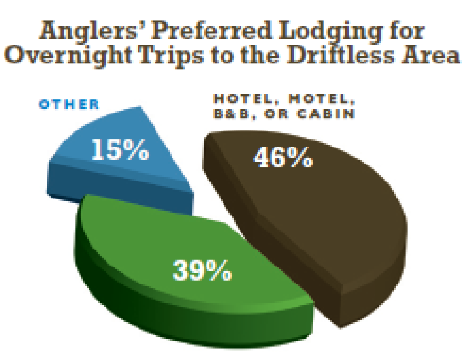
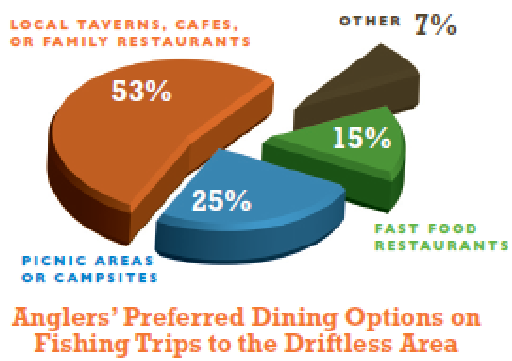
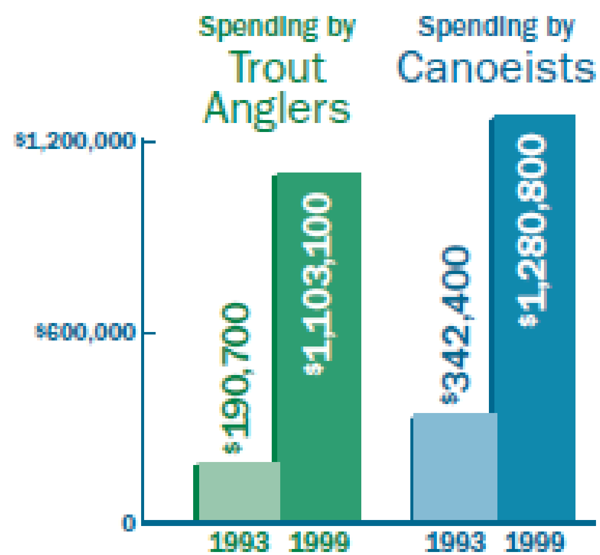
Wide Ranging Benefits

- Healthier populations of fish and wildlife
- Improved water quality
- Restored wetland functions
- Decreased flooding
- Reduced closures and safer roads
- Increased recreation and tourism benefits

Economic benefits of healthy waters and increased recreation







What is the challenge?

- Replacement costs are paid primarily by municipal transportation departments
- Easy to calculate the incremental cost of culvert improvements
- The initial cost to upgrade a crossing may be difficult to justify with limited budgets.
- There is very limited data about the total life cycle costs of culverts.

Understanding true life cycle cost

- Total life cycle cost = (initial replacement/ construction cost) + …
- 50% increase in stream span = 20% to 33% increase in total project cost. (Gubernick 2011)

Understanding true life cycle cost

Total life cycle cost = (initial replacement & construction cost)

+ (cost of annual maintenance)
+ (total structure life span)
+ (cost of flood failure/damage)

Flood Resiliency Lessons – New York & Vermont

- Tropical Storm Irene
  - Linking flood resiliency and ecological connectivity.
  - Modest increases in initial investment to implement stream simulation designs yield substantial societal and economic benefits
  - Often times, a municipality will spend <u>LESS $ and LESS TIME over the long term (~50-75 years).</u>

Massachusetts

On average, upgrade of the 3 culverts in the study was 38% less expensive than in-kind replacement and maintenance over 30 years.

COST CATEGORY	ASSUMPTION	COSTS
Estimated Replacement In-Kind Cost	Every 50 years	$180,000
Maintenance Costs	Annual	$13,000
Long-term maintenance	25 after replacement	$100,000
Total Costs	-	$560,000

COST CATEGORY	ASSUMPTION	COSTS
Replacement Cost	Every 25 years	$120,000
Maintenance Costs	Annual	$9,000
Total Costs	-	$390,000

COST CATEGORY	ASSUMPTION	COSTS
Replacement Cost	Every 25 years	$170,000
Maintenance Costs	Annual	$24,000
Total Costs	-	$750,000

Table 5. Eastern Maine Culvert Cost Estimates (2007 dollars) [10]

Scenario	Description	Average annual cost over 50 year time-frame	
		Arch culvert	Round culvert
Case 1	10' x 4'5" arch replaces two 2.5' round culverts	$1,357	$1,706
Case 2	12' x 5' arch replaces 3.5' round culvert	$1,545	$1,887
Case 3	12' x 5' arch replaces 3' round culvert	$2,265	$1,461
Case 4	12' x 5' arch replaces 4' round culvert	$2,452	$2,000

- Installation, operation, and maintenance

Lowering long term culvert costs

- UW Madison cost benefit analysis
- Green Bay culvert inventory of 1615 culverts
- Findings suggest that the initial investment to install larger culverts (that do not constrict the stream) has many environmental benefits and <u>often has net direct economic benefits</u>!


COST-BENEFIT ANALYSIS OF STREAM-SIMULATION CULVERTS

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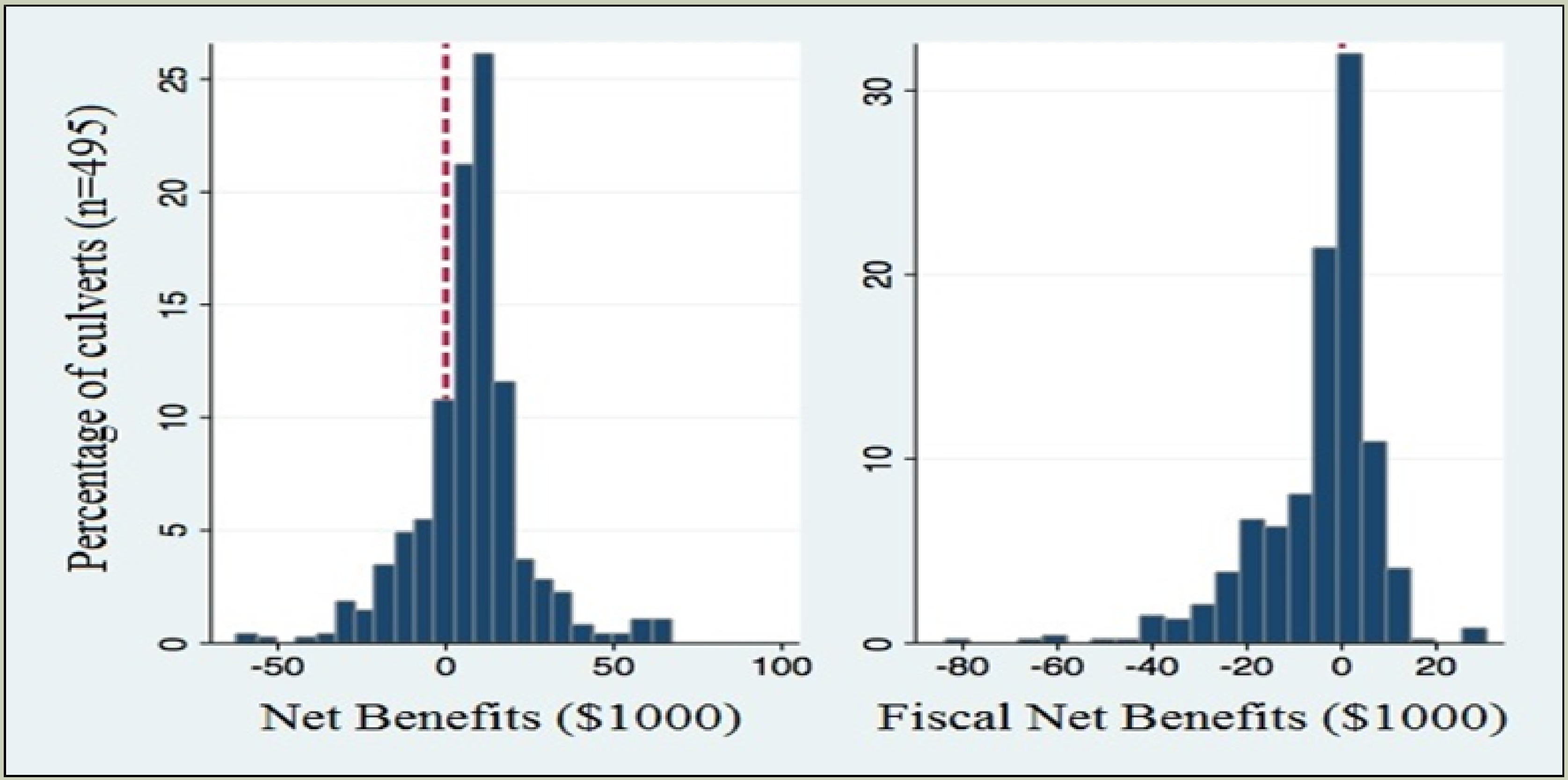
Green Bay Data: 1,615 crossings. Results from 495 stream constricting sites.



Mean = $7,800
77% positive

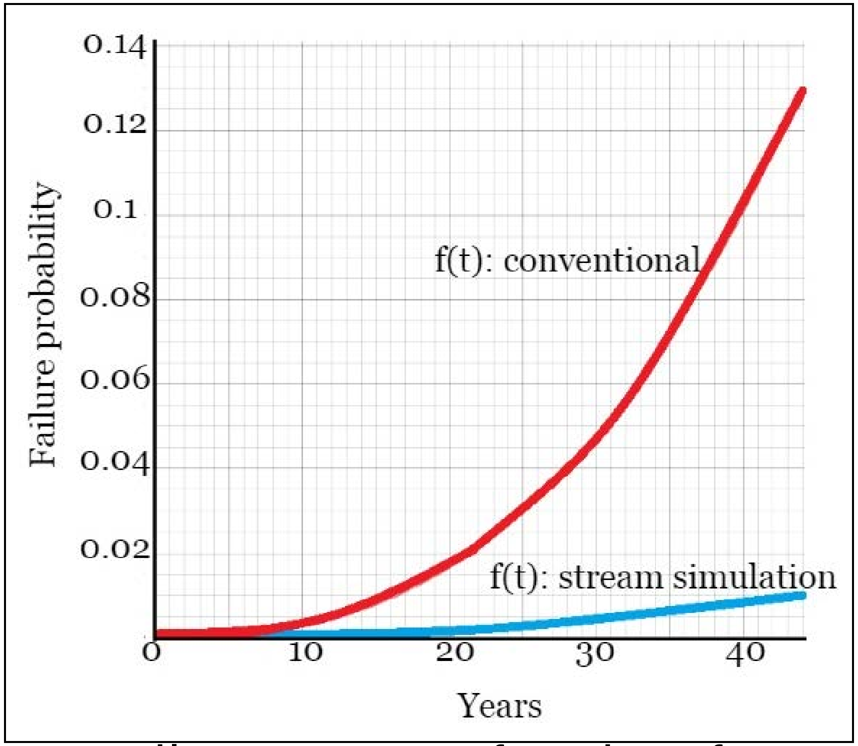
Mean = -$4,500
44% positive

Increase the culvert lifespan

Bankfull width structures are better protected from abrasion from stream bed load movement

Reduce chance of failure

Probability of “catastrophic” culvert failure over the long term is much lower with stream spanning culverts



Failure rates as a function of time for conventional and stream simulation culverts.

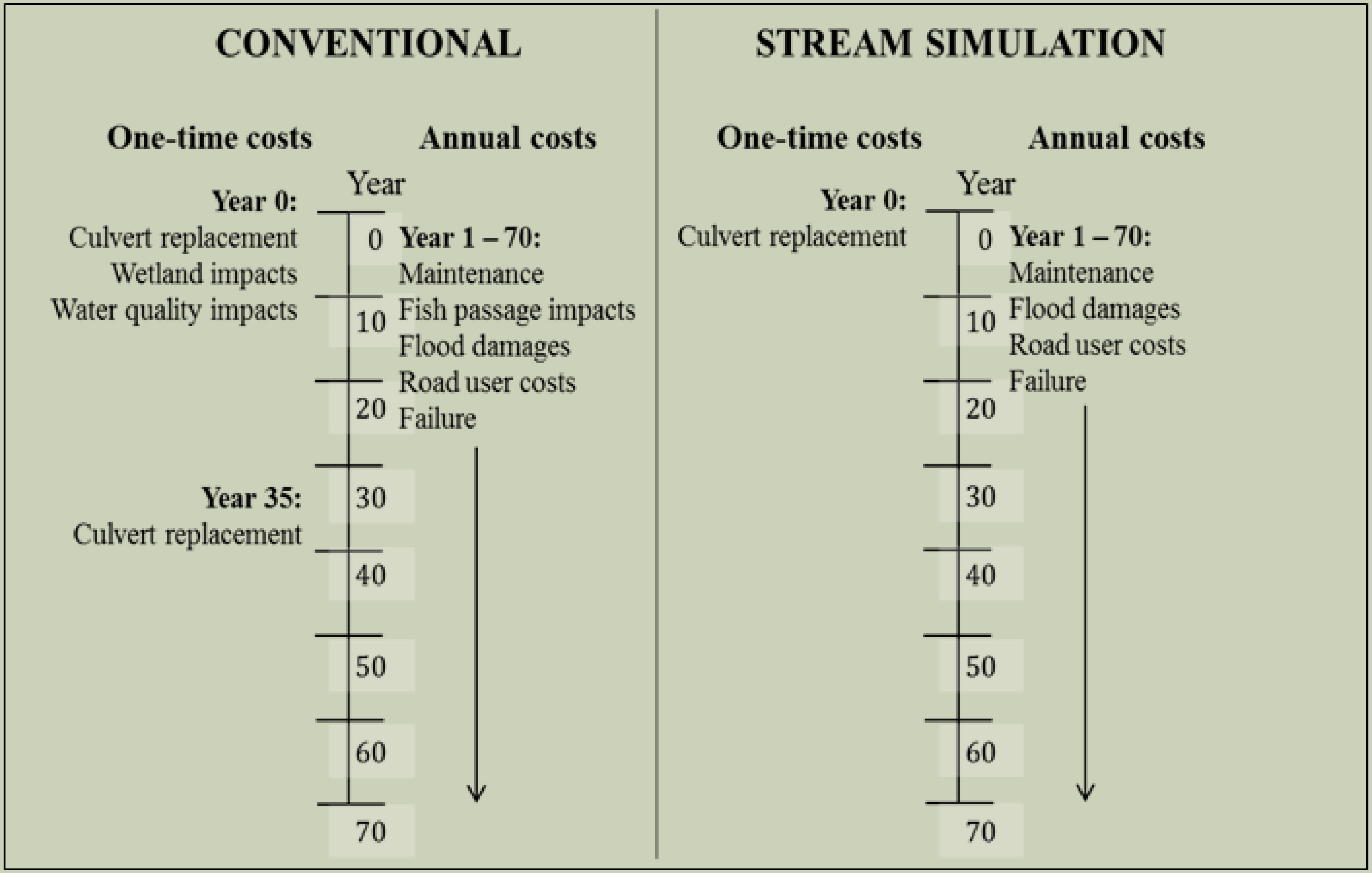
Type of road	Cornell Local Roads design storm recommendation*
Town road with low traffic	10 year storm
Town road with high traffic or county road with low traffic	25 year storm
County road with high traffic	50 year storm

Reduce chance of failure

- **In most forest environments, the dominant culvert failure mechanism is wood and sediment blocking the inlet.**
- White River watershed in Vermont following flooding from Tropical Storm Irene in 2011. $728,000 damage to roads. 70% due to debris plugging culverts.

Woody debris transported during floods is often < BFW in length

- Typical conventional culvert lifetime: 25-50 years
- Typical stream-simulation lifetime: 50-75 years



(Gillespie et. al. 2014)

Avoid added cost of flood damage

- Added costs to repair damage to roads, streams, property, and delayed travel.
- Widespread road closures and detours can be detrimental to tourism, forestry, industry, and public safety
- Project costs during a major flood are generally higher than planned replacement costs.

Study finds Midwest flooding more frequent

Research covered more than 50 years of data in 14 states

This aerial view of a flooded Midwestern farm has been all too common during four severe floods that have affected the region since 2008. Photo courtesy of Aneta Goska.

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The U.S. Midwest and surrounding states have endured increasingly more frequent flood episodes over the past half-century, according to a study from the University of Iowa.

The UI researchers based their findings on daily records collected by the U.S. Geological Survey at 774 stream gauges in 14 states from 1962-2011, a data-collection period in common for all the stations.

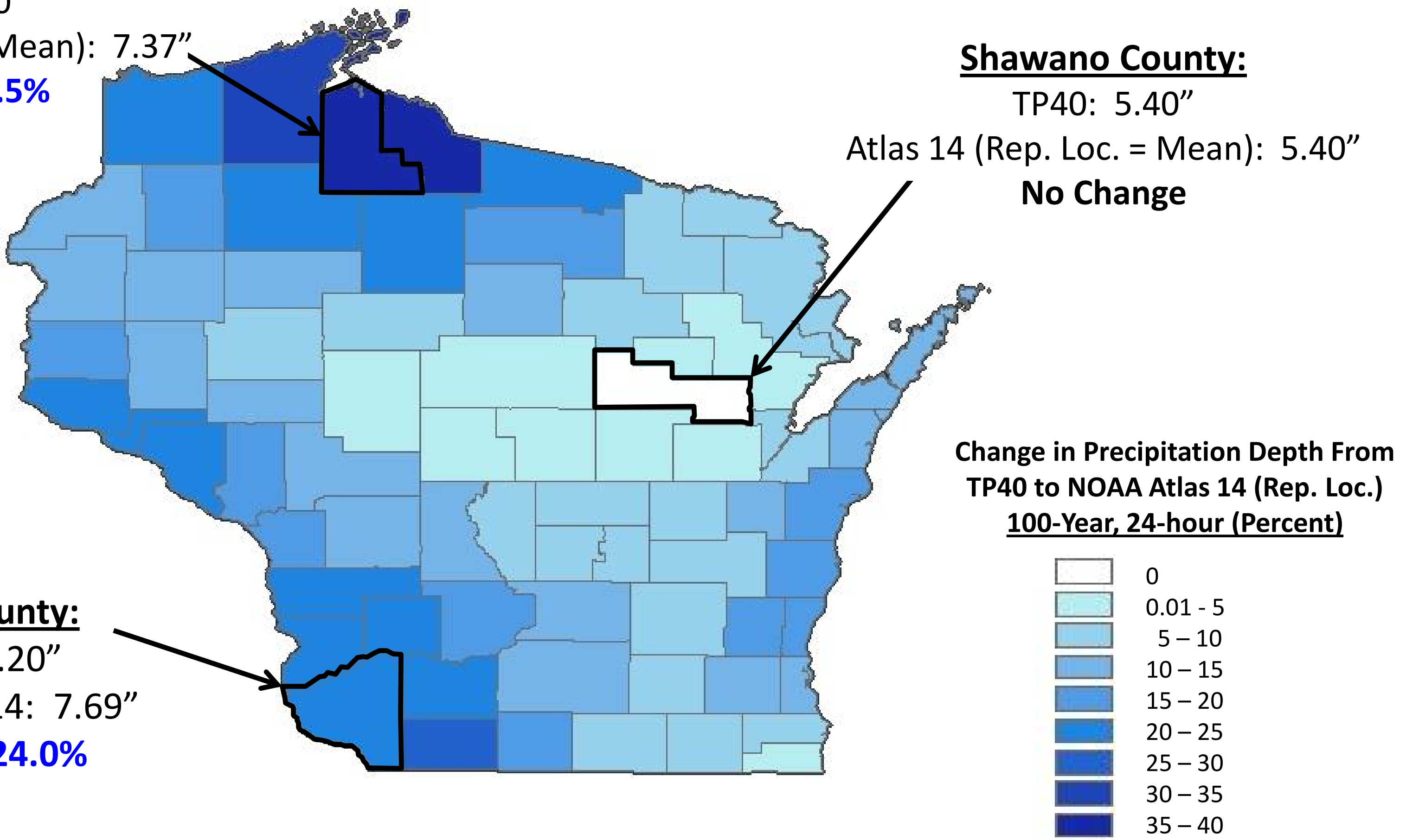
TP40 Versus NOAA Atlas 14 Precipitation Depths

100-Yr, 24-Hr Precipitation Depths
Percent Change From TP40 to NOAA Atlas 14 (Representative Location)

Ashland County:
TP40: 5.40”
Atlas 14 (Rep. Loc. = Mean): 7.37”
Increase 36.5%

Shawano County:
TP40: 5.40”
Atlas 14 (Rep. Loc. = Mean): 5.40”
No Change

Grant County:
TP40: 6.20”
NOAA Atlas 14: 7.69”
Increase 24.0%



Decreasing culvert maintenance

- More stream constriction = more maintenance trips
- Larger culverts = less debris removal, shoulder repair, riprap repair, fixing road surface, etc.

Recommendations

- Culvert inventories
  - prioritize both flood prone and ecologically important crossings
- Early coordination
  - cost sharing opportunities
- Better documentation of true total life cycle culvert costs
  - understand the fiscal benefits of investing in larger structures
- Improvements for adequate funding and financial incentives for long-term improvements

References

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