Evaluation of Wildlife Crossing Structures on US 93 in Montana's Bitterroot Valley

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Acknowledgements

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Outline

I. Study Area & Objectives

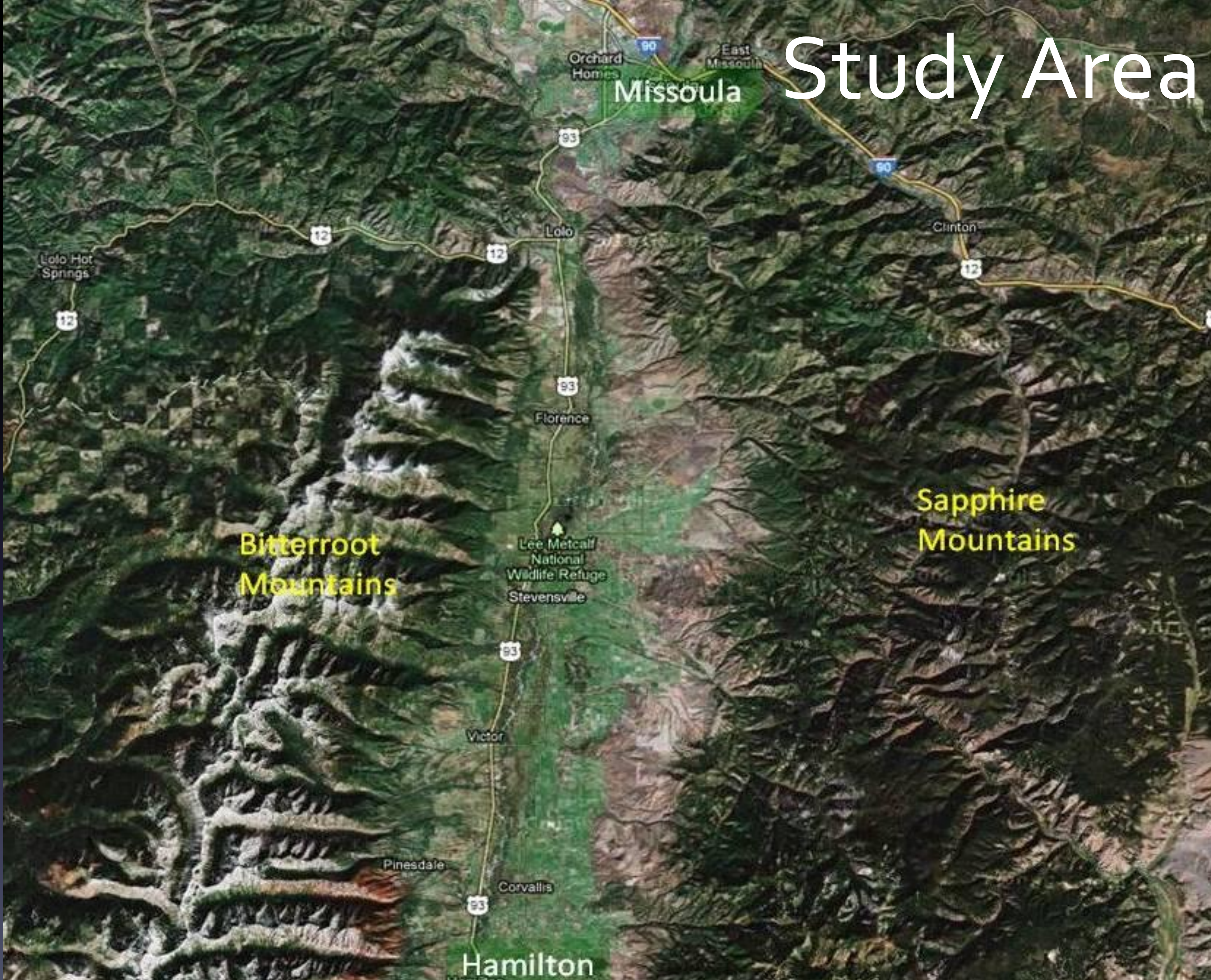
II. Chapter 2 - Deer Use of Sites & Structures

III. Chapter 3 - Deer Use Rates and Explanatory Variables

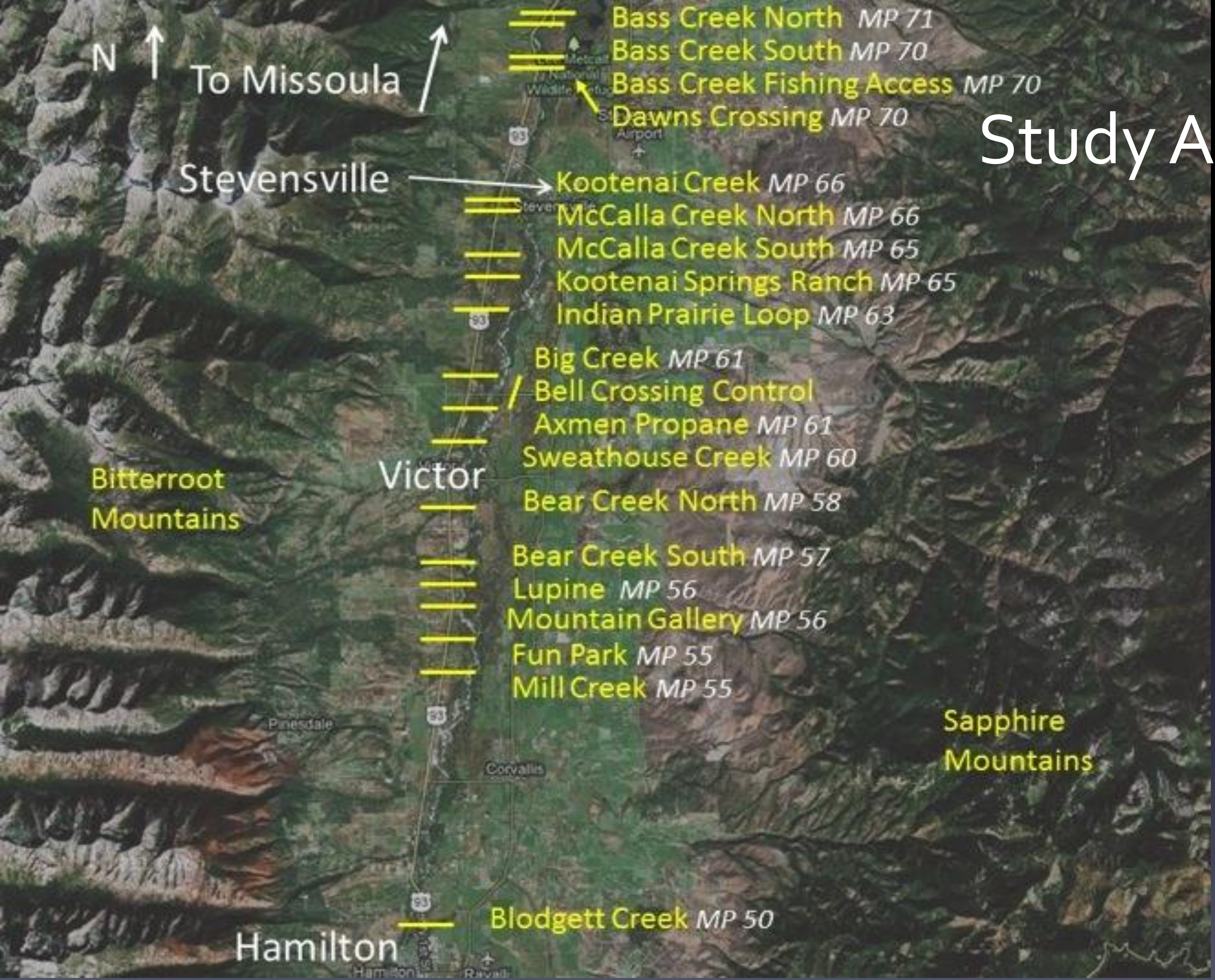
IV. Chapter 4 - Wildlife-Vehicle Collision Relationships to Structures

V. Chapter 5 - Recommendations

Study Area


Orchard Homes
East Missoula
Missoula
90
93
Lolo
12
Lolo Hot Springs
Clinton
Florence
Lee Metcalf National Wildlife Refuge
Stevensville
Bitterroot Mountains
Sapphire Mountains
Victor
Pinesdale
Corvallis
Hamilton

Study Area


N
To Missoula
Bass Creek North MP 71
Bass Creek South MP 70
Bass Creek Fishing Access MP 70
Dawns Crossing MP 70
Stevensville
Kootenai Creek MP 66
McCalla Creek North MP 66
McCalla Creek South MP 65
Kootenai Springs Ranch MP 65
Indian Prairie Loop MP 63
Big Creek MP 61
Bell Crossing Control
Axmen Propane MP 61
Sweathouse Creek MP 60
Victor
Bitterroot
Mountains
Bear Creek North MP 58
Bear Creek South MP 57
Lupine MP 56
Mountain Gallery MP 56
Fun Park MP 55
Mill Creek MP 55
Sapphire
Mountains
Blodgett Creek MP 50
Hamilton

Objectives

1. White-tailed deer use of wildlife crossing structures and wildlife crossing sites;

2. White-tailed deer usage rates of wildlife crossing structures including height, width, length, and material;

3. Relationships between usage rates of wildlife crossing structures and landscape variables;

Objectives

4. Changes in wildlife-vehicle collisions between pre-construction and post-construction of wildlife crossing structures within a 40 kilometers (25 mile) stretch of US 93

5. Relationships between wildlife-vehicle collisions and wildlife crossing structures over time and space.

Types of Structures

- 12 Bridges
  - Single span and Double Span
  - Varying Heights
- 7 Culverts
  - 2 Corrugated Steel
    - 1 Big
    - 1 Small
  - 5 Concrete Box

Double Span Bridge - Big Creek 183 Feet (56 Meters) Span

Single Span Bridge McCalla North 79 Feet (24 Meters) Span

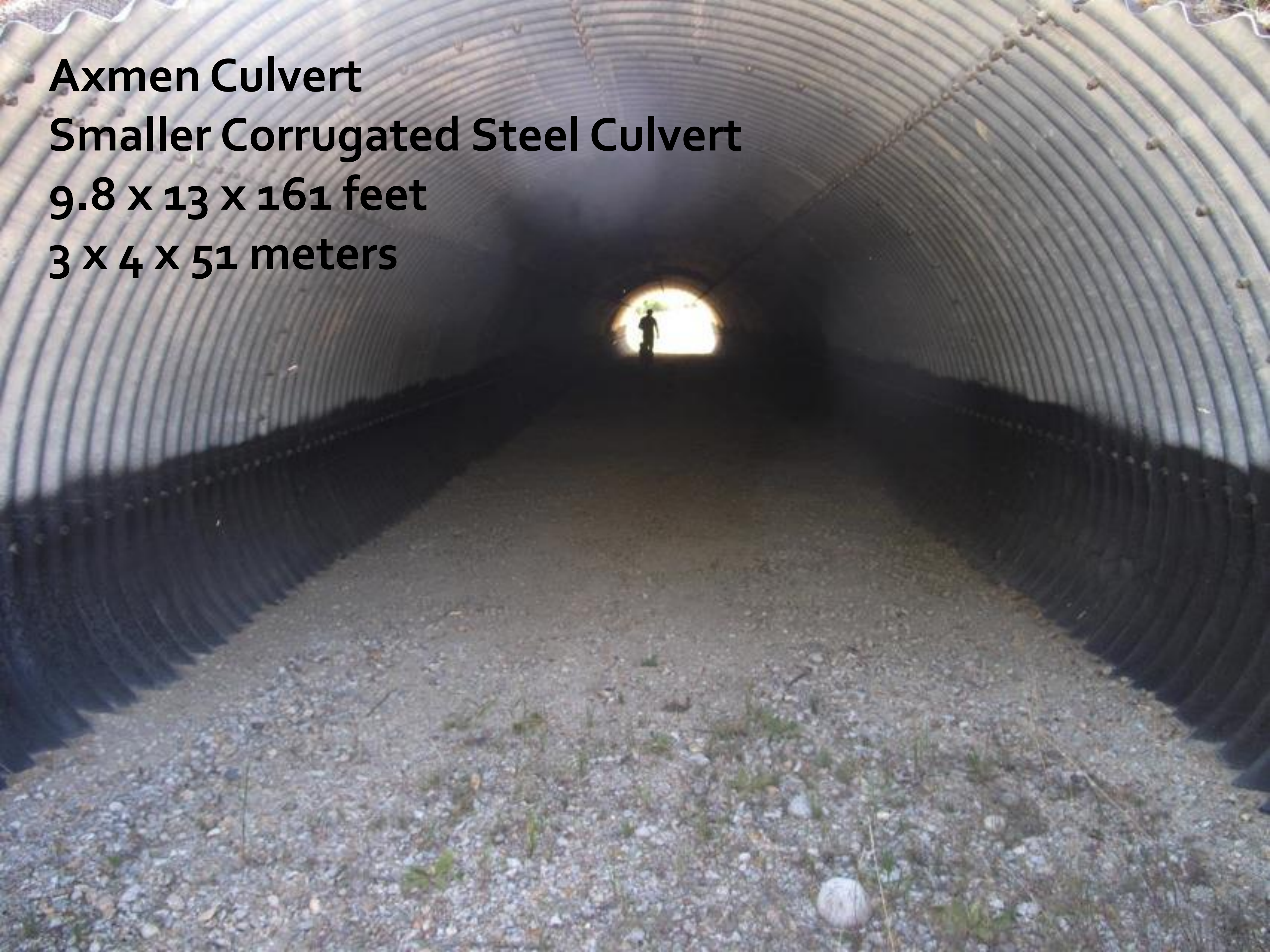
Bear Creek North Bridge – 4.3 Feet High (1.3 Meters)

Some Bridges Added to the US 93 South Projects AFTER Environmental Impact Statement – Others Present, But Overall NO TIME TO RE-ADJUST BRIDGE HEIGHTS

Bear Creek South Bridge – 12.5 Feet High (3.8 Meters) on Hillside Pathways

Larger Corrugated Steel Culvert
Bass Fishing Access Culvert
12.7 x 20 x 190 feet
3.9 x 6 x 58 meters

Axmen Culvert
Smaller Corrugated Steel Culvert
9.8 x 13 x 161 feet
3 x 4 x 51 meters




Fun Park Concrete Box Culvert
10 x 10 x 190 feet
3 x 3 x 59 Meters

Chapter 2 – White-Tailed Deer Use of Structures

Methods - Camera Placement

Pre-Construction Monitoring

Original Bridges, Habitat, ROW on 93 and CR 370

Control Cameras

ROW on CR 370

Post-Construction Monitoring

19 Structures

Pre-Construction Structures

Pre-Construction Habitat

Control Right-of-Way

Pre-Construction and Control Photo Analyses

Success Movement – individual animal went over US 93 or CR 370

Repellency Movement – individual moved away from US 93 or CR 370

Parallel Movement – individual moved parallel to US 93 or CR 370

Success + Repellency + Parallel = Total Movements

Post-Construction Monitoring

Post Construction Photo Analyses

<u>Success Movement</u> – individual animal went through structure

<u>Repellency Movement</u> – individual moved away from structure

<u>Parallel Movement</u> – individual moved parallel to structure

Success + Repellency + Parallel = Total Movements

Post-Construction Success Movement

Post-Construction Repellency

Post-Construction Parallel

Methods – Photo Analyses

$$\text{Success Rate} = \frac{\text{Success movements}}{\text{Total movements}}$$

$$\text{Success per Camera Day} = \frac{\text{Success movements}}{\text{Number camera days}}$$

$$\text{Abundance} = \frac{\text{Total movements}}{\text{Number camera days}}$$

Chapter 2 Results Pre-Construction and Control

Pre-Construction and Control Monitoring

64 % Success Rate moving over US 93 , repellency = 8%
63% Success Rate moving over CR 370, repellency = 5%

Pre-construction over US 93 elk Success Rate = 58%

Established Performance Measures

Minimum Success Rate = 60%
Rate of Repellency = 10% or less

Chapter 2. Pre-Construction Results

ROW PRE-CONSTRUCTION

Right of Way Camera Location	Success	Repellency	Parallel	Total Movements	Success Rate (%)	Rate of Repellency (%)
Lupine (south camera)	16	3	1	20	80	15
Fun Park (east camera)	606	85	80	771	79	11
Mill Creek	525	115	111	751	70	15
Bear Creek South	140	15	52	207	68	7
Mountain Gallery (south camera)	24	1	14	39	61	3
Kootenai Springs Ranch (west camera)	26	5	17	48	54	10
Sweathouse Creek	219	17	189	425	52	4
Fun Park (west camera)	57	4	49	110	52	4
Mountain Gallery (north camera)	64	6	72	142	45	4
Kootenai Springs Ranch (east camera)	72	12	142	226	32	5
Lupine (north camera)	0	1	0	1	0	100
Total	1,749	264	727	2,740	64%	8
Control Site CR 370	5,381	426	2,717	8,524	63%	5

Chapter 2 Results Post-Construction

Cameras recorded white-tailed deer successfully moving through wildlife crossing structures on 24,878 occasions.

Nine wildlife crossing structures (eight bridges, one culvert) exceeded the performance measures.

Ten structures (four bridges, six culverts) did not exceed the performance measures.

Chapter 2 Post-Construction Results

Top 9 Most Successful Wildlife Crossing Structures based on white-tailed deer success rate

Wildlife Crossing Structure	Success	Repel-lency	Parallel	Total Movements	Success Rate (%)	Rate of Repel-lency (%)	Parallel Rate (%)
Dawns Crossing Bridge	5204	65	94	5363	97	1	2
Bass Creek Fishing Access Culvert	3257	118	21	3396	96	3	1
Bear Creek South Bridge	2554	30	113	2697	95	1	4
Sweathouse Creek Bridge	2419	61	102	2582	94	2	4
Blodgett Creek Bridge	1037	25	36	1098	94	3	3
Kootenai Creek Bridge	2470	150	97	2717	91	5	4
Big Creek Bridge	2769	237	317	3323	83	7	10
McCalla Creek North Bridge	2058	142	265	2465	83	6	11
Mill Creek Bridge	1036	117	283	1436	72	8	20

Chapter 2 Post-Construction Results

10 Lowest Performing Wildlife Crossing Structures

Wildlife Crossing Structure	Success	Repel-lency	Parallel	Total Movements	Success Rate (%)	Rate of Repel-lency (%)	Parallel Rate (%)
Bass Creek North Bridge	260	33	188	481	54	7	39
Indian Prairie Loop Culvert	1039	228	1403	2670	39	8	53
McCalla Creek South Bridge	293	154	310	757	39	20	41
Bear Creek North Bridge	35	21	39	95	37	22	41
Bass Creek South Bridge	13	6	17	36	36	17	47
Lupine Culvert	70	43	132	245	29	17	54
Axmen Propane Culvert	235	133	969	1337	18	10	72
Mountain Gallery Culvert	26	28	307	361	7	8	85
Kootenai Springs Ranch Culvert	103	329	2170	2602	4	13	83
Fun Park Culvert	0	40	410	450	0	9	91

Chapter 2 Results

Examples of Use of Individual Structures

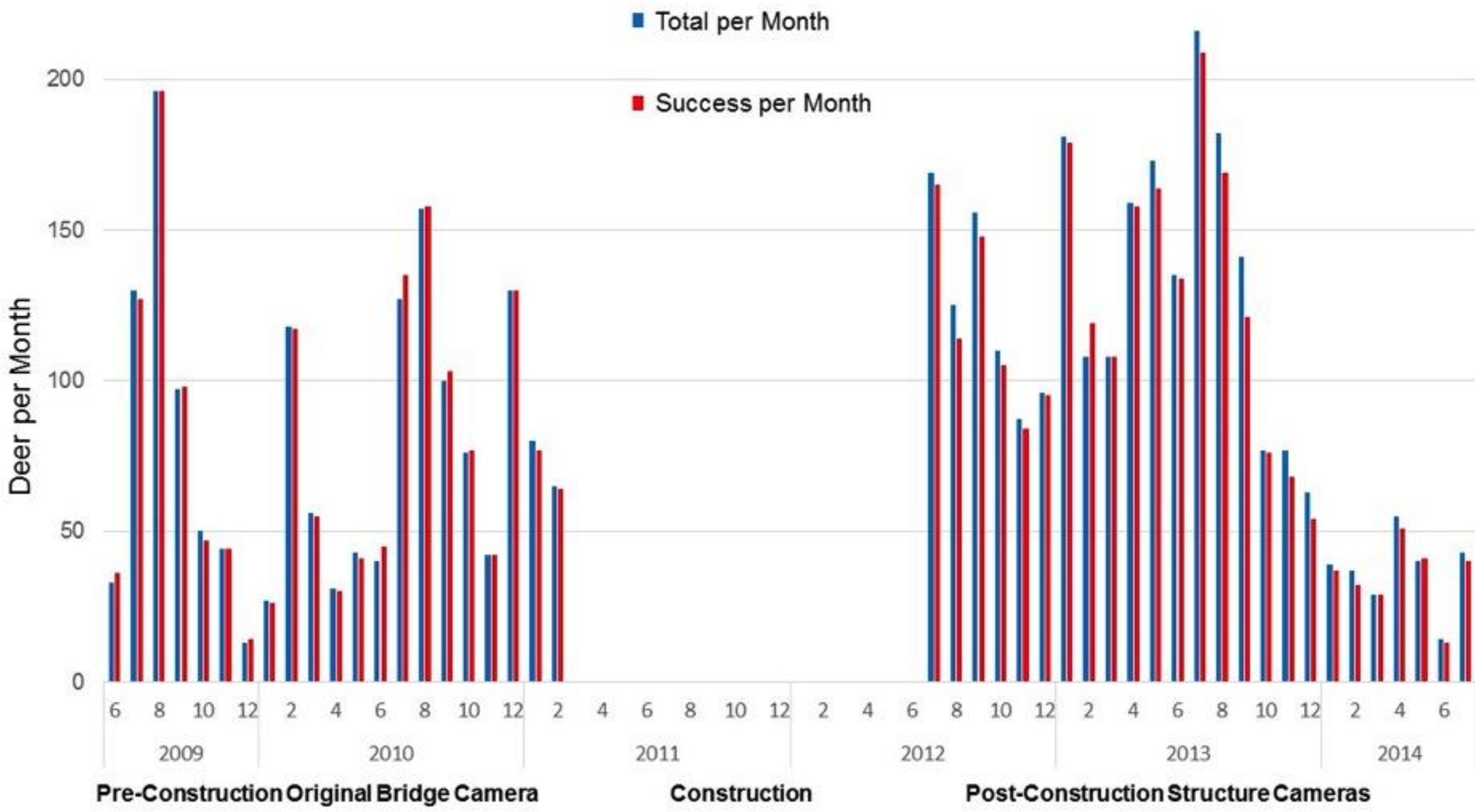
Success Rates over time

Changes in numbers of deer over time

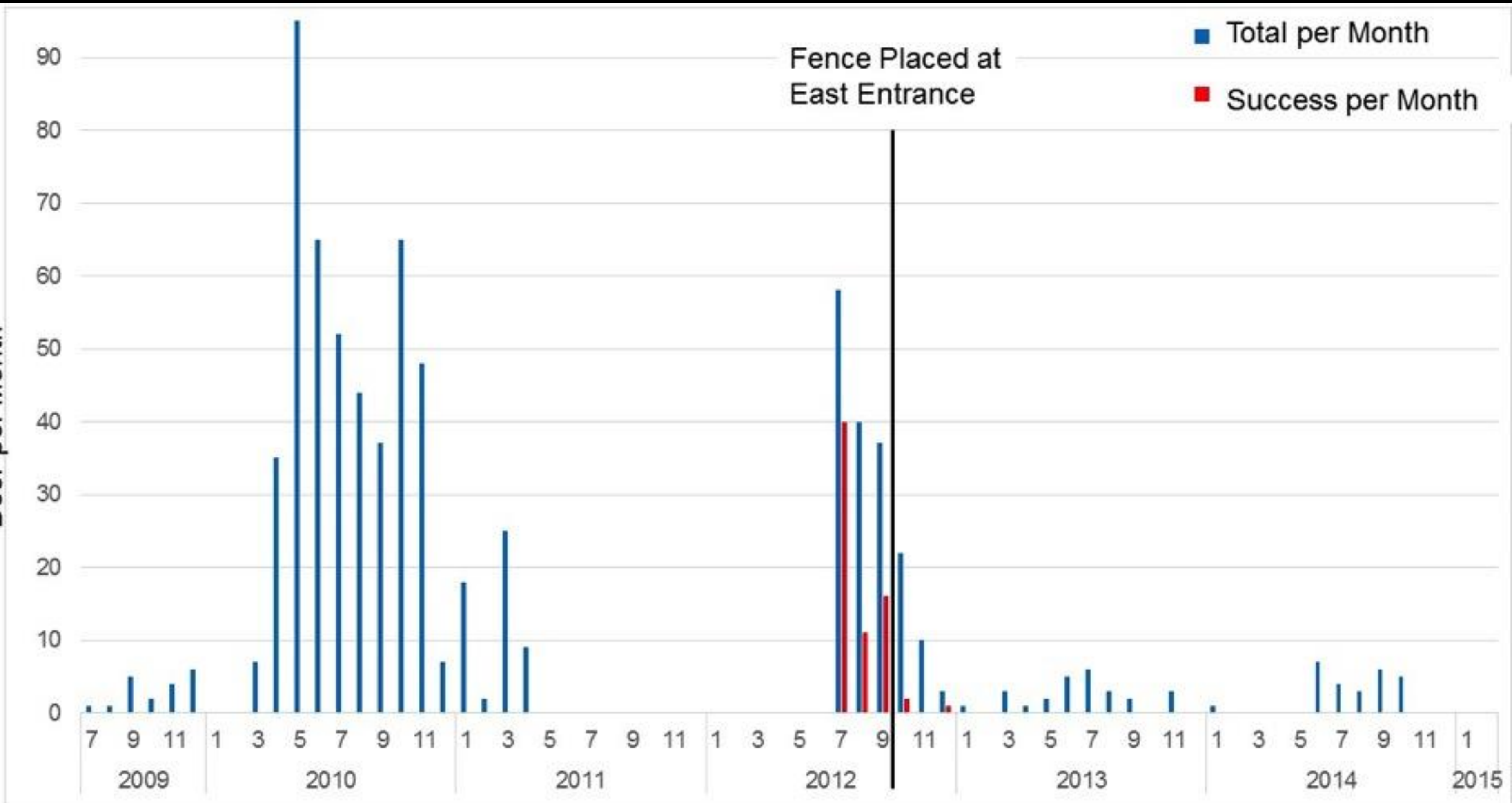
Increasing use

No Use

High Performing Bear Creek South Bridge– But Also Decreasing Trend

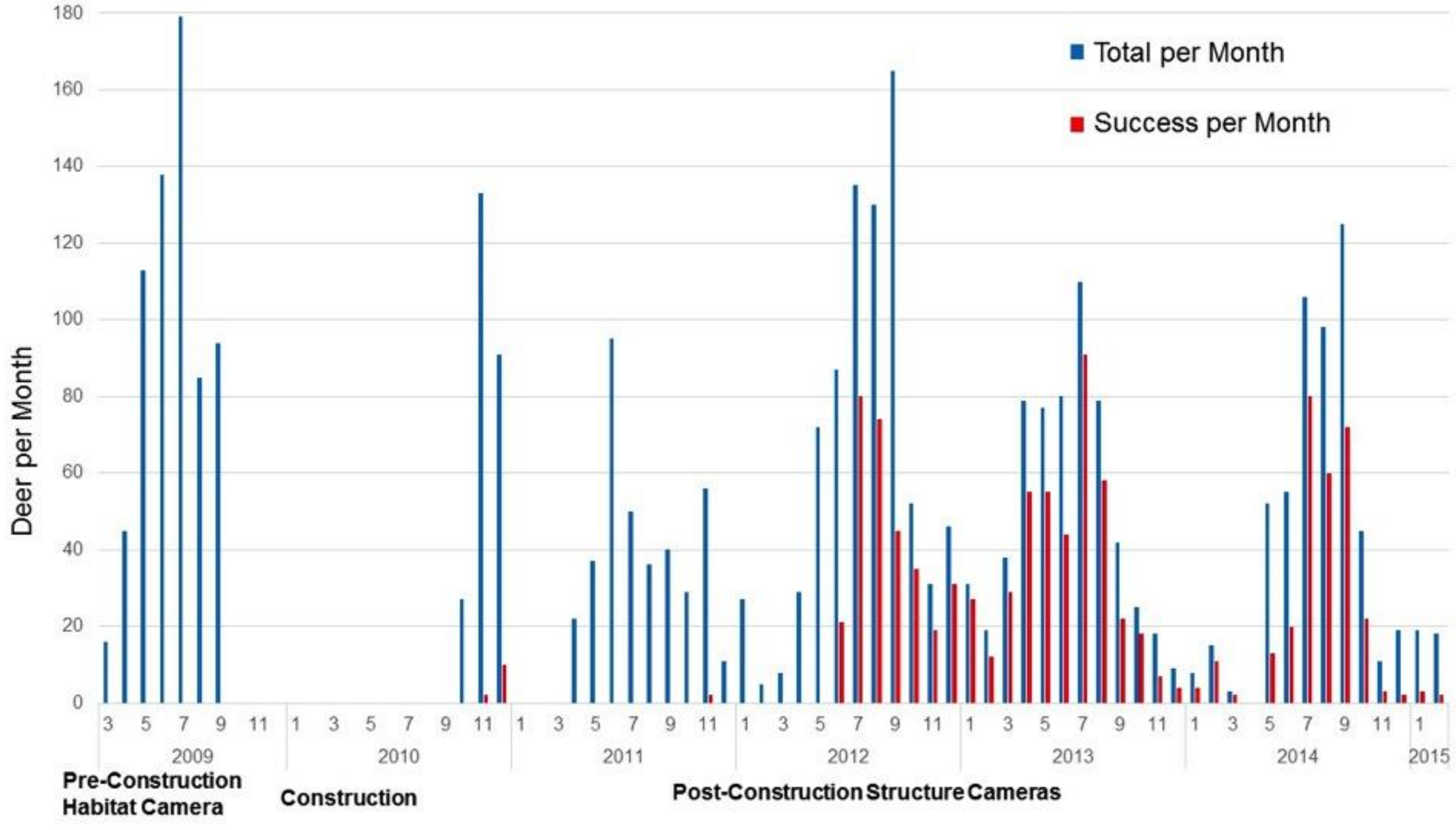


Low Performance to No Use
Lupine Culvert

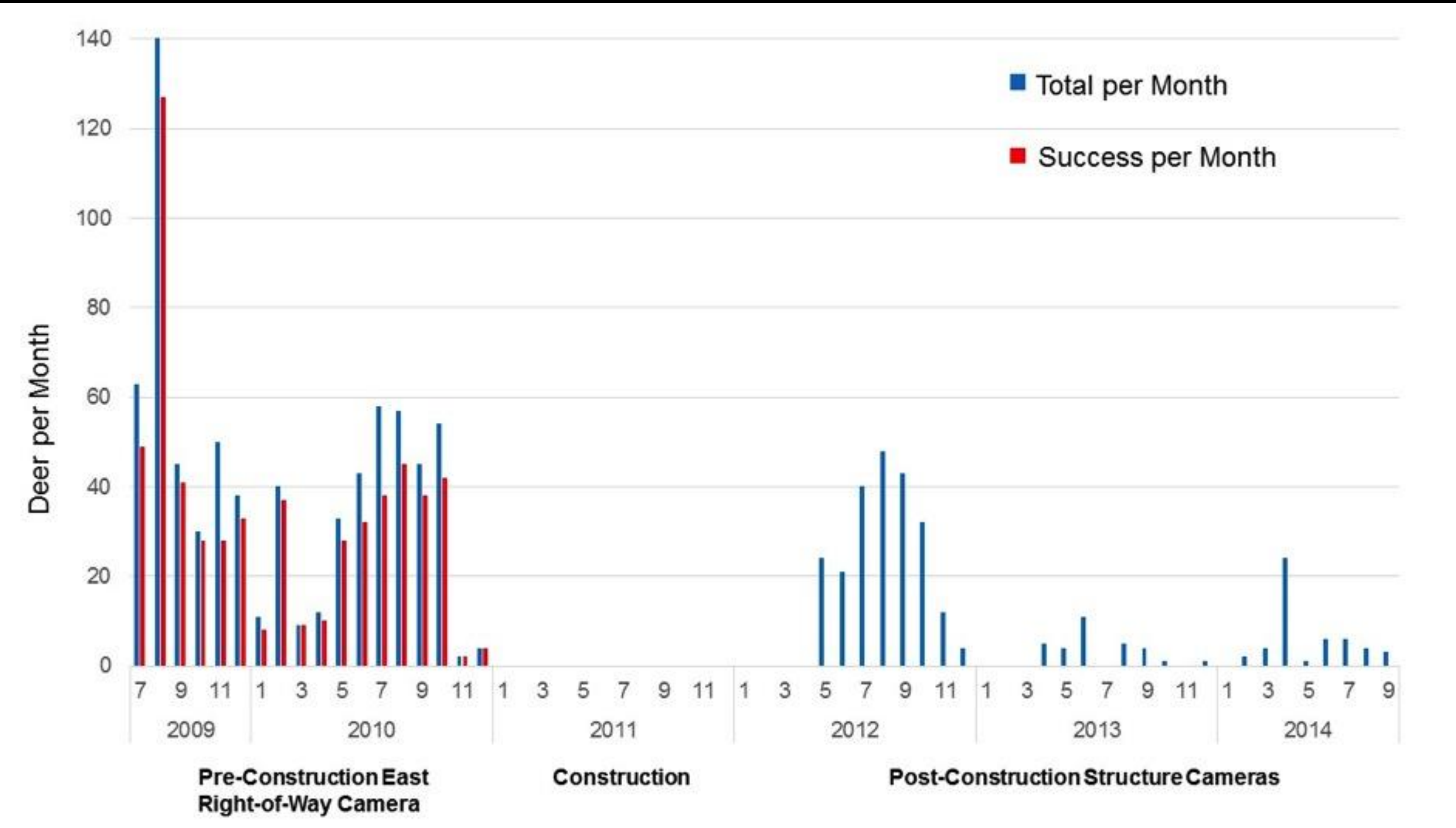


Pre-Construction North Habitat Cameras **Construction** **Post-Construction Structure Cameras**

Increasing Use Trend
Indian Prairie Culvert



Results- No Use
Fun Park Culvert



Chapter 3 – Relationships Between Usage Rates and Explanatory Variables

Usage Rates	Explanatory Variables
Success Rate	Structure Type
Rate of Repellency	Structure Height
Parallel Rate	Structure Width
Success per Camera day	Structure Length
	Structure Openness
	Fence, Guardrail, Humans, Grass, Forbs, Shrubs, Trees, Bare Ground, Water, Fecal Pellets

Chapter 3 Methods

What does *p*-value really mean?

p-value is the probability of observing the effect from your data from random chance, assuming the null hypothesis is true.

Low *p*-value : the effects are unlikely to be due to random chance

Chapter 3 Statistical Methods

Generalized Linear Models were Used to Analyze Relationships

- Generalized Mix Linear Model with a binomial response for rates related to structure types
- One Way ANOVA was used for success per camera day
- Linear Regression for use rates and explanatory variables
- Two-sample test used for bridges vs culverts and explanatory variables

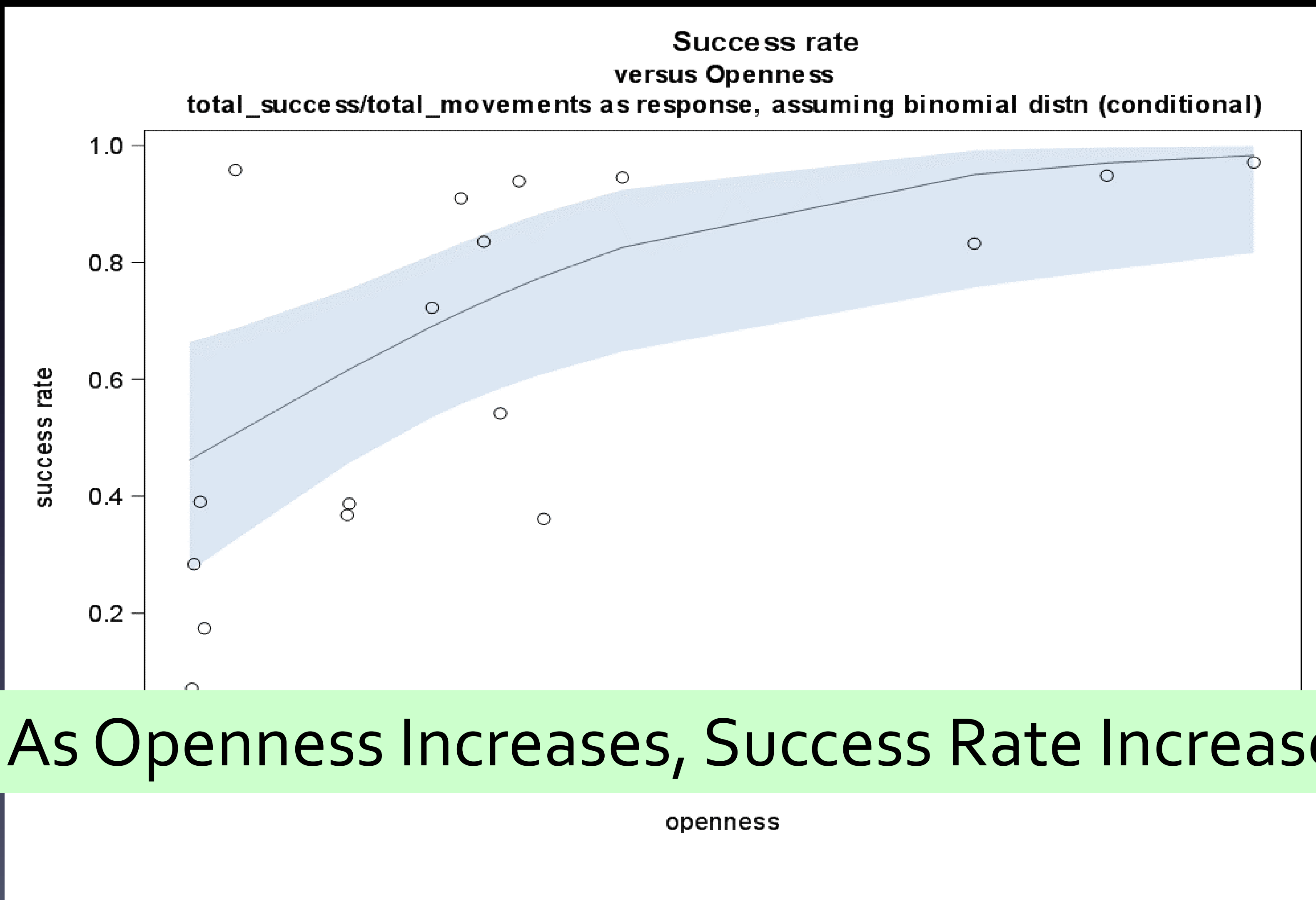
	Success per Day	Success Rate	Rate of Repellency	Parallel Rate	Type of Structure
Type of Structure B: bridge C: culvert	p = 0.08 B: 0.92 C: 0.23	p = 0.005 B: 81% C: 16%	p = 0.19	p = 0.01 B: 12% C: 57%	
Height	p = 0.70	p = 0.20	p = 0.01 Slope = -0.56	p = 0.28	p = 0.26
Width	p = 0.0008 Slope = 0.03	p = 0.01 Slope = 0.08	p = 0.10 Slope = -0.02	p = 0.006 Slope = -0.09	p < 0.001 B: 26.8 C: 3.8
Length	p = 0.09 Slope = -0.02	p = 0.04 Slope = -0.06	p = 0.25	p = 0.03 Slope = 0.06	p < 0.001 B: 26.0 C: 52.0
Openness	p = 0.0007 Slope = 0.24	p = 0.009 Slope = 0.74	p = 0.009 slope= -0.28	p = 0.009 Slope = -0.86	p < 0.001 B: 2.5 C: 0.2
Fence	p = 0.45	p = 0.63	p = 0.98	p = 0.59	p = 0.56
Guard rail	p = 0.21	p = 0.04 Slope = 0.004	p = 0.02 Slope = -0.004	p = 0.04 Slope = -0.004	
Humans per day	p = 0.54	p = 0.80	p = 0.63	p = 0.84	p = 0.10 B: 0.15 C: 0.06
Grass	p = 0.37	p = 0.81	p = 0.39	p = 0.68	p = 0.74
Forbs	p = 0.15	p = 0.90	p = 0.95	p = 0.89	p = 0.21
Shrubs	p = 0.21	p = 0.10 slope= 0.13	p = 0.04 Slope = -0.07	p = 0.12	p = 0.53
Trees	p = 0.99	p = 0.23	p = 0.38	p = 0.24	p = 0.62

Chapter 3 Statistical Test Results

Green Boxes Show Strong Evidence of Relationship

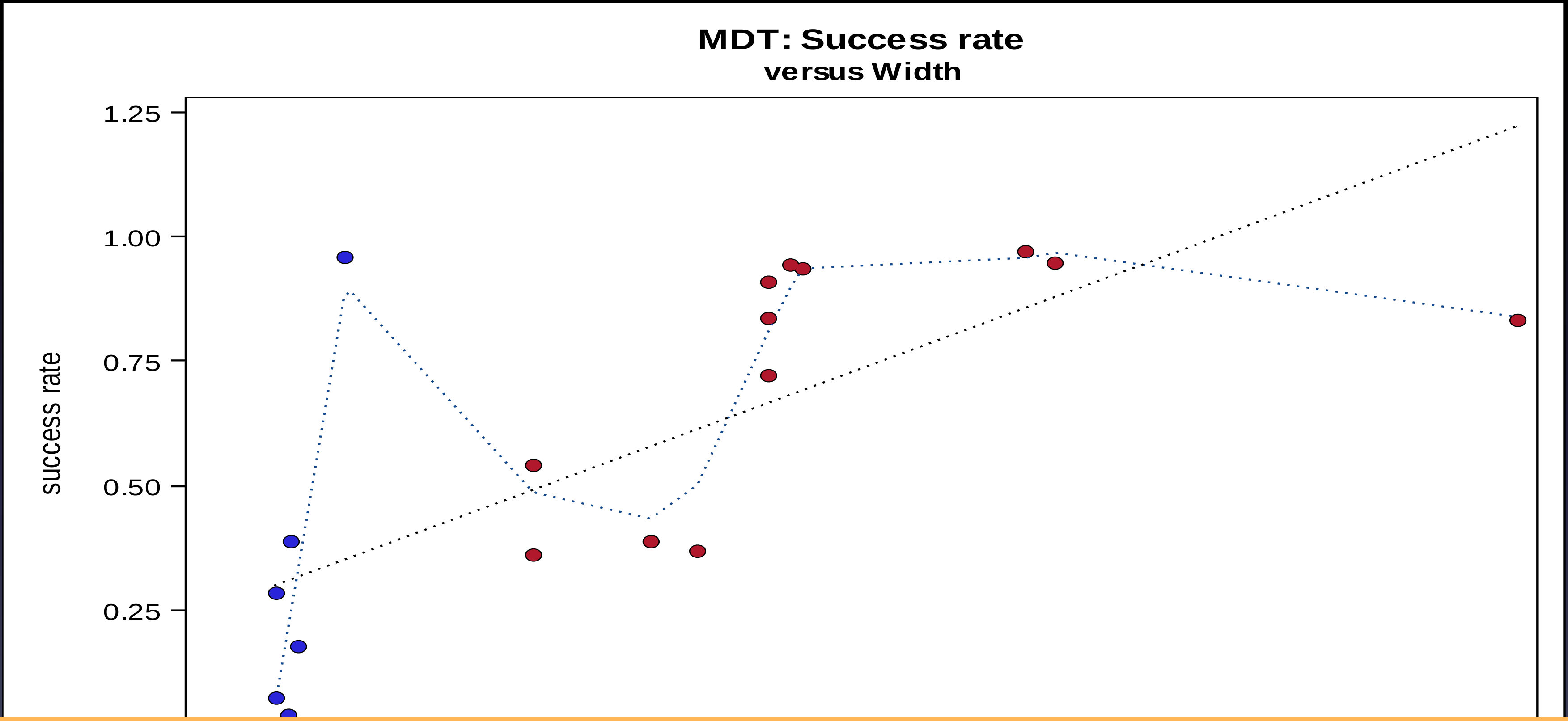
Light Green Boxes Show Uncertain Evidence

White-Tailed Deer Success Rate with Openness



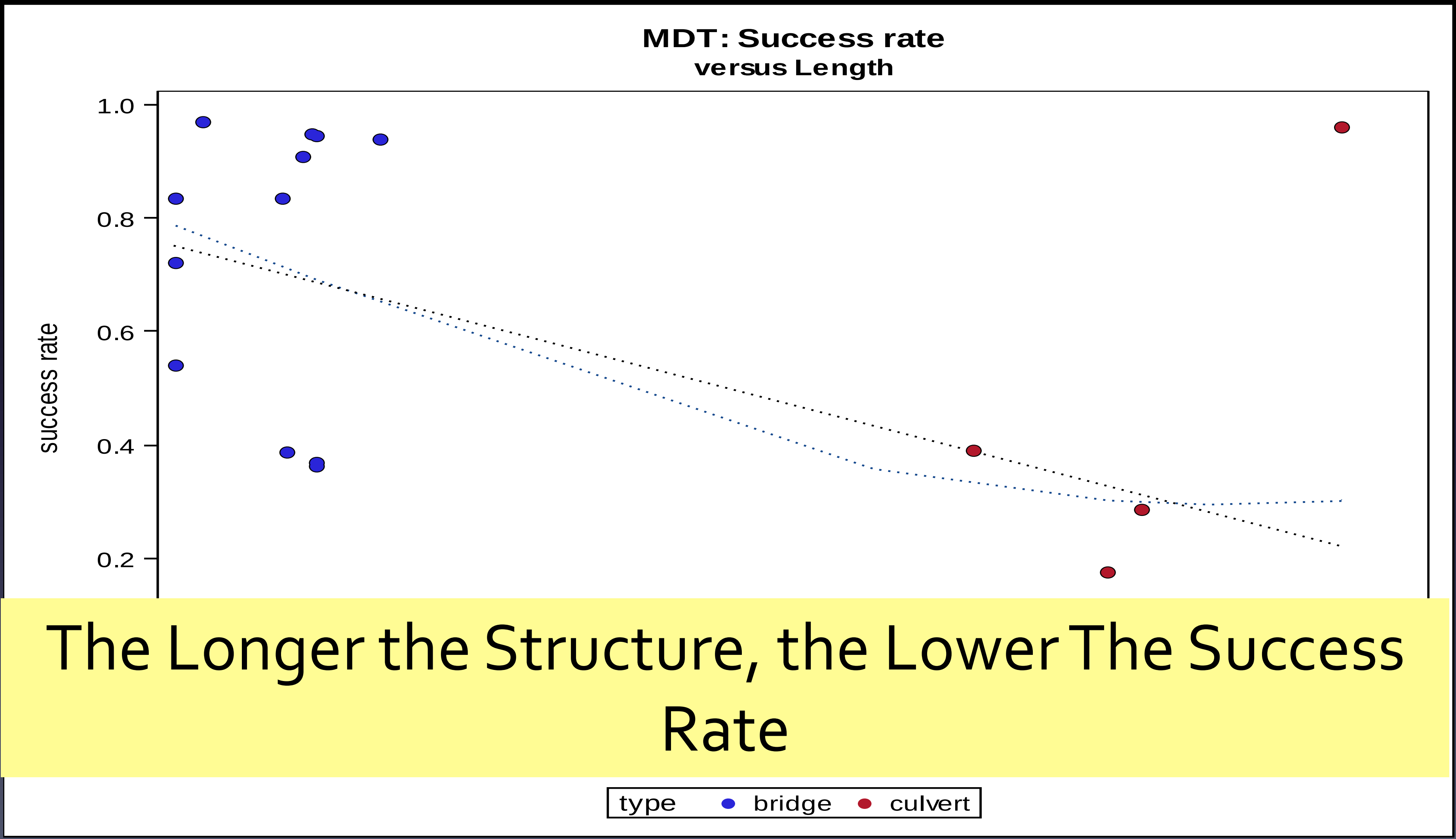
As Openness Increases, Success Rate Increases

White-Tailed Deer Success Rate Compared with Structure Width



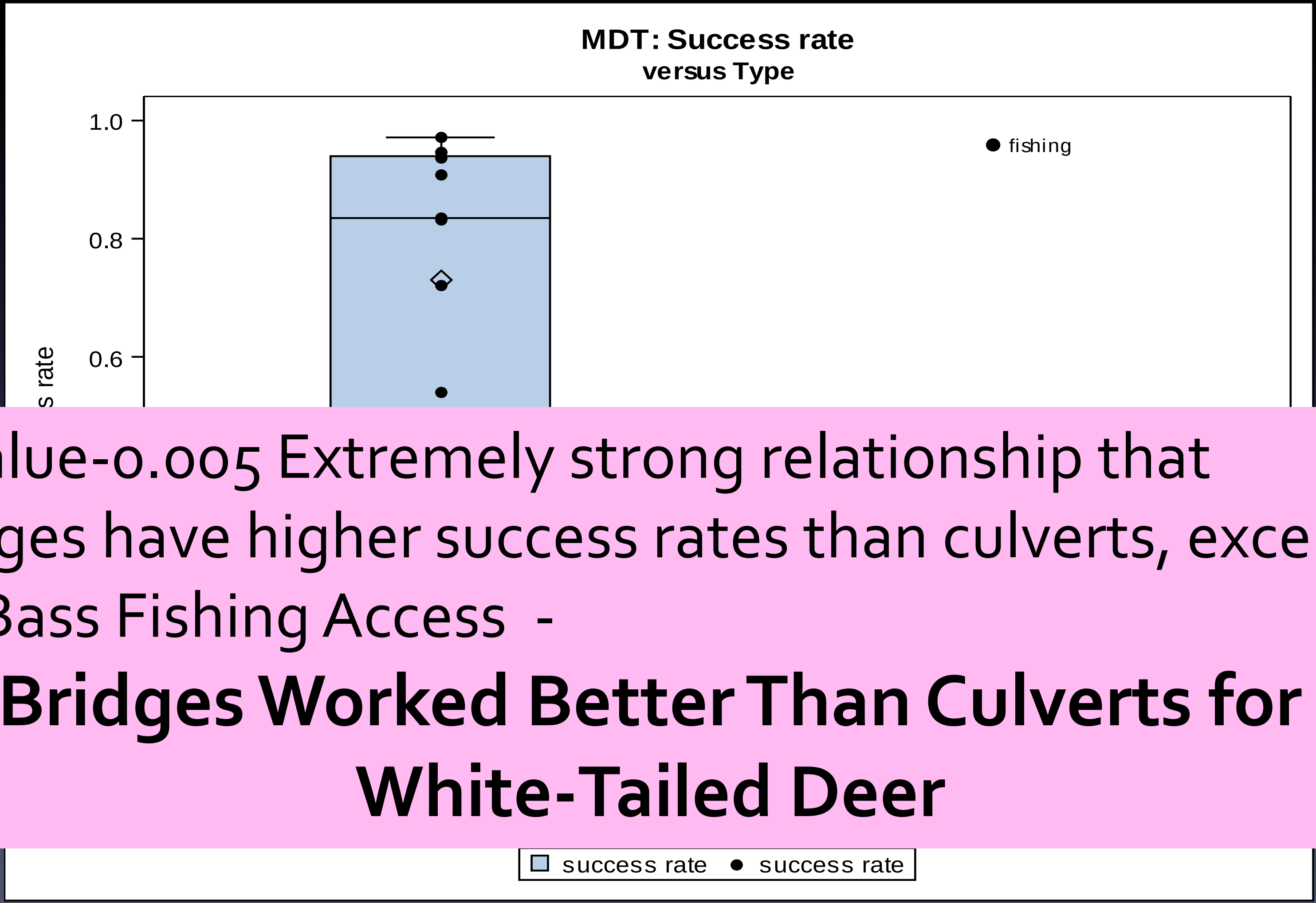
The Wider the Structure, the Greater Success Rate

White-Tailed Deer Success Rate Compared with Length of Structure



The Longer the Structure, the Lower The Success Rate

White-Tailed Deer Success Rate with Bridges & Culverts



P-value-0.005 Extremely strong relationship that bridges have higher success rates than culverts, except for Bass Fishing Access -

Bridges Worked Better Than Culverts for White-Tailed Deer

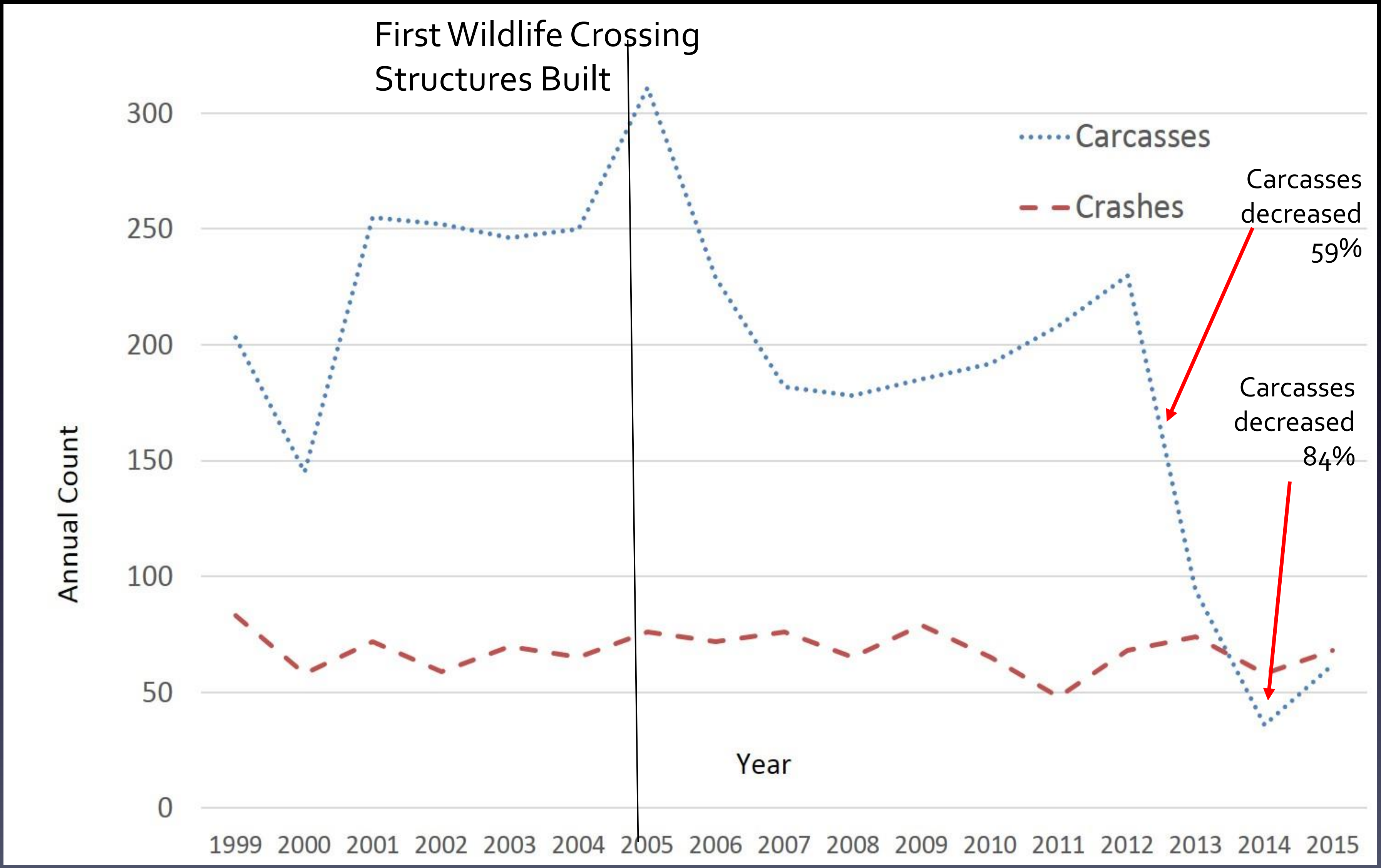
Chapter 4 – Wildlife-Vehicle-Collisions Over Space & Time

Objectives

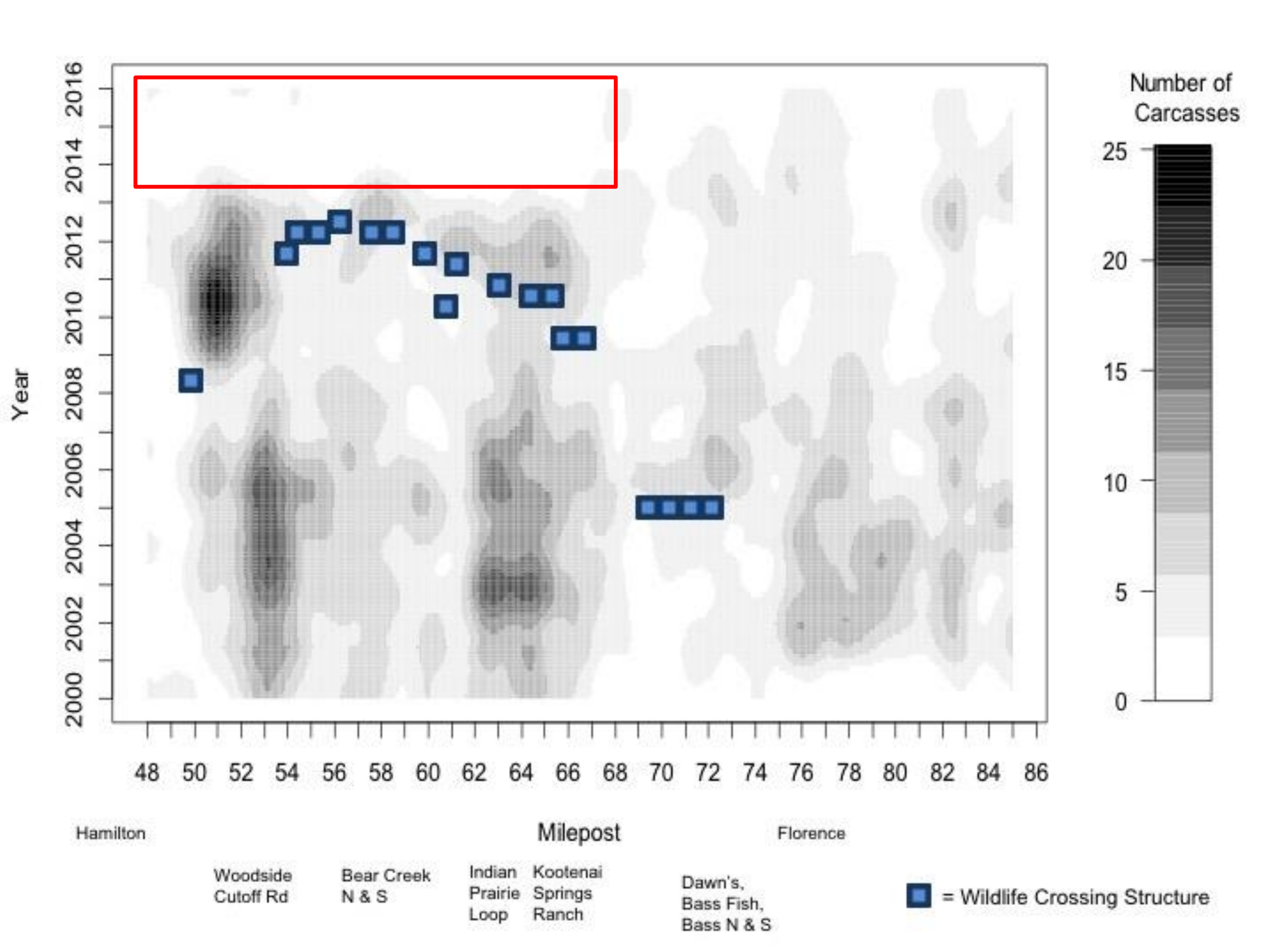
Changes in wildlife-vehicle collisions between pre-construction and post-construction of wildlife crossing structures within a 40 kilometers (25 mile) stretch of US Highway 93 South, mile post (MP) 74 to MP 49, and;

Relationships between wildlife-vehicle collisions and wildlife crossing structures over time and space.

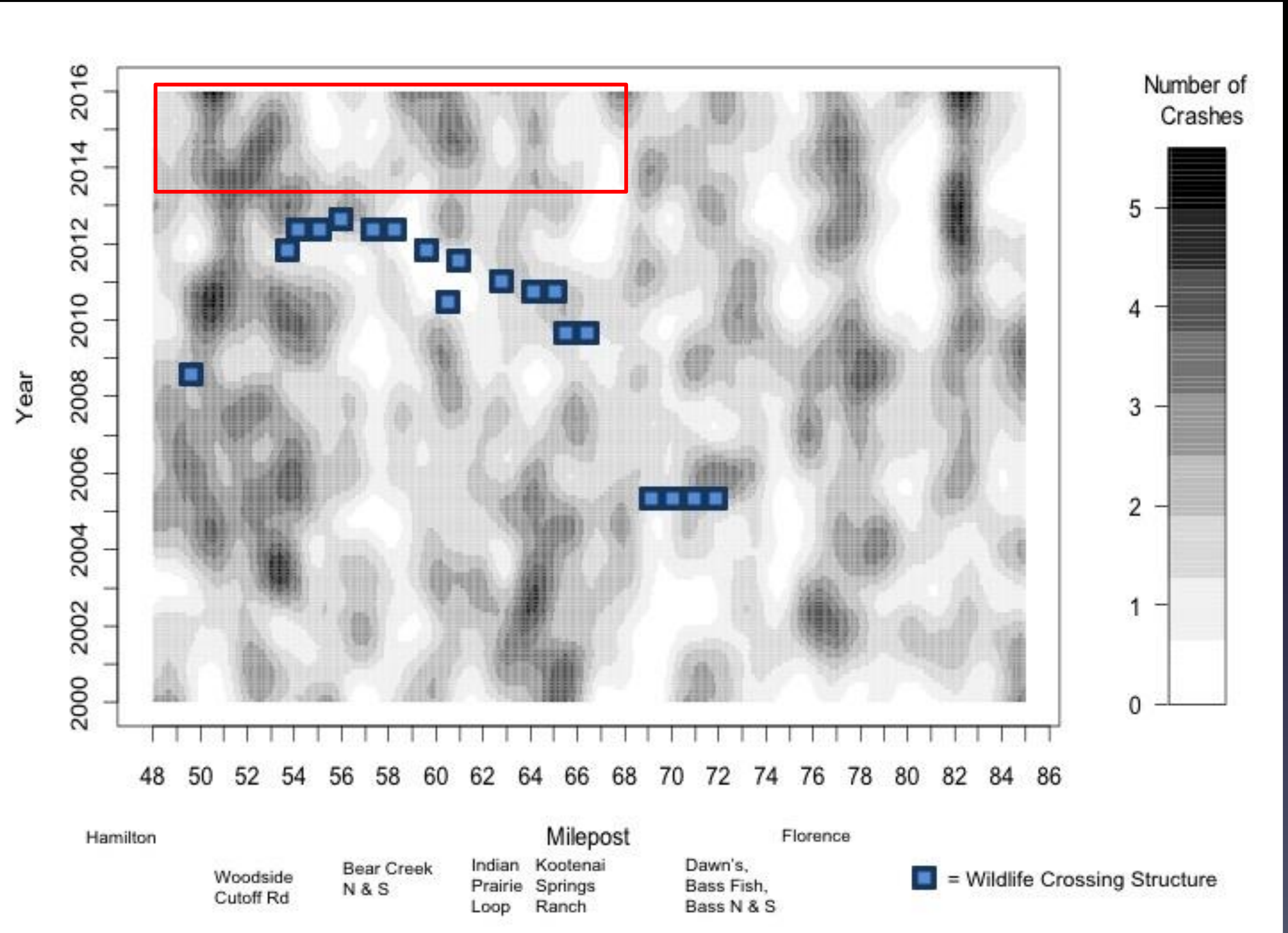
Chapter 4 WVC Crash & Carcass Data



Chapter 4 WVC Carcass Data Kernel2d



Chapter 4 WVC Crash Data Kernel2d



Chapter 4 White-tailed Deer Abundance, Traffic Volume Predictive Model

Statistical modeling to determine predictive relationship between WVC and traffic volume and deer abundance commenced. Findings:

- Total white-tailed deer annual harvest rates were the best predictor of deer abundance, of the data available after 2005 end of aerial flight estimates.
- Data collection on WVC carcasses, crashes, traffic volume and deer harvest rates were insufficient to build a fine scale model needed to predict WVC rates based on various traffic volumes and deer abundance.

Chapter 4 Before-After-Control-Impact (BACI) Analysis of Changes in WVC Crash Rates

Before = pre-construction wildlife crossing structure sites

After = post-construction for individual sites and segments of construction

Control = mp50.5 - 54.2 in south, and mp 66.5 – 69 in north

Intervention = Period after construction for both wildlife crossings and control

Chapter 4 BACI Methods

Generalized Linear Mixed Model used to compare WVC crash rate changes between pre and post-construction at the wildlife crossing structures with
Changes in WVC rates between pre and post-construction at control sections

Structure	Construction	Crossing Space Time	Control Space Time	Crossing Differen.	Control Difference	p-value	Relative Differenc.
	(Year)	(mp, pre yrs, post yrs)	(mp, pre yrs, post yrs)	(Crashes/yr/mi)	(Crashes/yr/mi)		(Crashes/yr/mi)
Bass North, mp 71.1	2004-2005	71.3-70.9, 99-03, 10-15	69.0-66.5, 99-03, 10-15	1.0	0.3	0.77	0.7
Bass South, mp 70.5	2004-2005	70.7-70.3, 99-03, 10-15	69.0-66.5, 99-03, 10-15	-0.4	0.3	0.55	-0.7
Fishing, mp 70.1 and Dawns, mp 69.7	2004-2005	70.4-69.0, 99-03, 10-15	69.0-66.5, 99-03, 10-15	1.5	0.3	0.35	1.2
Kootenai, mp 66.2 and McCalla North, mp 66.1	2008-2009	66.4-65.9, 99-07, 10-15	69.0-66.5, 99-07, 10-15	-2.5	0.1	0.11	-2.6
McCalla South, mp 65.1 and Kootenai Springs, mp 64.6	2009-2010	65.3-63.8, 99-06, 11-15	54.2-50.5, 99-06, 11-15	-1.3	-0.1	0.22	-1.2
Indian, mp 63.4	2010	63.7-63.1, 99-06, 11-15	54.2-50.5, 99-06, 11-15	-1.0	-0.1	0.42	-0.9
Big, mp 61.6	2010-2011	61.8-61.4, 99-06, 12-15	54.2-50.5, 99-06, 12-15	-1.6	0.2	0.3	-1.8
Axmen, mp 60.7	2010	60.9-60.5, 99-06, 11-15	54.2-50.5, 99-06, 11-15	0.2	-0.1	0.88	0.3
Sweathouse, mp 59.7	2011	59.9-59.5, 99-06, 12-15	54.2-50.5, 99-06, 12-15	-0.6	0.2	0.58	-0.8
Bear North, mp 58.3	2011	58.5-58.1, 99-06, 12-15	54.2-50.5, 99-06, 12-15	0.3	0.2	0.95	0.1
Bear South, mp 57.1	2011	57.3-56.9, 99-06, 12-15	54.2-50.5, 99-06, 12-15	-1.6	0.2	0.3	-1.8
Lupine, mp 56.7	2011	56.9-56.5, 99-06, 12-15	54.2-50.5, 99-06, 12-15	0.0	0.2	0.91	-0.2
Gallery, mp 56.2	2011	56.4-56.0, 99-06, 12-15	54.2-50.5, 99-06, 12-15	0.6	0.2	0.8	0.4
Fun Park, mp 55.5	2011	55.7-55.3, 99-06, 12-15	54.2-50.5, 99-06, 12-15	-1.6	0.2	0.34	-1.8
Mill Creek, mp 54.6	2011	54.8-54.4, 99-06, 12-15	54.2-50.5, 99-06, 12-15	0.3	0.2	0.93	0.1
Blodgett, mp 50.3	2008	50.5-50.1, 99-06, 09-15	54.2-50.5, 99-06, 09-15	1.6	0.2	0.49	1.4

Chapter 4 BACI Results

Wildlife Crossing Structures had no statistical significant effect on WVC crash rates

Best results were at the McCalla North and Kootenai Creek Bridges, just south of Stevensville: annual crash rate decreased by 2.6 crashes. Statistical difference p-value = 0.11

Blodgett Creek Bridge at mp 50 had highest increases: of 1.4 crashes per year post-construction

Chapter 5 Recommendations

1. Accurate Carcass Data Collection is Necessary to Locate Problem Areas and Evaluate Solutions

2. Build Wildlife Crossing Structures with the Largest Possible Openness Ratios

3. High Openness is Best Created with Bridges Rather Than Culverts – Consider Bridges Whenever Possible

But…. Openness ratio is not the sole factor, and bridges don't always work better than culverts

We need to evaluate each location, each structure type, and each dimension, for an overall open structure

Bass Fishing Access Culvert
12.7 x 20 x 190 feet,
Openness (meters): 0.4: 1.3 in feet
Success Rate: 96%

Bear Creek North Bridge 4.3 x 69 x 90 feet
Openness (meters): 1.0: 3.3 in feet
Success Rate: 37%

Chapter 5 Recommendations

4. The Most Important Structure Dimension is Width – Maximize Width

5. Minimize Length of Structures

6. Maximize Height of Structures to Help Increase Openness

Recommendations

7. Extended wildlife fencing did Not improve deer use of structures, but helped decrease WVC. Use caution with extended fencing.

8. Wildlife Crossing Structures work in a suburban –wild land setting

9. MDT will need to consult with MTFWP for location of structures and design to maximize types of species that will use them

Recommendations

10. Conduct pre-construction monitoring to understand what is happening and to help set performance measures

11. Monitor with cameras and inspect infrastructure regularly to help adaptively manage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Thank-You