WELCOME: ARC WILDLIFE CROSSING SOLUTIONS

Technology Presentation
Lakewood, CO June 1, 2012

Roger W. Surdahl, P.E.
Technology Delivery Engineer
FHWA – CFLHD
ARC WILDLIFE CROSSING SOLUTIONS: PRESENTER

Rob Ament
Road Ecology Program Manager
Montana State University
Western Transportation Institute
GOAL: Ensuring safe passage for both humans and animals on and across our roads.

We do this through supporting the study, design and construction of wildlife crossing structures throughout North America.
INCREDIBLE PARTNERS & SUPPORT

Others: Western Governors’ Wildlife Council, Parks Canada Agency, Canadian Pacific, Center for Large Landscape Conservation
WILDLIFE CROSSINGS
WHY TAKE ACTION?

• Improve motorist safety
• Reduce collision costs
• Reduce wildlife mortality
• Conserve T and E species
• Improve wildlife population survival
• Address mass mortality
• Loss or suffering of wildlife
• Promote habitat connectivity
WVCs: International Issue (Transportation Safety)

<table>
<thead>
<tr>
<th></th>
<th>US</th>
<th>Canada</th>
<th>Europe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal-vehicle-Collisions</td>
<td>1-2 million (deer)</td>
<td>± 28,000</td>
<td>507,000 (ungulates)</td>
</tr>
<tr>
<td>Human injuries</td>
<td>29,000</td>
<td>1,565</td>
<td>30,000</td>
</tr>
<tr>
<td>Human fatalities</td>
<td>211</td>
<td>18</td>
<td>300</td>
</tr>
<tr>
<td>Property damage</td>
<td>&gt; 8 billion US$</td>
<td>200 million CAN$</td>
<td>&gt; 1 billion US$</td>
</tr>
</tbody>
</table>

Conover et al., 1995; Cook & Daggett, 1995; Groot Bruinderink & Hazebroek, 1996; L-P Tardiff & Associates Inc. 2003; Huijser et al. 2008

per year
.... and increasing
U.S. trend: animal-vehicle collisions

AVCs: $P < 0.001$, $R^2 = 0.89$

GES (General Estimates System Sub-sample for every US state)

Huijser et al., 2008

1-2 million ungulate-vehicle collisions / year in US (Huijser et al. 2008)
# Species and Numbers

A Conservation Issue

<table>
<thead>
<tr>
<th>Species</th>
<th>Road kills *</th>
<th>Country</th>
<th>Year/Period</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertebrates</td>
<td>365</td>
<td>USA</td>
<td>1960's</td>
<td>Humane Society 1960, in Lalo 1987</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>ES</td>
<td>1990's</td>
<td>Caletro et al. 1996</td>
</tr>
<tr>
<td></td>
<td>6.5</td>
<td>FI</td>
<td>2002</td>
<td>Maniari 2002</td>
</tr>
<tr>
<td></td>
<td>4.0</td>
<td>BE</td>
<td>1994</td>
<td>Rodts et al. 1998</td>
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<tr>
<td>Birds</td>
<td>8.5</td>
<td>SE</td>
<td>1998</td>
<td>Svensson 1998</td>
</tr>
<tr>
<td></td>
<td>5.0</td>
<td>BL</td>
<td>1983</td>
<td>Mankinov &amp; Todorov 1983</td>
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<tr>
<td></td>
<td>4.0</td>
<td>UK</td>
<td>1966</td>
<td>Hodson 1966</td>
</tr>
<tr>
<td></td>
<td>3.7</td>
<td>DK</td>
<td>1981</td>
<td>Hansen 1982</td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td>UK</td>
<td>1965</td>
<td>Hodson &amp; Snow 1965</td>
</tr>
<tr>
<td></td>
<td>2.0</td>
<td>NL</td>
<td>1993</td>
<td>Tempel 1993</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
<td>SE</td>
<td>1970's</td>
<td>Göransson et al. 1978</td>
</tr>
<tr>
<td></td>
<td>0.6</td>
<td>NL</td>
<td>1977</td>
<td>Jonkers &amp; De Vries 1977</td>
</tr>
<tr>
<td>Birds &amp; Mammals</td>
<td>2.0</td>
<td>CAN</td>
<td>1970's</td>
<td>Oxley &amp; Fenton 1976</td>
</tr>
<tr>
<td>Large &amp; Medium</td>
<td>1.5</td>
<td>DK</td>
<td>1980</td>
<td>Hansen 1982</td>
</tr>
<tr>
<td>Sized Mammals</td>
<td>0.5</td>
<td>SE</td>
<td>1970's</td>
<td>Göransson et al. 1979</td>
</tr>
<tr>
<td></td>
<td>3.0</td>
<td>DK</td>
<td>1982</td>
<td>Hansen 1982</td>
</tr>
<tr>
<td>Ungulates</td>
<td>0.5</td>
<td>USA **</td>
<td>1991</td>
<td>Romin &amp; Bissonette 1996</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>EU</td>
<td>1995</td>
<td>Groot-Bruinderink &amp; Hazenroek 1996</td>
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<td></td>
<td>0.004</td>
<td>F</td>
<td>1990's</td>
<td>SETRA 1998</td>
</tr>
<tr>
<td></td>
<td>0.002</td>
<td>ES</td>
<td>1992</td>
<td>Fernandez 1993</td>
</tr>
</tbody>
</table>

* in millions per year, nationwide

** only deer (Odocoileus spp.)

Seiler (2003)
# Federally Listed T&E Species

<table>
<thead>
<tr>
<th>Species Group</th>
<th>Species Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amphibians</td>
<td>California tiger salamander ((\text{Ambystoma californiense}), \text{C. CA, S. Barb., Son. county})</td>
</tr>
<tr>
<td>Amphibians</td>
<td>Flatwoods salamander ((\text{Ambystoma cingulatum}))</td>
</tr>
<tr>
<td>Amphibians</td>
<td>Houston toad ((\text{Bufo houstonensis}))</td>
</tr>
<tr>
<td>Reptiles</td>
<td>American crocodile ((\text{Crocodylus acutus}))</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Desert tortoise ((\text{Gopherus agassizii}), \text{except in Sonoran Desert})</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Gopher tortoise ((\text{Gopherus polyphemus}), \text{W of Mobile/Tombigbee Rs.})</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Alabama red-bellied turtle ((\text{Pseudemys alabamensis}))</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Bog turtle ((\text{Muhlenberg}) \text{ northern population (Clemmys muhlenbergii}))</td>
</tr>
<tr>
<td>Reptiles</td>
<td>Copperbelly water snake ((\text{Nerodia erythrogaster neglecta}))</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Species Group</th>
<th>Species Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reptiles</td>
<td>Eastern indigo snake, eastern indigo ((\text{Drymarchon corais couperi}))</td>
</tr>
<tr>
<td>Birds</td>
<td>Audubon's crested caracara ((\text{Polyborus plancus audubonii}), \text{FL pop.})</td>
</tr>
<tr>
<td>Birds</td>
<td>Hawaiian goose ((\text{Branta sandvicensis}))</td>
</tr>
<tr>
<td>Birds</td>
<td>Florida scrub jay ((\text{Aphelocoma coerulescens}))</td>
</tr>
<tr>
<td>Mammals</td>
<td>Lower Keys marsh rabbit, ((\text{Sylvilagus palustris hefneri}))</td>
</tr>
<tr>
<td>Mammals</td>
<td>Key deer ((\text{Odocoileus virginianus clavium}))</td>
</tr>
<tr>
<td>Mammals</td>
<td>Bighorn Sheep, Peninsular CA pop. ((\text{Ovis canadensis}))</td>
</tr>
<tr>
<td>Mammals</td>
<td>San Joaquin kit fox ((\text{Vulpes macrotis mutica}))</td>
</tr>
<tr>
<td>Mammals</td>
<td>Canada lynx ((\text{Lynx canadensis}), \text{lower 48 states})</td>
</tr>
<tr>
<td>Mammals</td>
<td>Ocelot ((\text{Leopardus pardalis}))</td>
</tr>
<tr>
<td>Mammals</td>
<td>Florida panther ((\text{Felis concolor coryi}))</td>
</tr>
<tr>
<td>Mammals</td>
<td>Red wolf ((\text{Canis rufus}), \text{except where XN})</td>
</tr>
</tbody>
</table>

Huijser et al. 2008
North America: costs of collisions

<table>
<thead>
<tr>
<th>Description</th>
<th>Deer</th>
<th>Elk</th>
<th>Moose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle repair costs per collision</td>
<td>$2,622</td>
<td>$4,550</td>
<td>$5,600</td>
</tr>
<tr>
<td>Human injuries per collision</td>
<td>$2,702</td>
<td>$5,403</td>
<td>$10,807</td>
</tr>
<tr>
<td>Human fatalities per collision</td>
<td>$1,002</td>
<td>$6,683</td>
<td>$13,366</td>
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<tr>
<td>Towing, accident attendance and investigation</td>
<td>$125</td>
<td>$375</td>
<td>$500</td>
</tr>
<tr>
<td>Hunting value animal per collision</td>
<td>$116</td>
<td>$397</td>
<td>$387</td>
</tr>
<tr>
<td>Carcass removal and disposal per collision</td>
<td>$50</td>
<td>$75</td>
<td>$100</td>
</tr>
<tr>
<td>Total</td>
<td>$6,617</td>
<td>$17,483</td>
<td>$30,760</td>
</tr>
</tbody>
</table>

Huijser et al. 2009, Ecology and Society
## Effective Measures

<table>
<thead>
<tr>
<th>Mitigation measure</th>
<th>Effectiveness</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seasonal wildlife warning sign</td>
<td>26%</td>
<td>Sullivan et al. (2004): 51%; Rogers (2004): 9%</td>
</tr>
<tr>
<td>Fence, gap, crosswalk</td>
<td>40%</td>
<td>Lehnert and Bissonette (1997): 42%, 37%</td>
</tr>
<tr>
<td>Population culling</td>
<td>50%</td>
<td>Review in Huijser et al. 2007a</td>
</tr>
<tr>
<td>Relocation</td>
<td>50%</td>
<td>Review in Huijser et al. 2007a</td>
</tr>
<tr>
<td>Anti-fertility treatment</td>
<td>50%</td>
<td>Review in Huijser et al. 2007a</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clevenger et al. (2001): 80%; Dodd et al. (2007): 87%</td>
</tr>
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<tr>
<td></td>
<td></td>
<td>Clevenger et al. (2001): 80%; Dodd et al. (2007): 87%</td>
</tr>
<tr>
<td>Animal detection system (ADS)</td>
<td>87%</td>
<td>Mosler-Berger and Romer (2003): 82%; Dodd and Gagnon (2008): 91%</td>
</tr>
<tr>
<td>Fence, gap, ADS</td>
<td>87%</td>
<td>Mosler-Berger and Romer (2003): 82%; Dodd and Gagnon (2008): 91%</td>
</tr>
<tr>
<td>Elevated roadway</td>
<td>100%</td>
<td>Review in Huijser et al. 2007a</td>
</tr>
<tr>
<td>Road tunnel</td>
<td>100%</td>
<td>Review in Huijser et al. 2007a</td>
</tr>
</tbody>
</table>
Fences in combination with crossing structures
DESIGN*

Overpass Design:
1 Landscape bridge
2 Wildlife overpass
3 Multi-use overpass
4 Canopy crossing

Underpass Design:
5 Viaduct/Flyover
6 Large mammal underpass
7 Multi-use underpass
8 Underpass with waterfall
9 Small/Medium-size mammal underpass
10 Modified culvert design
11 Herp tunnel

Wildlife Crossings, Eco-ducts, Fauna Passages
A Brief History

1950s - First wildlife crossings in Europe and USA
1960s – France: First wildlife overpasses; Hunters involved
1970s – 1st Overpasses in North America (UT, NJ)
1980s – 1st Wildlife Crossings in Banff National Park
1990s – Florida I-75 Alligator Alley, 1st large-scale works
       1st Overpass in Canada (Coquihalla Highway, BC)
       1st Overpasses in Banff National Park (phase 3A)

*From a history of road ecology (Forman et al. 2003)
Present state of wildlife crossing integration with transportation networks

On all major continents
Most active: Europe, North America, Australia
Increasing activity: Asia, India, Latin America

Urcel, France
European wildlife overpasses

A sampler
What does the endangered crested newt like?...
50-m wide overpasses with water.
Topside View of Overpass in Holland
New transportation infrastructure
9 wildlife overpasses on new highways
World Bank funding
Landscape:
Central European hardwood forest
*Eurasian brown bear, lynx, wolf*
Spain

Landscape:
Agricultural/riparian mix
Wolves, roe deer, wild boar

Paso superior, Autovia de Matilla Arzon (Zamora), España

Paso superior, Autovia de Algadef LE-4 (Leon), España
Current North American wildlife crossings
Wildlife underpasses - over 500

Wildlife overpasses - 13
  British Columbia (1)
  Alberta (4)
  Utah (1)
  New Jersey (2)
  Florida (1)
  Montana (1)
  Nevada (1)
  Wyoming (2)

*More in planning stages*
  Washington (2)
  Alberta (2)
LESSONS FROM BANFF NATIONAL PARK
Use of Crossing Structures
Banff National Park, Albert (Nov ‘96 to Oct ‘08)

185,683 detections, 12 large mammal species, 28 crossing structures

<table>
<thead>
<tr>
<th>Ungulates</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Deer</td>
<td>127,553</td>
</tr>
<tr>
<td>Elk</td>
<td>37,772</td>
</tr>
<tr>
<td>Moose</td>
<td>144</td>
</tr>
<tr>
<td>Bighorn sheep</td>
<td>4,592</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Carnivores</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Black bear</td>
<td>1,191</td>
</tr>
<tr>
<td>Grizzly bear</td>
<td>679</td>
</tr>
<tr>
<td>Bear ssp.</td>
<td>24</td>
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<tr>
<td>Wolf</td>
<td>5,113</td>
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<tr>
<td>Coyote</td>
<td>7,202</td>
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<tr>
<td>Cougar</td>
<td>1,405</td>
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<tr>
<td>Lynx</td>
<td>4</td>
</tr>
<tr>
<td>Wolverine</td>
<td>4</td>
</tr>
</tbody>
</table>

Clevenger et al., 2009
Wildlife-Vehicle Collision Reduction

86% reduction (79-99%)

Clevenger et al., 2002
Differential Use of Crossing Type

Wildlife Use of Banff Overpasses and Underpasses

Pair-wise comparison of Wolverine Overpass/Underpass and Red Earth Overpass/Underpass

Species

Proportion of Crossings

Overpass

Underpass

Moose  Grizzly  Deer  Elk  Wolf  Black Bear  Fox  Coyote  Cougar

0  4  573  1361  327  56  1  291  312  65

72  226  9061  417  120  44  1  39  39
INTERESTING INTERACTIONS

Wolf v. Elk (underpass)  Sparring Grizzlies (overpass)

Photos: WTI Research Cameras
Banff TransCanada Highway Wildlife Mitigation

Costs as proportion of expansion project:

- TCH phase 1 & 2 (1986) - 15%
- TCH phase 3A (1997) - 25-30%
- TCH phase 3B (2008) - 40-45%
Costs of Wildlife Crossing Mitigation?

1997 and 2008 figures

Wildlife overpass, 50-m wide* = $C 2.5 - 3 M
Wildlife overpass, 60-m wide* = $C 9 M

Wildlife underpass, 4 x 12 m* = $C 750,000
Wildlife underpass, 5.5 x 24 m* = $C 6 M

Wildlife underpass, 4 x 7 m* = $C 500,000
Wildlife underpass, 4 x 7 m* = $C 1.5 M

Wildlife underpass, box culvert* = $C 250,000
Wildlife underpass, box culvert* = $C 1.2 M

Fencing, wood posts w/apron = $C 35 per metre
Fencing, wood posts w/apron = $C 110 per metre

*Span 4-lanes with 32 m median.
An irresistible idea ...

Why not have a competition?
ARC DESIGN COMPETITION: The Rationale

WCs proven effective in reducing WVCs
WVCs increasing significantly across NA
WCs passing many types of species
Overpasses may support different species
WCs becoming increasingly expensive
Europe developing more diverse overpass designs
Context Sensitive, Green Highways, Climate Change
DESIGN COMPETITION

Objective: a real-time, in-situ application

Site competition: sent notice out to various networks (AASHTO, Transwild, WFT Listserve, etc.) regarding interest in potential sites

• 22 locations were nominated/suggested across North America

• Nominations reviewed by ARC Technical Advisory Committee

• ARC Steering Team selected Vail Pass

• Worked with CDOT and signed MOU
Phases & Stats

Phase 1 - Call for Expressions of Interest
100 firms
9 countries
36 teams

Phase 2 – Invited
5 finalist teams
Partnership among disciplines

Engineering  Ecology  Architecture

Landscape Architecture

Wildlife Biology  Transportation

Landscape Design  Graphic Design
Jury

Prof. Charles Waldheim (Jury Chair), John E. Irving
Professor and Chair of Landscape Architecture, Harvard University,
Graduate School of Design

Jane Wernick, Structural Engineer and Director of Jane Wernick

William L. Withuhn, Curator Emeritus, History of Technology and
Transportation, Smithsonian Institution

Prof. Jane Wolff, Associate Professor and Chair of Landscape
Architecture, John H. Daniels Faculty of Landscape, Architecture and
Design, University of Toronto

Dr. Anthony Clevenger, Senior Research Scientist (Road
Ecology), Western Transportation Institute, Montana State University
Finalist teams

Balmori Associates (New York)
with StudioMDA, Knippers Helbig Inc., David Skelly, CITA, Bluegreen, John A. Martin & Associates, & David Langdon

HNTB with Michael Van Valkenburgh & Assoc. (New York)
with Applied Ecological Services, Inc.

Janet Rosenberg & Associates (Toronto)
with Blackwell Bowick Partnership, Dougan & Associates, & Ecokare International

The Olin Studio (Philadelphia)
with Explorations Architecture, Buro Happold, & Applied Ecological Services

Zwarts & Jansma Architects (Amsterdam)
with OKRA Landscape Architects, IV-infra, & Planecologie
Janet Rosenberg & Associates (Toronto) with Blackwell Bowick Partnership, Dougan & Associates, and Ecokare
Rosenberg Team 3-D model
ARC DESIGN COMPETITION

FINALISTS

MCS MODULAR CROSSING SYSTEM

Balmori Associates (New York) with StudioMDA, Knippers Helbig Inc., David Skelly, CITA, Bluegreen, John A. Martin & Associates, and David Langdon
ARC DESIGN COMPETITION

FINALISTS

Zwarts & Jansma Architects (Amsterdam) with OKRA Landscape Architects, IV-infra and Planecologie
Jury assessment:

“the winning proposal by HNTB Engineering with Michael Van Valkenburgh & Associates was not only eminently possible; it has the capacity to transform what we think of as possible.”
**hypar - nature**

*hyper-nature:* /hi-pər nə-cher/
A landscape of optimal ecological function at the point of scalar compression

*hypar (hyperbolic paraboloid) vault:* /hi-pər vōlt/
A saddle-like structure using a doubly curved surface with a form that depends on a counter-resistance to the exertion of lateral thrust.
Crux of Hypar-nature

HNTB + MVVA
Modular Deployability

- Soil Base for Habitat Planting
- Temporary Falswork
- Balanced Pick Point for One-Crane Operation
- Light-Touch Footings
- Jack-Tunnel Extension Under Road Keeps Lands Open During Construction

Remains Open to Traffic
Road Closed

HNTB + MVVA
Design selected for I-70 wild crossing near Vail

By Jessica Fender
The Denver Post

POSTED: 01/24/2011 01:00:00 AM MST
UPDATED: 01/24/2011 08:46:26 AM MST

Calling it a potential "model for the world," a panel of engineers Sunday picked a New York design for a wildlife bridge crossing over I-70 west of Vail. The bridge would be on U.S. 6 at the crest of Vail Pass, the first structure of its kind ever proposed for the United States.

The winners, HNTB with Michael Van Valkenburg Associates, a landscape architecture firm with offices in New York City and Cambridge, Mass., and a design team, associated with the construction firm HNTB, submitted a proposal for a bridge made of lightweight concrete panels that are snapped into place and covered with foliage. The bridge is broad enough to allow for stripes — lanes, actually — that resemble forests, shrubs and meadows with the aim of satisfying the tastes of any of the animals in the area. Miles of fences on either side of the highway would funnel animals to the bridge.

For the Designers, the bridge could be a "model for the world," a panel of engineers Sunday picked a New York design for a wildlife crossing over I-70 west of Vail.

The design selected for I-70 wild crossing near Vail

By Jessica Fender
The Denver Post

POSTED: 01/24/2011 01:00:00 AM MST
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For the Designers, the bridge could be a "model for the world," a panel of engineers Sunday picked a New York design for a wildlife crossing over I-70 west of Vail.

A New York team has won a unique international competition to design a special bridge for wildlife crossing I-70 west of Vail Pass, the first structure of its kind ever proposed for the United States. The winners, HNTB with Michael Van Valkenburg Associates, a landscape architecture firm with offices in New York City and Cambridge, Mass., and a design team, associated with the construction firm HNTB, submitted a proposal for a bridge made of lightweight concrete panels that are snapped into place and covered with foliage. The bridge is broad enough to allow for stripes — lanes, actually — that resemble forests, shrubs and meadows with the aim of satisfying the tastes of any of the animals in the area. Miles of fences on either side of the highway would funnel animals to the bridge.

The bridge, which will take home a prize of $40,000, was chosen by a panel of engineers Sunday from among proposals by four teams from around the world. The bridge would be on U.S. 6 at the crest of Vail Pass, the first structure of its kind ever proposed for the United States. The winners, HNTB with Michael Van Valkenburg Associates, a landscape architecture firm with offices in New York City and Cambridge, Mass., and a design team, associated with the construction firm HNTB, submitted a proposal for a bridge made of lightweight concrete panels that are snapped into place and covered with foliage. The bridge is broad enough to allow for stripes — lanes, actually — that resemble forests, shrubs and meadows with the aim of satisfying the tastes of any of the animals in the area. Miles of fences on either side of the highway would funnel animals to the bridge.

For the Designers, the bridge could be a "model for the world," a panel of engineers Sunday picked a New York design for a wildlife crossing over I-70 west of Vail.

A New York team has won a unique international competition to design a special bridge for wildlife crossing I-70 west of Vail Pass, the first structure of its kind ever proposed for the United States. The winners, HNTB with Michael Van Valkenburg Associates, a landscape architecture firm with offices in New York City and Cambridge, Mass., and a design team, associated with the construction firm HNTB, submitted a proposal for a bridge made of lightweight concrete panels that are snapped into place and covered with foliage. The bridge is broad enough to allow for stripes — lanes, actually — that resemble forests, shrubs and meadows with the aim of satisfying the tastes of any of the animals in the area. Miles of fences on either side of the highway would funnel animals to the bridge.

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Winning ARC entry by
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QUESTIONS?