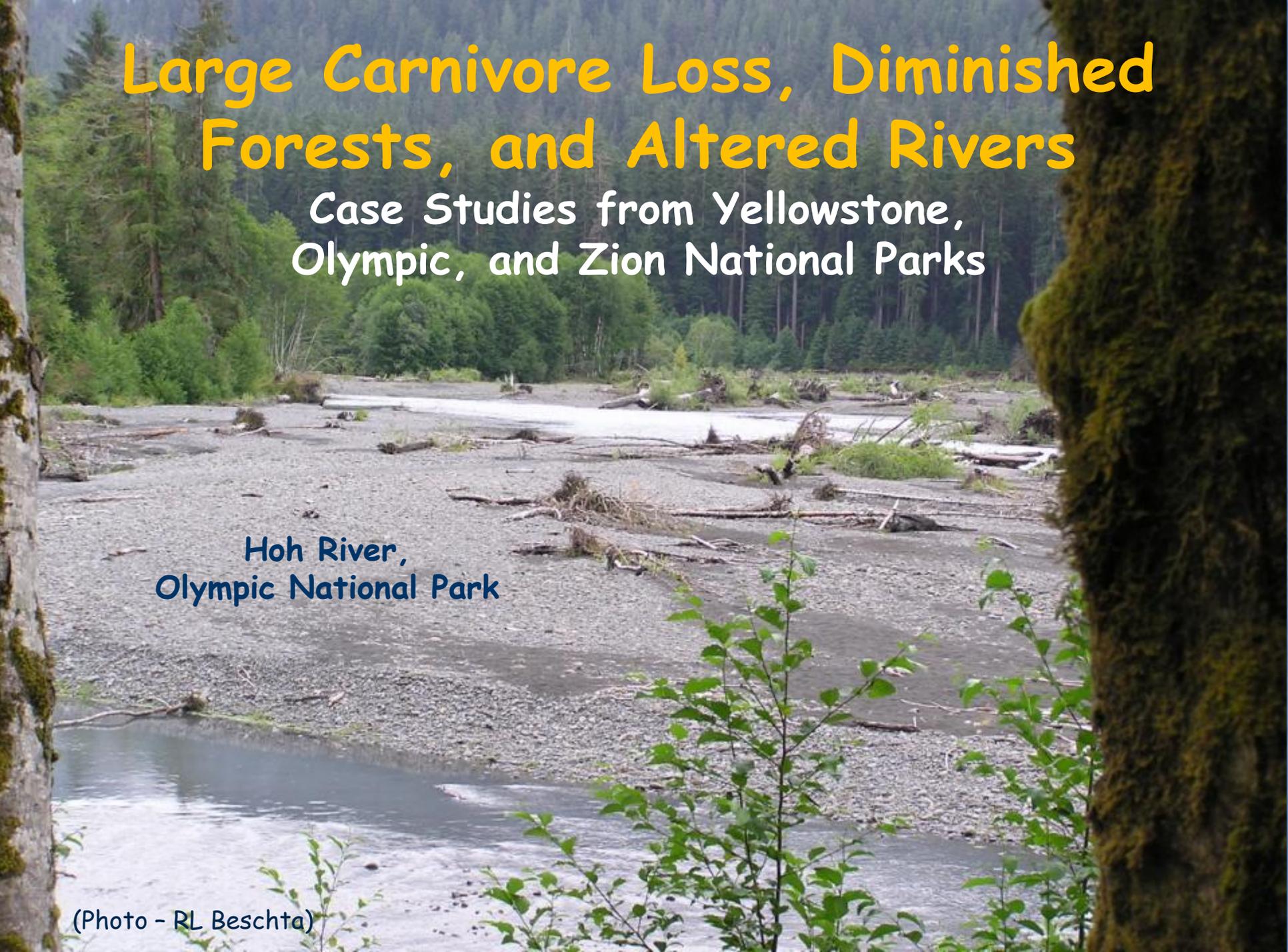


# Large Carnivore Loss, Diminished Forests, and Altered Rivers

Case Studies from Yellowstone,  
Olympic, and Zion National Parks

Hoh River,  
Olympic National Park

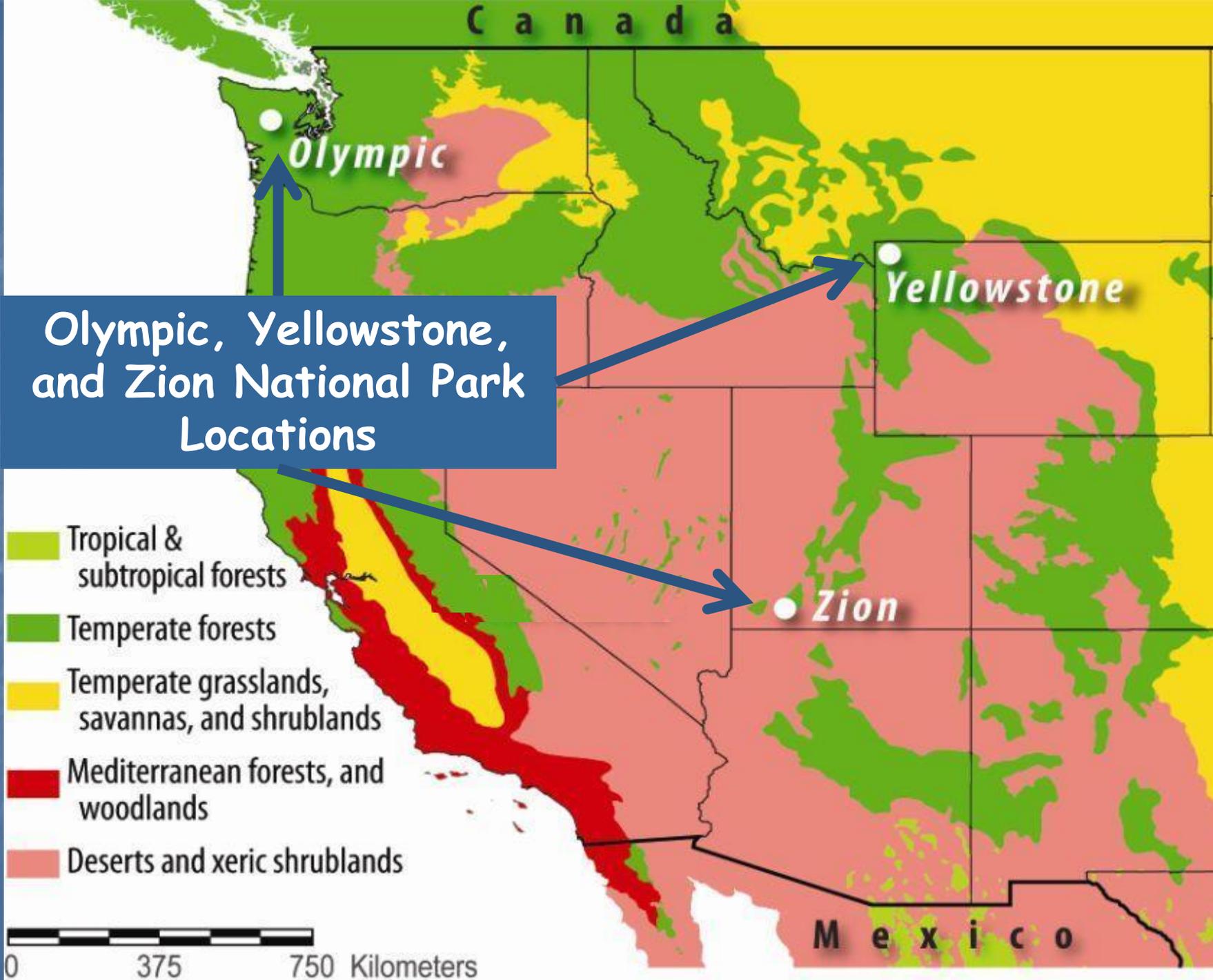
(Photo - RL Beschta)



## Fewer Predators, More Browsing

This presentation highlights long-term changes in (a) riparian plant communities and (b) river channels due to increased ungulate browsing that followed the loss of large mammalian predators. These changes are based on case studies from three national parks in the western United States:

- 1 - **Yellowstone National Park** - Browsing by Rocky Mountain elk increased following extirpation of gray wolves in the 1920s.
- 2 - **Olympic National Park** - Browsing by Roosevelt Elk increased following the extirpation of gray wolves in the early 1900s.
- 3 - **Zion National Park** - Browsing by mule deer increased following the displacement of cougars in the 1930s.



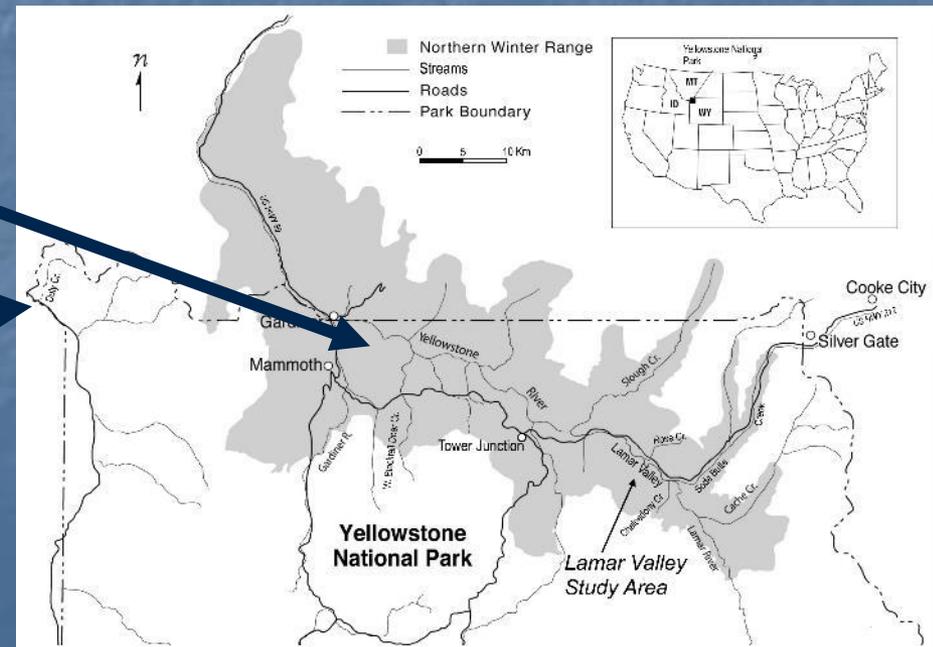
# 1 - Yellowstone National Park

Following the 1920s extirpation of wolves and cougar, browsing by Rocky Mountain elk increased significantly, altering riparian plant communities in winter ranges, including: (a) the northern winter range located along the north central portion of the park and (b) the Gallatin winter range located along the northwest corner of the park.

(a) Northern Winter Range

(b) Gallatin Winter Range

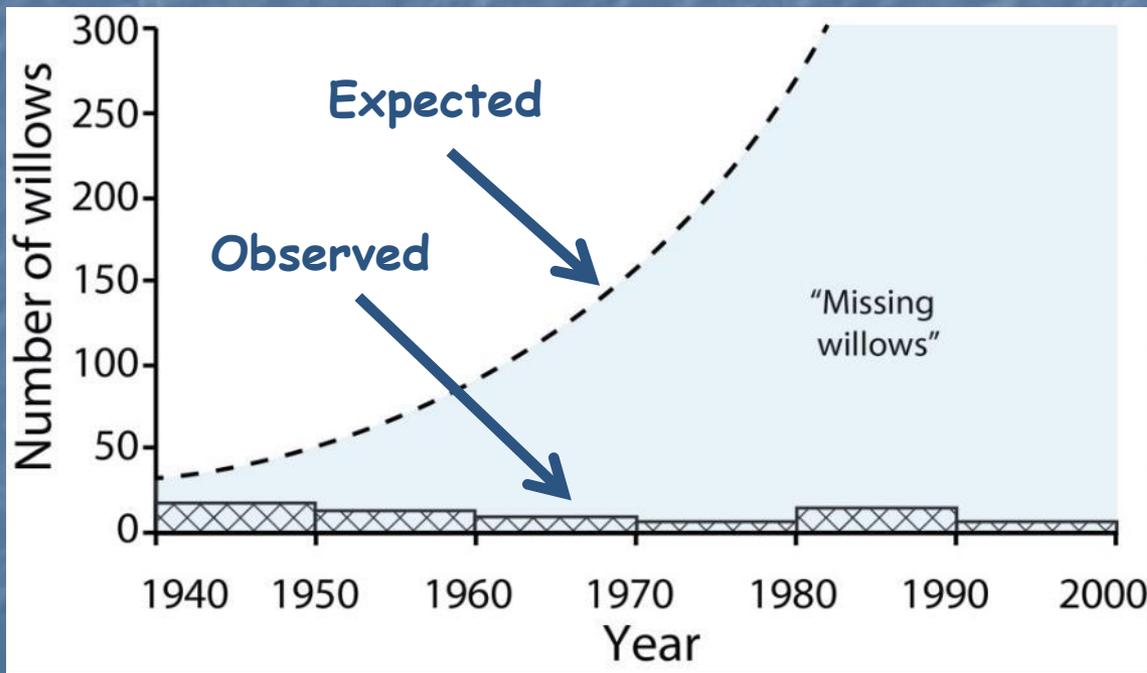
(Graph - Beschta 2005)



# Missing Willows

## Northern Range

Wolves were absent from the park for approximately seven decades, from the mid-1920s through the mid-1990s. Only a few willows were able to grow above the reach of elk during this period, resulting in many missing willows.



(Graph - Adapted from Wolf et al. 2007)

## Missing Cottonwoods Northern Range

By the 1970s, browsing pressure on woody species across the Lamar Valley had become severe, to the point that young cottonwoods, willows, and other woody plants were no longer able to grow tall.



Lamar Valley

circa. 1970s

By the 1990s, only a few groves of mature cottonwoods remained in the valley.

(Photos - top, National Park Service;  
bottom, RL Beschta)



Lamar Valley

1990s

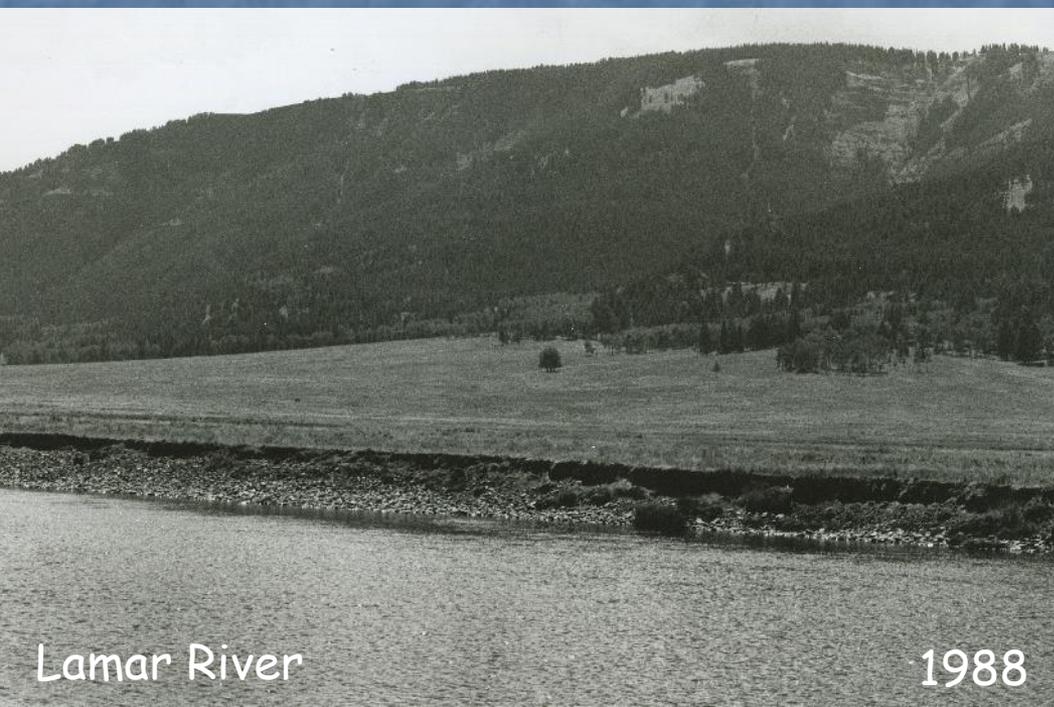


Lamar River

1921

## Eroding Riverbanks Northern Range

In this 1921 photo, the banks of the Lamar River supported dense willow-shrub communities that helped stabilize these banks.



Lamar River

1988

1988 - In the absence of wolves, intense elk browsing eventually depleted woody plants along riverbanks, thus contributing to accelerated bank erosion, increased rates of lateral channel migration, and over-widened channels.

(Photos - top, FJ Haynes; bottom, CE Kay)

## A Widening River Northern Range

After seven decades of wolf absence, riparian plant communities along most reaches of the Lamar River were generally depleted, except for a few remnant groves of mature cottonwood trees.

With no woody plant vegetation to stabilize its banks, the river's channel has greatly widened. At low flow (pictured here) the channel is braided and bordered by extensive deposits of unvegetated sand and gravel.



Lamar River

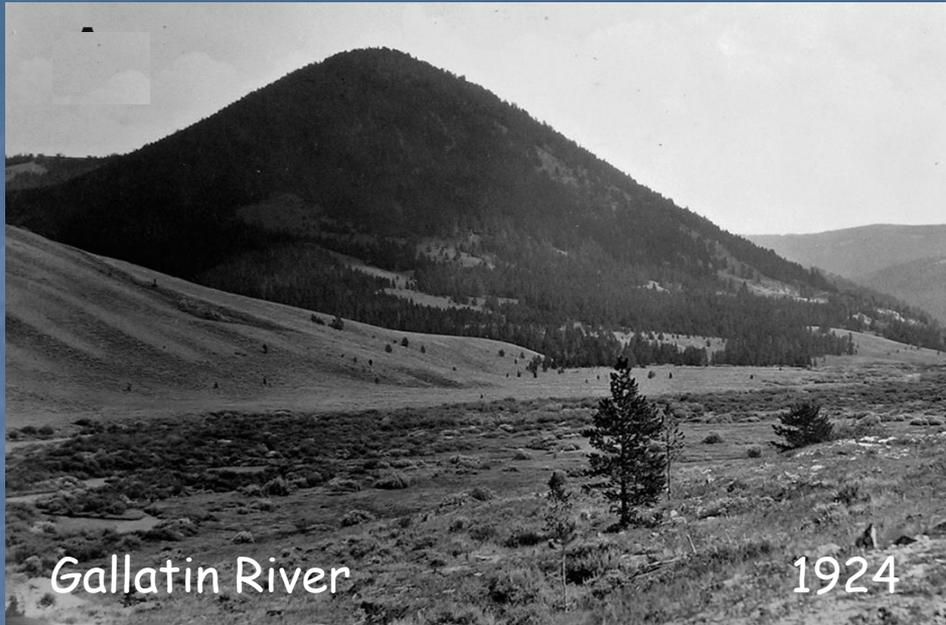
1996

(Photo - RL Beschta)

# Disappearing Floodplain Willows

## Gallatin Winter Range

In 1924, at about the time of wolf extirpation, the riverbanks and floodplain of the Gallatin River had a dense cover of willows.



Gallatin River

1924

By 1983, willows are almost entirely gone due to high rates of elk browsing over time.

The loss of woody plants allowed riverbanks to erode and the channel to widen.



Gallatin River

1983

(Photos - top, Montana Fish Wildlife and Parks; bottom, CE Kay)

# Straits of Juan de Fuca

Pacific  
Ocean



(Satellite Image - Advanced  
Satellite Productions, Inc.)

**2 - Olympic National Park**



# Complex Woody Plant Communities

Riparian communities in coastal forests of the Pacific Northwest contain a diversity of woody species, most of which are highly palatable to Roosevelt elk.

(Photos - RL Beschta and WJ Ripple)



Vine maple



Huckleberry



Western hemlock

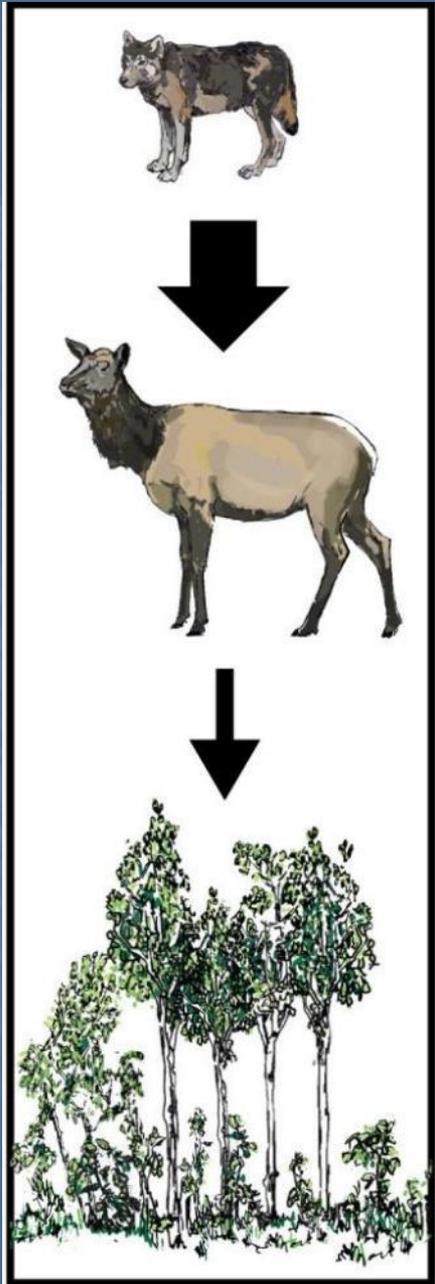


Elderberry



Thimbleberry

# Coastal Ecosystems: With and Without Wolves

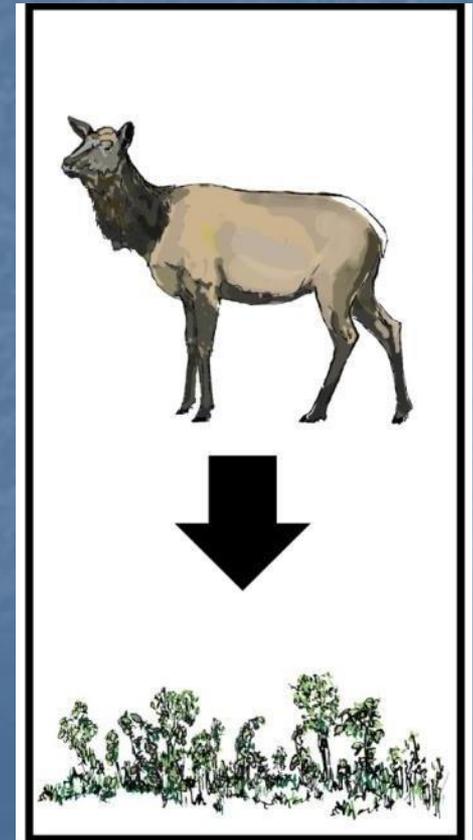


**With wolves**

Wolves, an apex predator, limit elk browsing by affecting their behavior and numbers, ensuring that healthy riparian plant communities are sustained over time, a trophic cascade.

**Without wolves**

In the absence of wolves, increased elk browsing occurs, thus suppressing the heights of palatable woody plants.



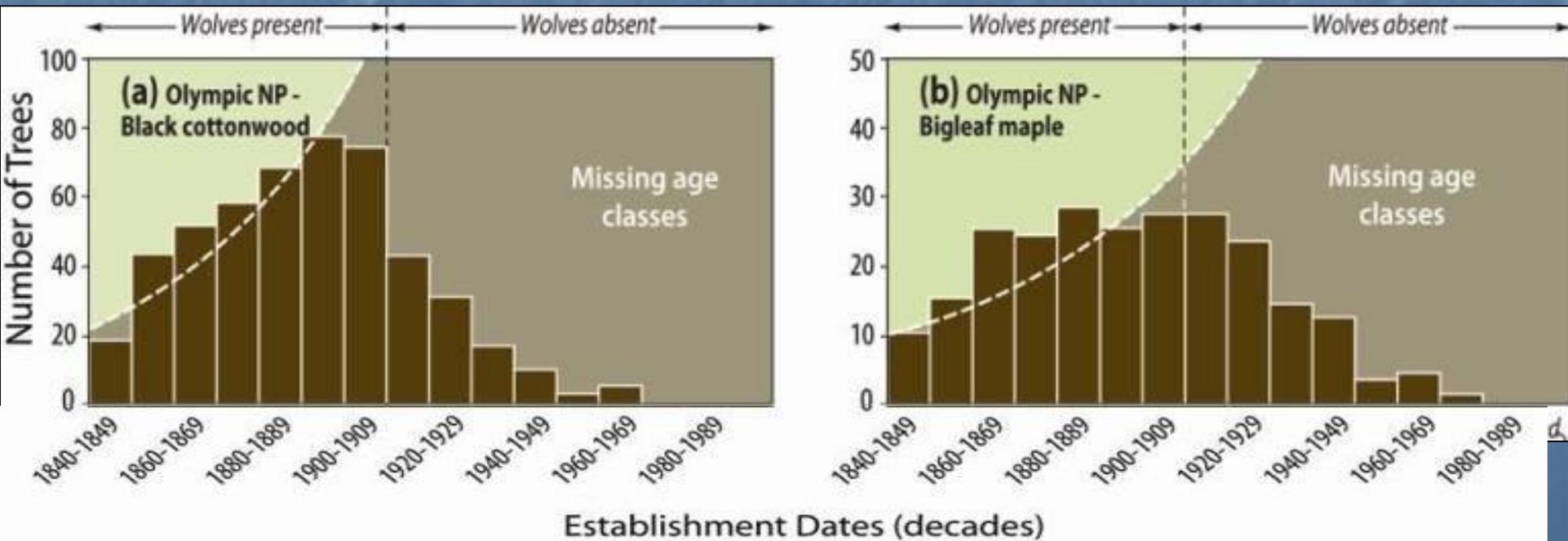
(Figures - Beschta et al., 2016)

# Tree Recruitment Curtailed in Riparian Forests

The number of trees by decade of establishment, or age structure (shown below), illustrates long-term trends in plant communities.

With wolves having been extirpated by the early 1900s in Olympic National Park, tree recruitment for black cottonwood and bigleaf maple soon began to decline (missing age classes) as browsing from elk increased.

By the late 1900s, recruitment essentially ceased due high levels of browsing.



(Graph - Beschta & Ripple 2008)



Grazing lawn

## Depleted Understories

Coastal forests normally support dense, understories of multiple shrub species. High levels of elk browsing have, however, dramatically altered the character of these understories.

A "grazing lawn" (above) grows under mature black cottonwoods on a river floodplain, while a "fern prairie" (right) dominates the understory of bigleaf maples on a river terrace. The absence of woody plants in these understories is the result of high levels of elk herbivory over a period of many years.



Fern prairie

# Fewer Tree Species in Riparian Areas

Even in highly productive coastal forests of the Pacific Northwest, intensive elk browsing over time can greatly simplify the species composition of riparian plant communities.

## Generalized Species Composition

### Wolves Present

- Red alder
- Sitka spruce
- Black cottonwood
- Bigleaf maple
- Douglas fir
- Western hemlock
- Western red cedar
- Willow
- Numerous shrub species

### Wolves Absent

- Red alder
- Sitka spruce
- Other woody species mostly occur only in areas relatively inaccessible to elk

The palatability of red alder and Sitka spruce is relatively low for elk.

# From Missing Plants to Riverbank Erosion

As elk browsing degraded riparian plant communities, riverbanks became more susceptible to erosion during high flows.

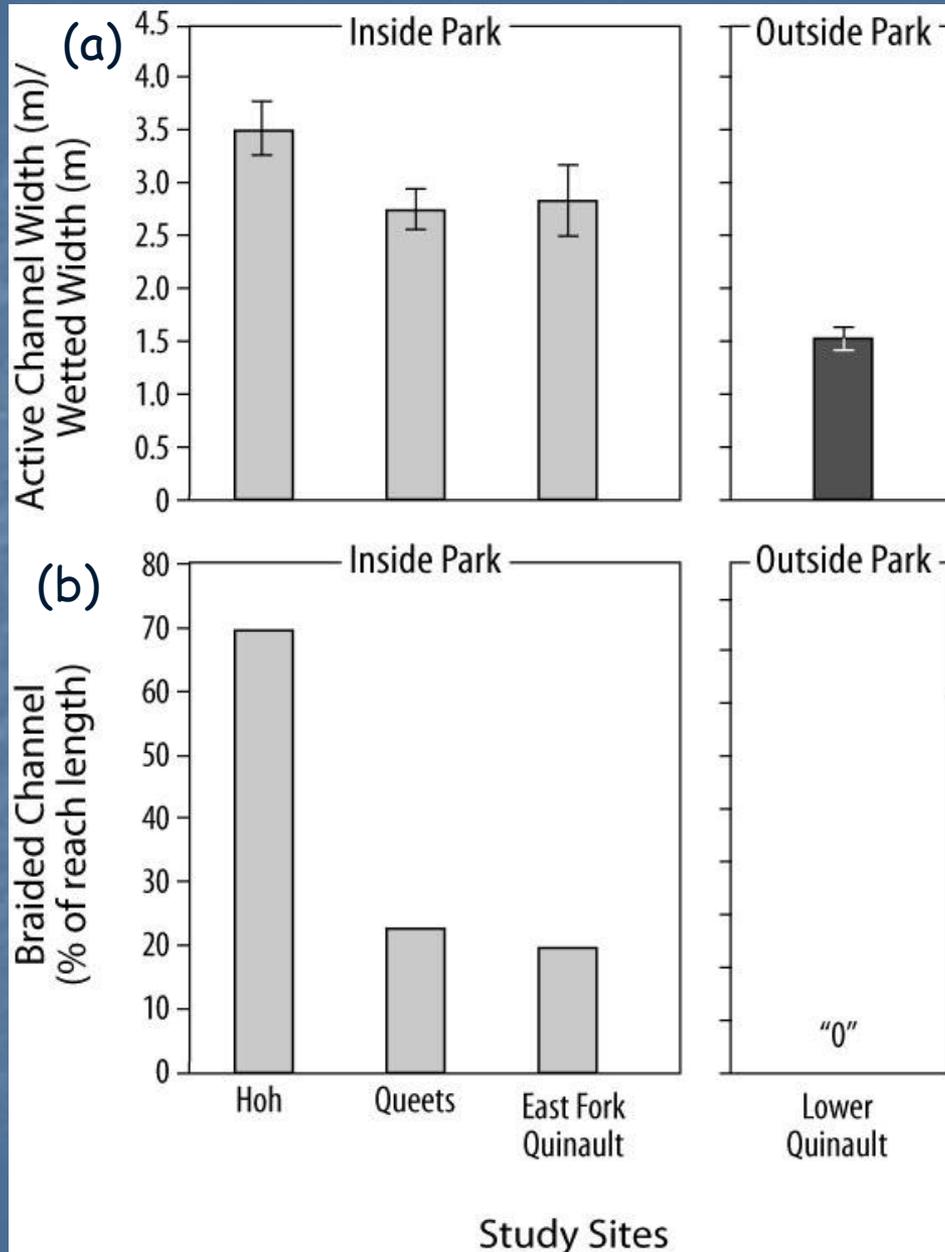
Formerly stable floodplains and their forests were lost due to accelerated riverbank erosion.



Hoh River

(Photo - WJ Ripple)

## Altered Channels



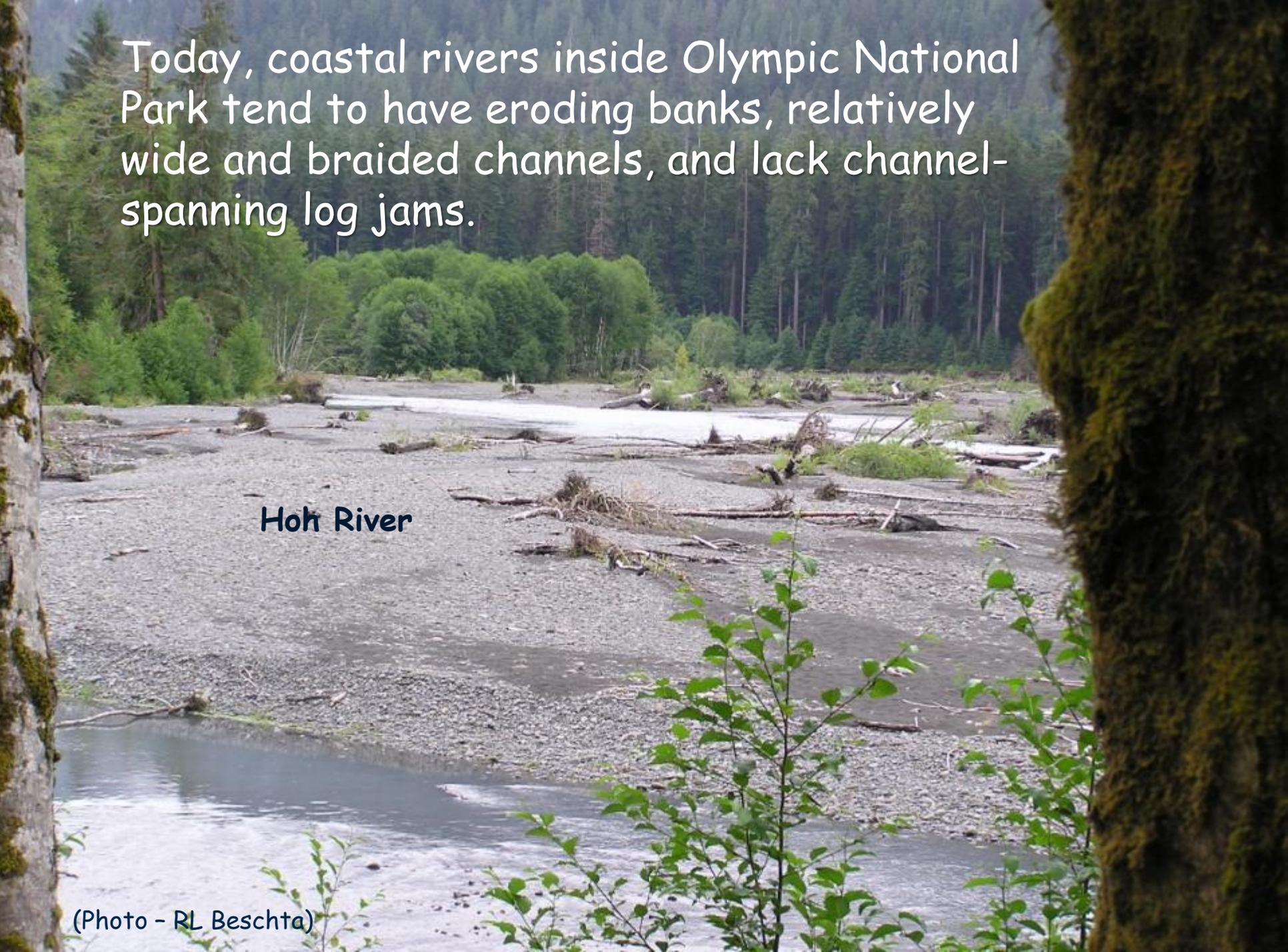
(a) Coastal rivers inside the park have Olympic National Park become relatively wide compared to those outside the park (where human hunting affects the behavior and numbers of elk). In addition, channel-spanning log jams that were historically common no longer occur in the over-widened river channels of the park.

(b) Channels inside the park tend to have more braiding (an indication of high bedload sediment transport from eroding riverbanks) relative to those outside the park.

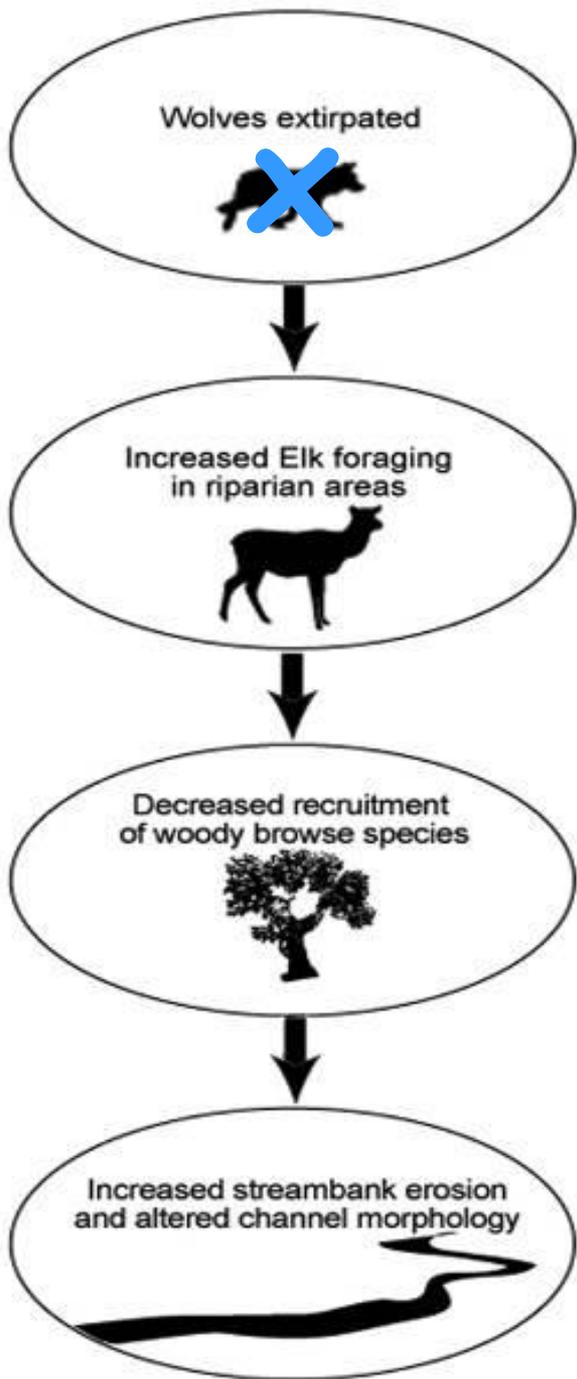
Today, coastal rivers inside Olympic National Park tend to have eroding banks, relatively wide and braided channels, and lack channel-spanning log jams.

**Hoh River**

(Photo - RL Beschta)



## An Altered Trophic Cascade



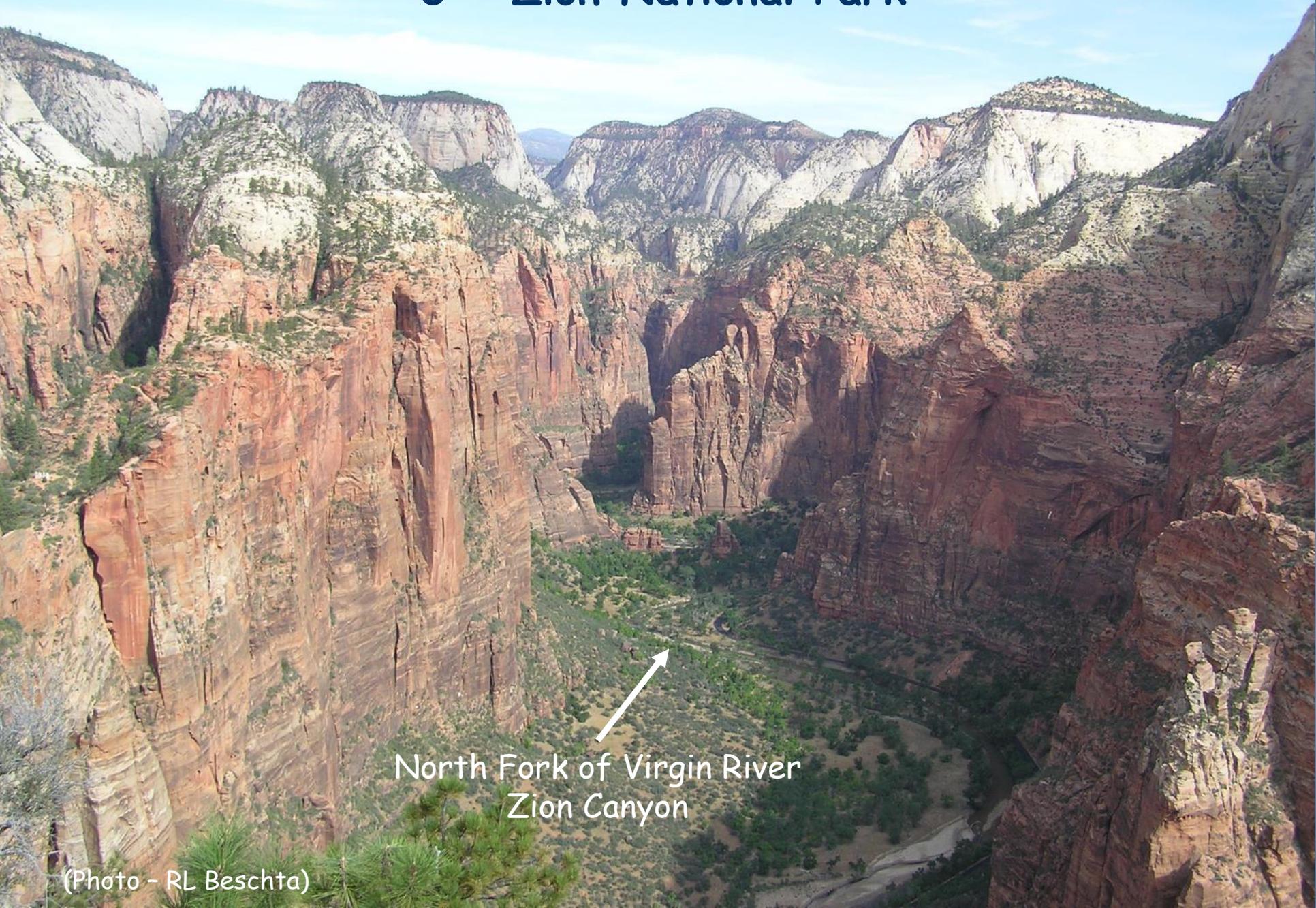
Although Pacific Northwest forests are some of the most productive in the United States, the extirpation of wolves in the early 1900s allowed elk browsing to increase, like in Yellowstone, thus altering riparian plant communities.

As a result, young woody plants were no longer able to grow above the upper browse level of elk, and their recruitment significantly decreased.

Depleted riparian vegetation led, in turn, to accelerated riverbank erosion and changes in channel morphology.

(Figure - Beschta & Ripple 2008)

# 3 - Zion National Park



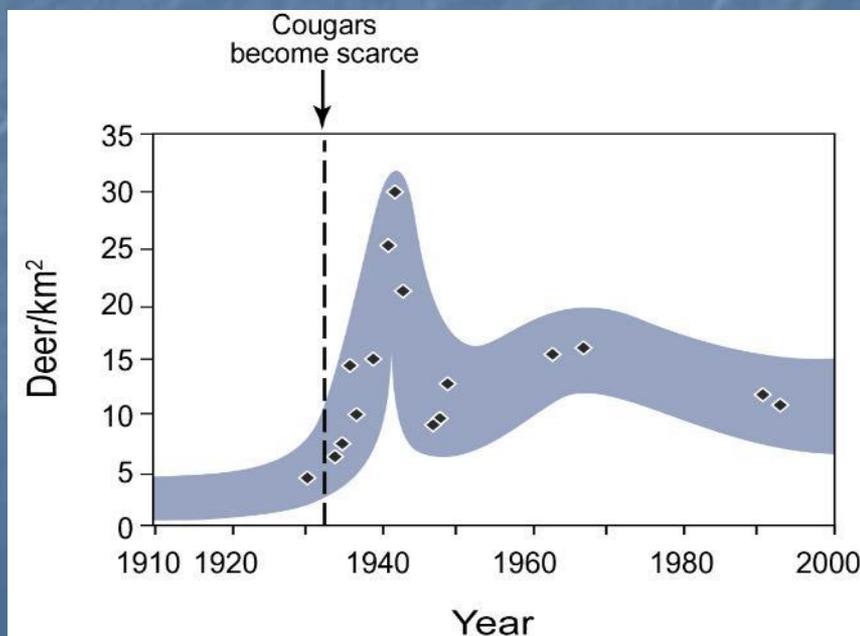
North Fork of Virgin River  
Zion Canyon

(Photo - RL Beschta)

# Predator-Prey History

Whereas Yellowstone and Olympic National Parks predominantly involved wolves and elk, in Zion National Park the primary large predator and ungulate prey were, respectively, cougars and mule deer.

As park visitation increased in the 1930s, cougars became displaced from Zion Canyon, the park's main canyon. As cougars became scarce in the 1930s, mule deer numbers increased and peaked in the early 1940s.



(Graph - Ripple & Beschta 2006)

Deer numbers have stabilized since the late 1940s. However, with few cougars to affect the behavior or numbers of deer, their intensive foraging has continued to exert enormous pressure on plant communities in Zion Canyon.

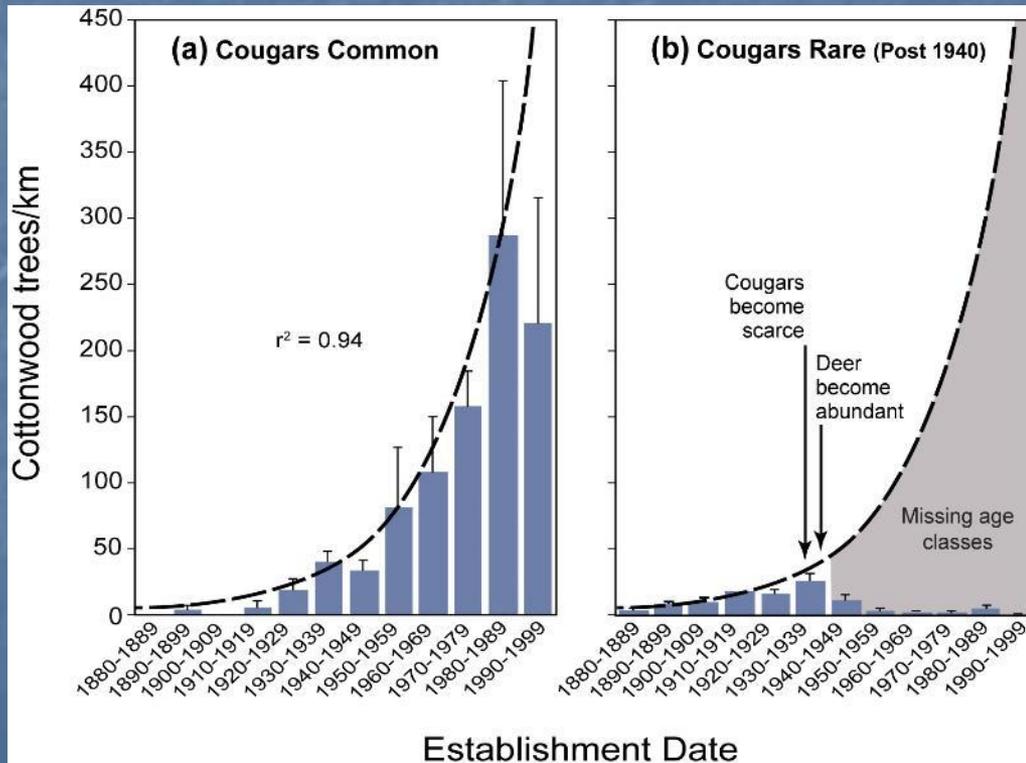


(Photos - National Park Service)

# Cottonwood Recruitment Shuts Down

The age structure of cottonwoods (graph below) provides an important indicator of long-term effects of cougar presence on plant communities in Zion Canyon.

(a) In areas where cougars are common outside of Zion Canyon, cottonwood tree recruitment has been ongoing over time.



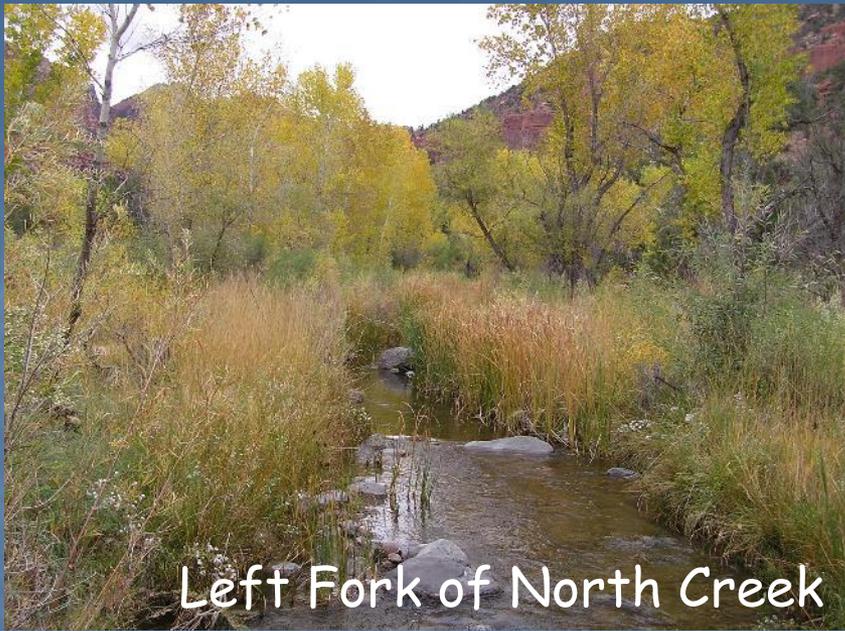
(b) However, when cougars in Zion Canyon became relatively scarce after 1940, the subsequent lack of cottonwood recruitment indicates that browsing pressure from deer had greatly increased. The "missing age classes" after 1940 confirms that browsing has had devastating effects on cottonwoods, as well as other plant communities.

(Graph - Ripple & Beschta 2006)

# Healthy Riparian Vegetation

## Cougar Common

In areas where cougars are common, riparian plant communities are densely vegetated and have a diverse species composition, thus helping to stabilize riverbanks during high flows.



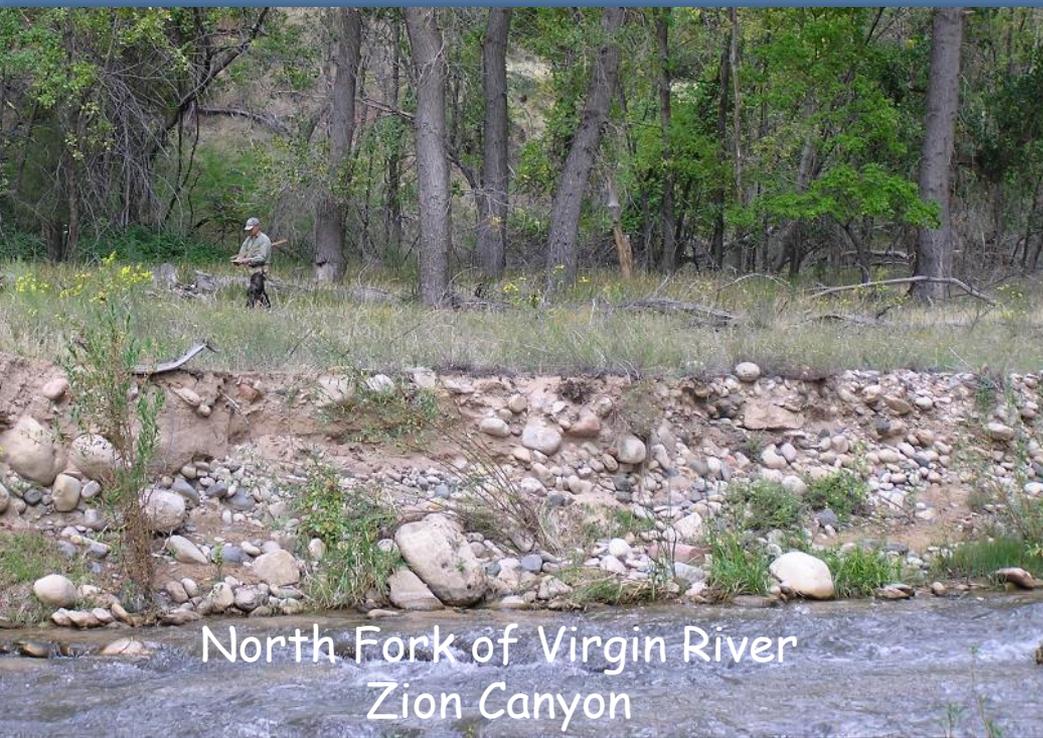
Left Fork of North Creek



North Creek



East Fork of Virgin River



North Fork of Virgin River  
Zion Canyon

## Riparian Vegetation Loss Cougar Rare

Dense plant communities along riverbanks have been largely removed due to intensive deer browsing over time.

Degraded riparian communities lead to accelerated bank erosion, channel widening, and channel incision during high flows.

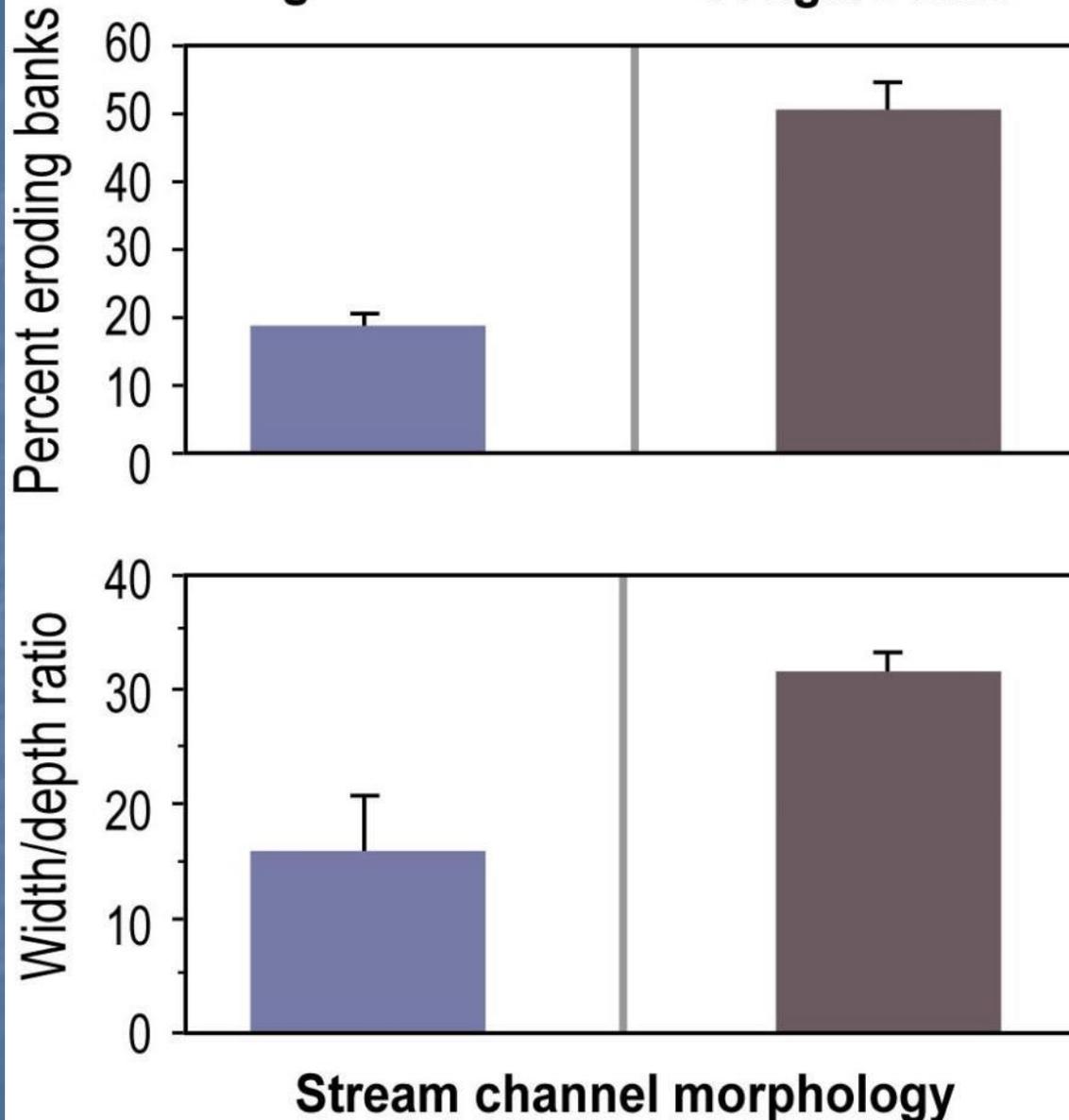
(Photos - top, WJ Ripple;  
bottom, RL Beschta)



North Fork of Virgin River  
Zion Canyon

**Cougars Common**

**Cougars Rare**



## Eroding Streams

Where cougars are relatively common, dense riparian plant communities occur and bank erosion is relatively infrequent. Channels are relatively narrow and deep.

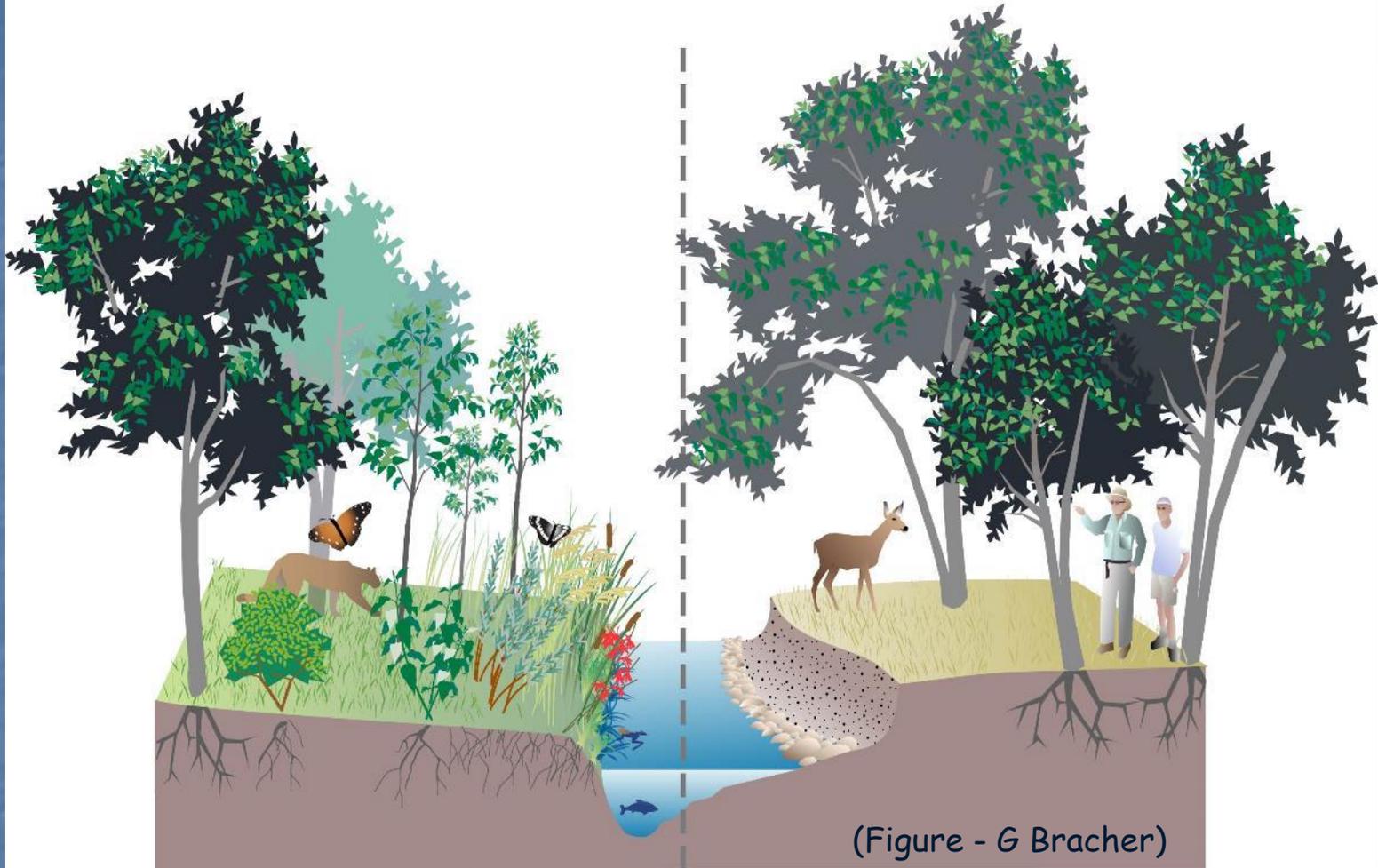
In areas where cougars are rare, degraded riparian plant communities have led to increased bank erosion. Channels are relatively wide and shallow.

(Graph - Ripple & Beschta 2006)

# Zion With and Without Cougars

Cougars Common

Cougars Rare



(Figure - G Bracher)

Artist's representation of biodiversity and channel morphology in areas where cougars are common (left) and rare (right). Once cougar numbers are reduced, ungulate herbivory begins to dominate the ecosystem.

## From Predators to Rivers

Yellowstone, Olympic, and Zion national parks each illustrate the power of large predators to trigger a cascade of ecological reactions, from prey to plants-- and even to rivers. As conservation scientists we consider these findings as both cautionary tales and encouraging prescriptions for maintaining the health of riparian plant communities and the structural integrity of streams and rivers.

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(May, 2021)

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Scientific literature associated with wolves, elk, and vegetation in northern Yellowstone, as well as others on trophic cascades and related topics, can be accessed at:

<http://trophiccascades.forestry.oregonstate.edu/publications>

# Scientific Names

## Plants

Black cottonwood - *Populus trichocarpa*

Bigleaf maple - *Acer macrophyllum*

Cottonwoods - *Populus* spp.

Elderberries - *Sambucus* spp.

Ferns - *Pteridophyta* spp.

Huckleberries - *Vaccinium* spp.

Thimbleberry - *Rubus parviflorus*

Vine maple - *Acer circinatum*

Western hemlock - *Tsuga heterophylla*

Western red cedar - *Thuja plicata*

Willows - *Salix* spp.

## Animals

Cougar - *Puma concolor*

Gray wolf - *Canis lupus*

Mule deer - *Odocoileus hemionus*

Rocky Mountain elk - *Cervus canadensis nelsoni*

Roosevelt elk - *Cervus canadensis roosevelti*

# Glossary of Selected Terms

**Herbivory** - The feeding or foraging of animals on living plants; browsing refers to their feeding on woody plants.

**Large predator** - A predator is an animal that lives by killing and eating other animals. A "large predator" is one that normally exceeds 15 kg (33 lbs) at maturity.

**Plant community** - A group of interacting plants sharing a common environment, for example: aspen community, willow community, sagebrush community.

**Recruitment** - Growth of a woody plants above the normal upper browse level of ungulates.

**Riparian areas** - Lands and associated plant communities immediately adjacent to and influenced by the waters of streams and rivers. Plant communities in riparian areas are often diverse and highly productive, thus important as physical habitat and food for a wide range of aquatic and terrestrial biota.

**Ungulates** - Hooved animals, such as elk, deer, moose, and bison.