Can Wolves Change Streams?

(Photo – RL Beschta)

Background

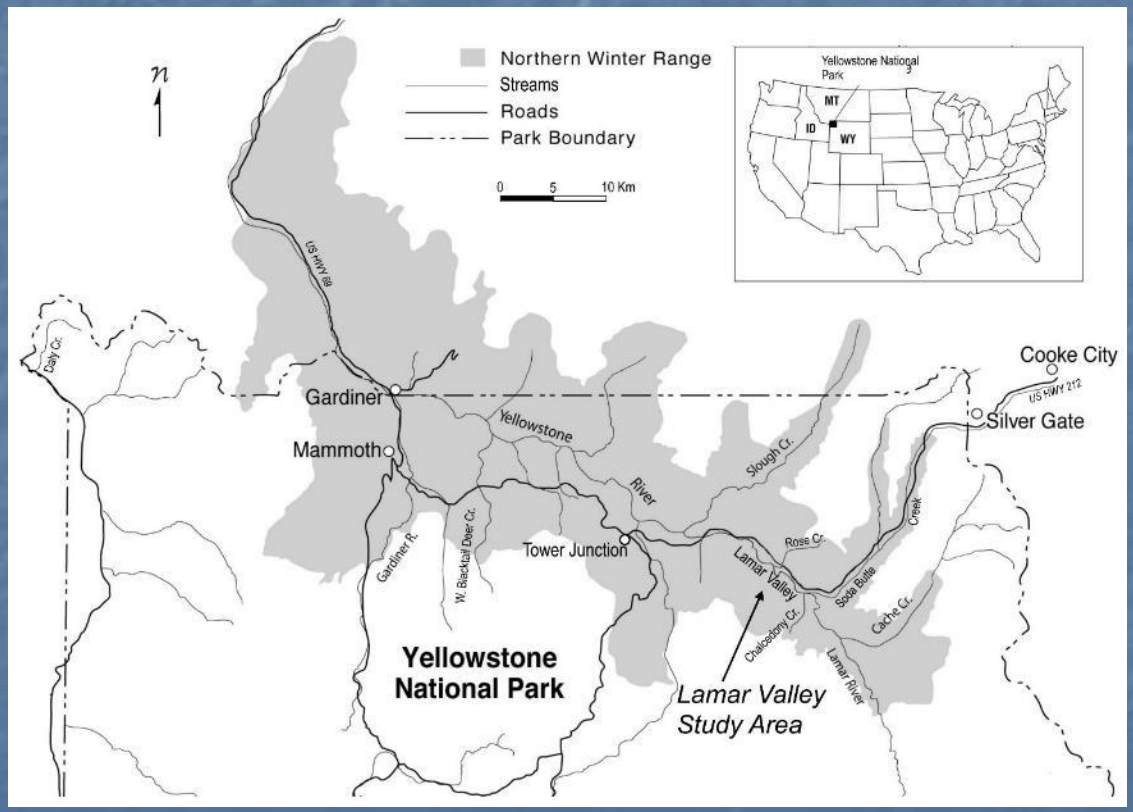
Gray wolves were extirpated from both Yellowstone and Olympic national parks in the early 1900s, resulting in increased elk herbivory that degraded riparian plant communities. The widespread loss of riparian vegetation was, in turn, followed by increased bank erosion, increased rates of stream channel migration, and wider, shallower channels. A similar pattern occurred in Zion National Park where cougars were displaced, thus allowing mule deer to feed unchecked, stripping riparian plant communities, and destabilizing streams.*

Such studies indicated that removing apex predators from an intact and fully functioning ecosystem can indeed trigger a cascade of ecological effects on streams and their channels. But is the reverse a possibility? Can heavily browsed streamside communities, and their streams, begin to recover following the return of an apex predator? It is this question that we briefly explore in the northern portion of Yellowstone National Park.

* Beschta & Ripple 2006, 2008, 2012; Ripple and Beschta 2006

Yellowstone's Northern Range

The northern elk herd winter range, or "northern range", occurs in the north-central portion of Yellowstone National Park and occupies ~1,500 km^2 (580 mi^2), most of which lies inside the park's boundary.



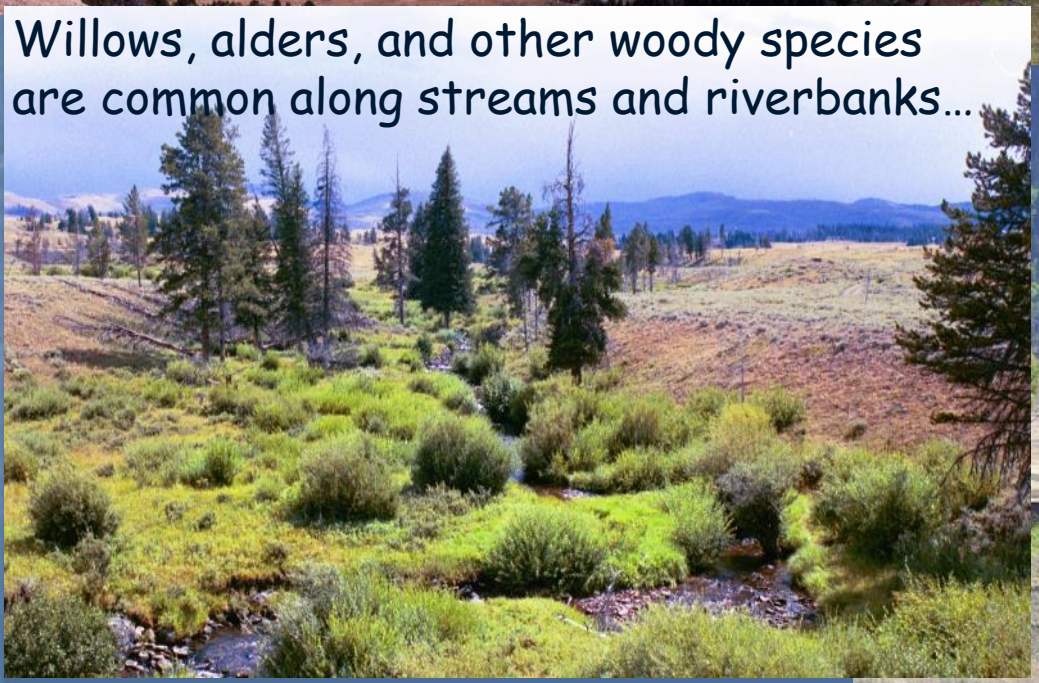
Elk spread across the surrounding mountains during summer and descend into northern range valleys to shelter and forage during winter months.

Northern Range Vegetation

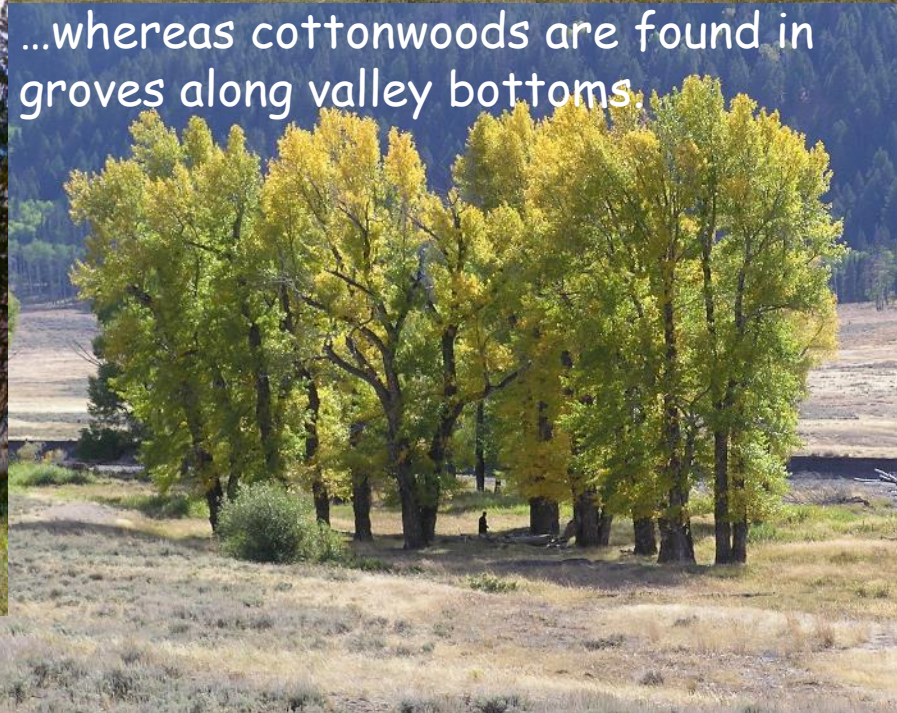
The northern range is vegetated primarily by sagebrush-grassland…

…with scattered aspen stands.

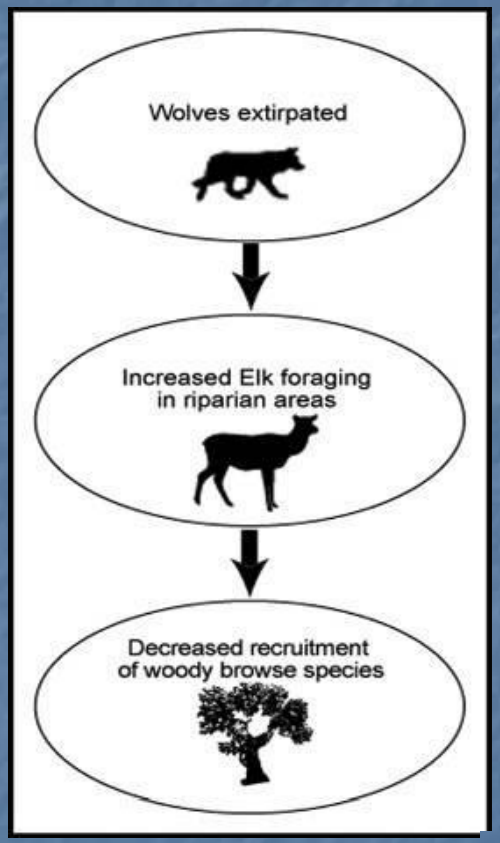
Willows, alders, and other woody species are common along streams and riverbanks…



…whereas cottonwoods are found in groves along valley bottoms.



(Photos – RL Beschta)

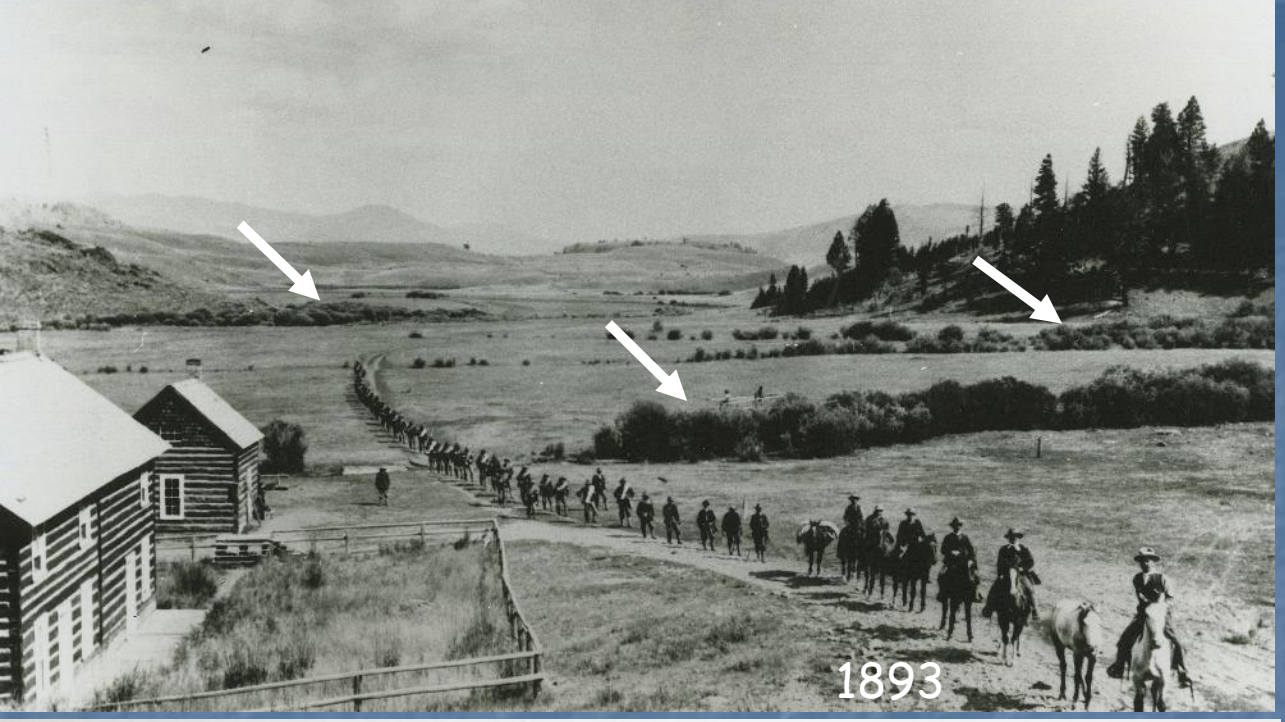


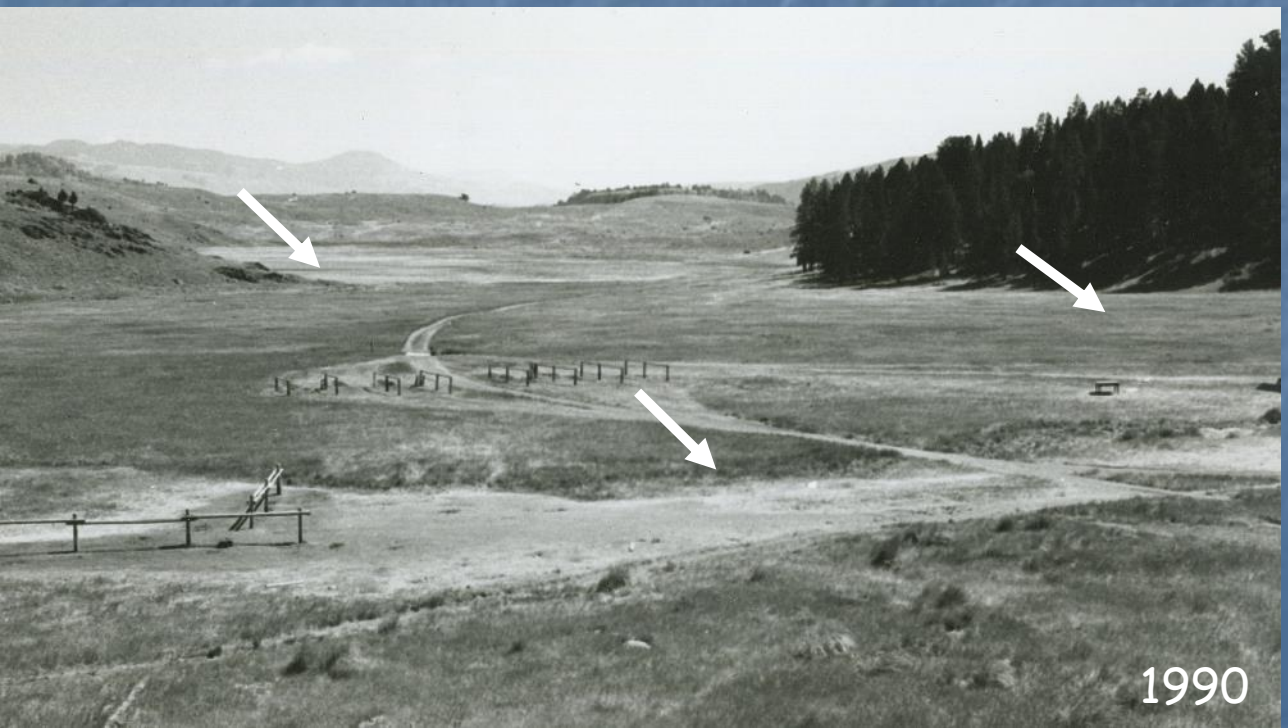
Loss of an Apex Predator

Wolves, and cougar, were extirpated from Yellowstone in the 1920s. Elk browsing increased in the subsequent decades and often eliminated woody species from many riparian areas along the park's streams and rivers.

Following are a couple of photographic examples indicating the magnitude of riparian vegetation loss in northern Yellowstone that occurred after large predator extirpation.

(Figure – Beschta & Ripple 2008)





Small Streams

Yancy's Hole

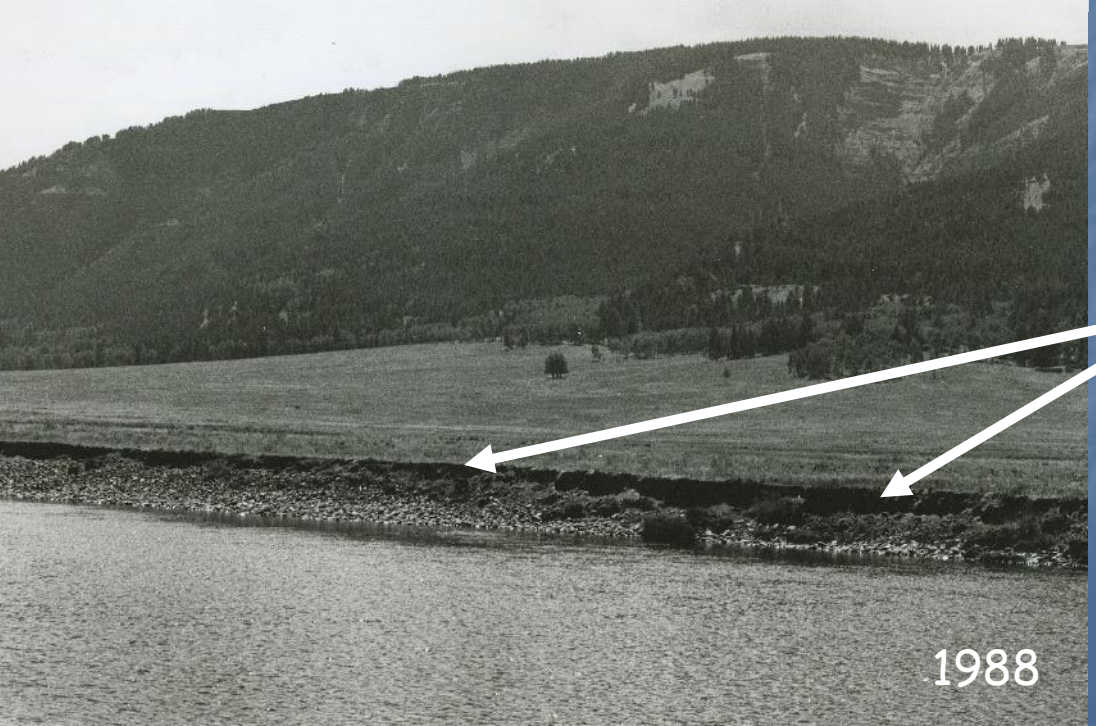
In the early years of the park, small streams were lined with willows, alders, and other woody species. Beaver were common.

A century later, intensive elk browsing had eliminated woody species from along many streams, and beaver colonies were no longer present in the northern range.

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

Riverbanks
Lamar Valley

Willows and other woody species line the banks of the Lamar River, providing bank stability and protection during high flows.



Woody species have been eliminated by elk browsing, leading to accelerated bank erosion.

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

Wolf Reintroduction and Riparian Vegetation Recovery

Gray wolves were reintroduced into Yellowstone in 1995-1996, restoring the park's large predator guild (cougars had naturally returned years earlier). Soon thereafter, the heights of young woody plants, previously suppressed by high levels of elk browsing, began to increase as elk browsing declined in various riparian areas of the northern range, a response indicative of a trophic cascade. Since then, recovering riparian plant communities have become increasingly widespread, a recovery that includes species such as willow, aspen, cottonwood, thinleaf alder, and berry-producing shrubs .

Increasing Heights of Riparian Willows

During 1988-1993, measurements of willow transects across the northern range found that less than ten percent of the willows exceeded 200 cm (6.6 ft) in height.* A height of 200 cm represents the general upper limit of elk browsing, thus plants that exceed this height are likely to continue to grow taller.

By 2001-2004, less than a decade after wolf reintroduction, approximately 30 percent of the willows sampled along these same transects were greater than 200 cm in height, increasing to nearly 50 percent by 2016-2018.

These results confirmed that many willows in the northern range have been able to grow taller in recent years, even though increased bison herbivory has continued to suppress willow heights in some locations.

In the following, repeat photographs illustrate some of the recovering willow and cottonwood communities in the northern range.

* Painter & Tercek 2020

Willow Recovery

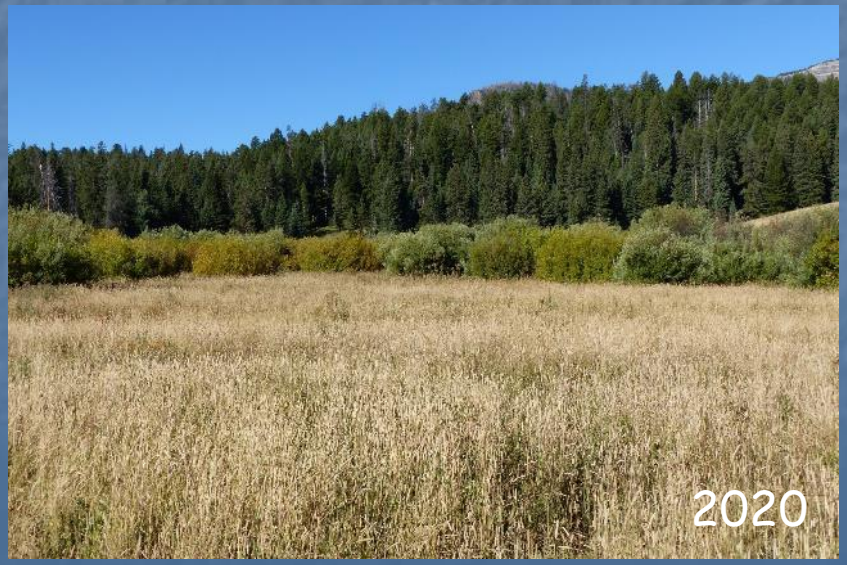
Soda Butte Creek at Round Prairie

In 1988, tall willows were absent across this floodplain whereas by 2020 an extensive community of tall willows (arrows) had become established.

(Photos – top, D Rosgen; bottom, RL Beschta)

Willow Recovery
Round Prairie Meadow

In the 1980s, willows had been almost eliminated in this meadow due to elk browsing, but by 2004 they were beginning to grow again as browsing intensities dropped.



By 2020, tall, robust willows had returned to this meadow.

(Photos – top, CE Kay; bottom, RL Beschta)

Cottonwood Recovery

Soda Butte Creek

In 1991, bands of cottonwood seedlings were present on gravel bars bordering the stream, but their heights remained suppressed by intensive elk browsing.

As elk browsing decreased following the return of wolves, these cottonwoods began to grow taller. By 2020 many of them were more than 5 m (16 ft) in height.

(Photos – top, R Keigley; bottom, RL Beschta)

Willow and Alder Recovery

Blacktail Deer Creek

After decades of intensive elk browsing, few willows or alders remained along this reach in the spring of 1991. Those that remained were short and unable to shade the stream, bank erosion was common.

Tall willows (light green) and alders (dark green), shown here in late summer of 2020, are now stabilizing streambanks, shading the stream, and providing habitat for wildlife.

(Photos – top, C Wambolt; bottom, RL Beschta)

A Closer Look at Riparian Vegetation Recovery along Blacktail Deer Creek

The East and West Forks of Blacktail Deer Creek have seen significant recovery of riparian plant communities in recent years. Willow measurements* and repeat photographs indicate the changes in riparian willow communities that have occurred following the reintroduction of wolves.

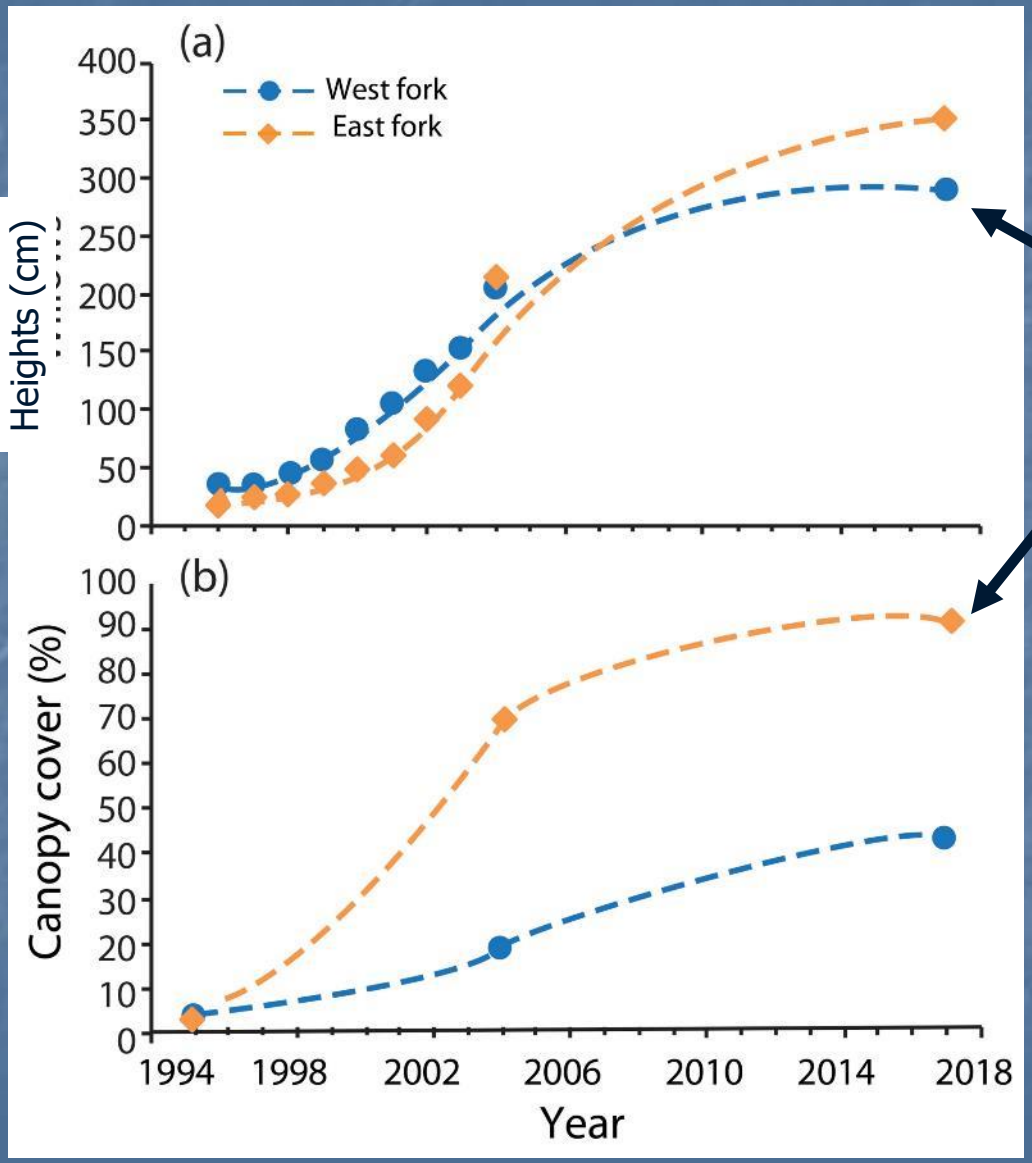
For example, when wolves were being reintroduced in the mid-1990s, 93-97 percent of the willows along the East and West Forks of Blacktail Deer Creek were annually browsed by elk. As a result, willow heights were short, averaging less than 50 cm (1.6 ft).

Approximately two decades after the return of wolves, tall willows more than 3 m (10 ft) in height were again present along these streams, as shown in the graphic that follows.

* Beschta & Ripple 2007, 2019

Recovering Riparian Vegetation

Blacktail Deer Creek



(Graphs – Beschta & Ripple 2019)

After the mid-1990s, riparian willows began to:

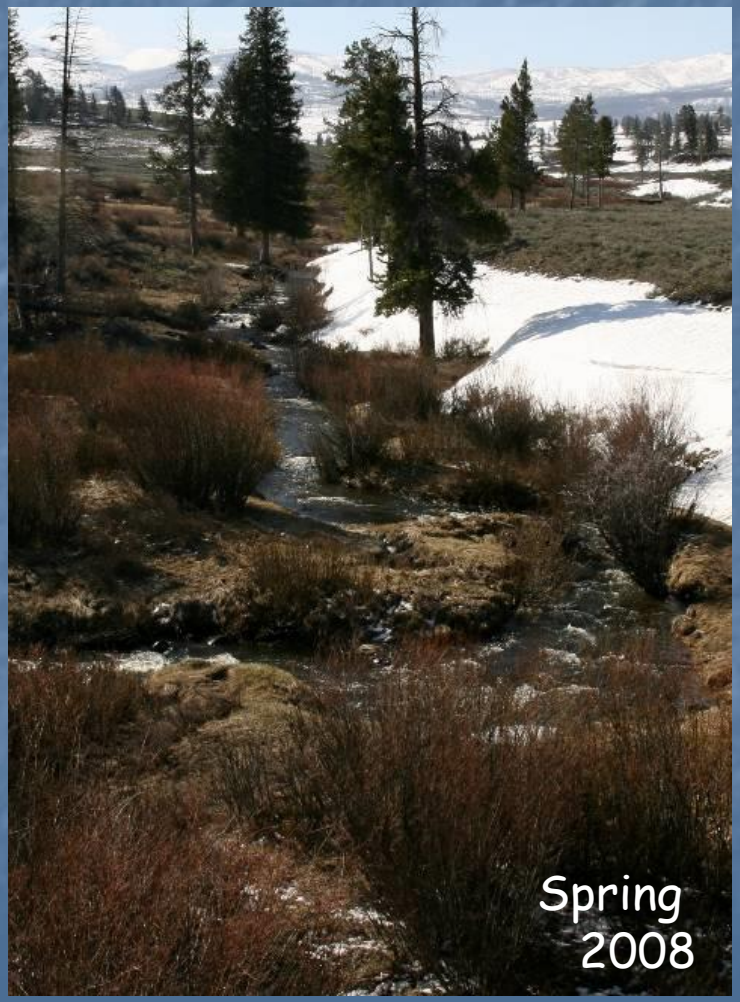
(a) grew taller and

(b) increase the amount of canopy cover over a stream.

These tall willow communities provide important habitat for birds, food for beaver, and more winter browse for ungulates such as elk, mule deer, and moose.

Recovering Willows
Blacktail Deer Creek

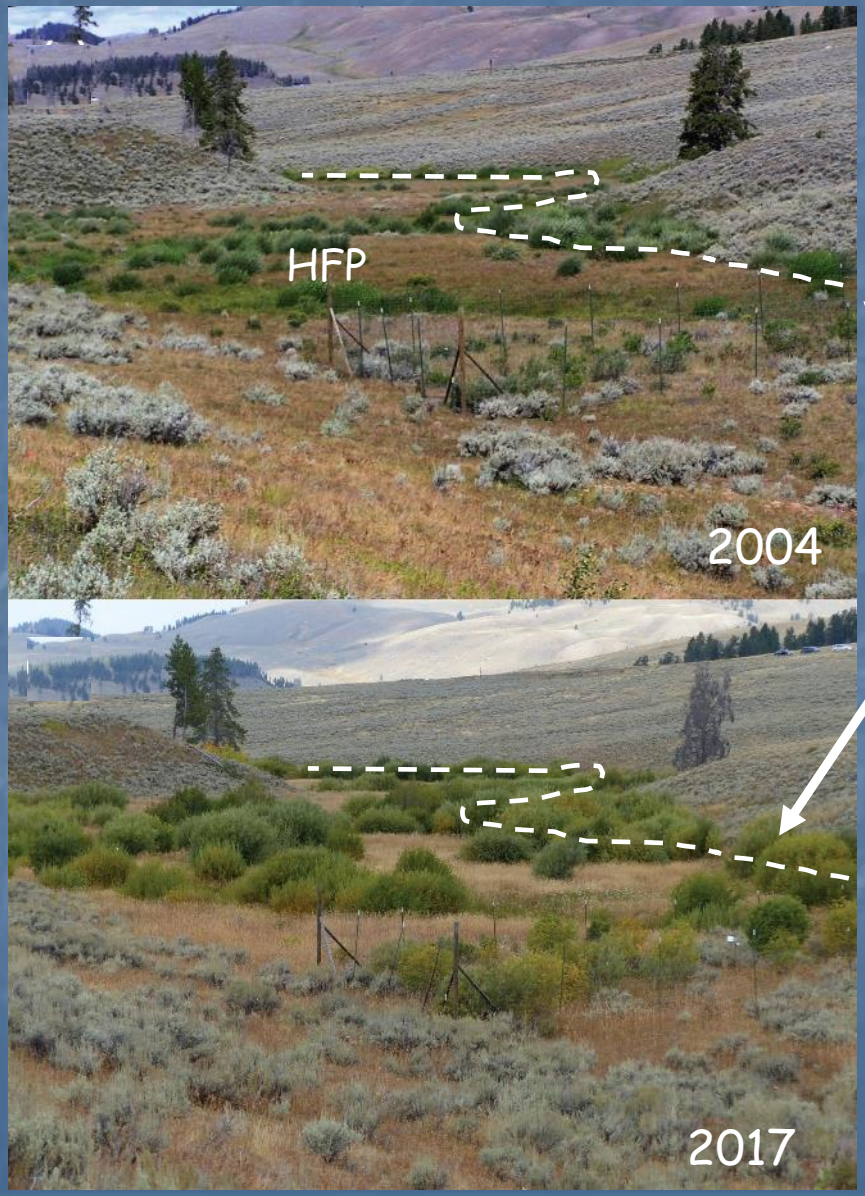
In this riparian area, willows that were suppressed by browsing in 1996 have increased in density and height by 2008.



(Photos – left, National Park Service; right, RL Beschta)

Recovering Willows

East Fork of Blacktail Deer Creek



In 2004, willows along on the historical floodplain (HFP) of the East Fork channel were beginning to grow taller due to decreased browsing by elk.

East Fork stream channel (dashed line)

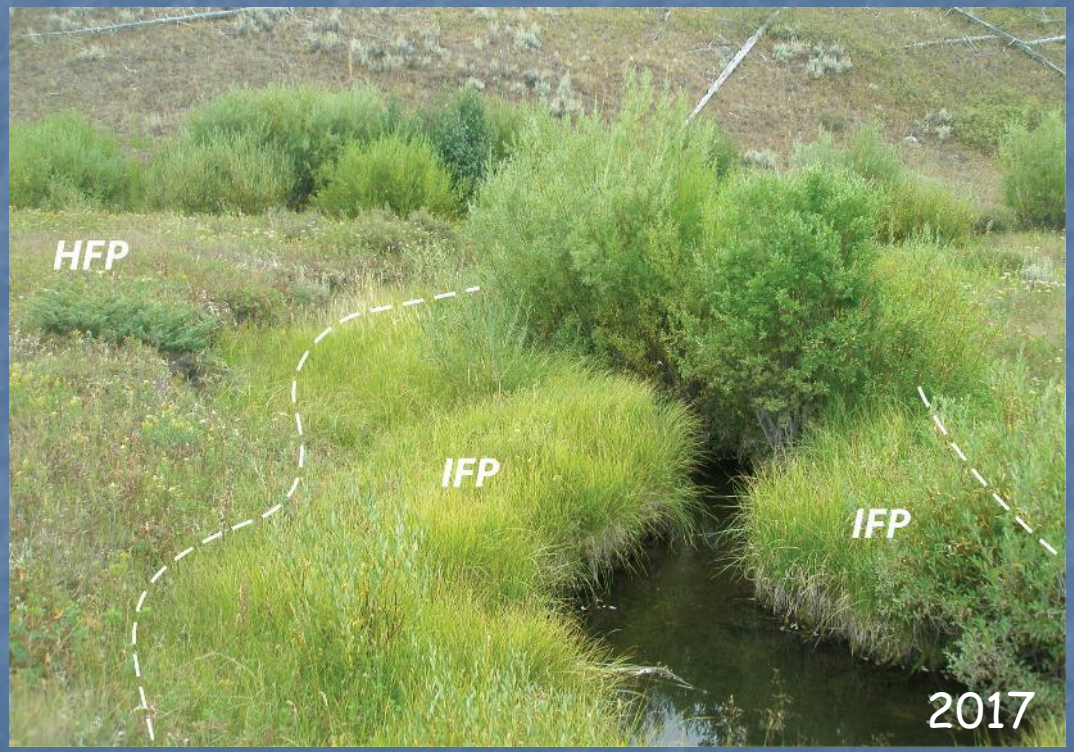
By 2017, tall willows in excess of 3 m (9.8 ft) had become increasingly common along the stream and floodplain.

(Photos – RL Beschta)

Functioning Floodplain

East Fork of Blacktail Deer Creek

When willow communities were degraded by intensive elk browsing, much of Blacktail Deer Creek experienced accelerated bank erosion and channel incision, thereby creating an oversized channel and effectively severing hydrologic connections between the stream and its historical floodplain (HFP).



HFP = historical floodplain
IFP = inset floodplain

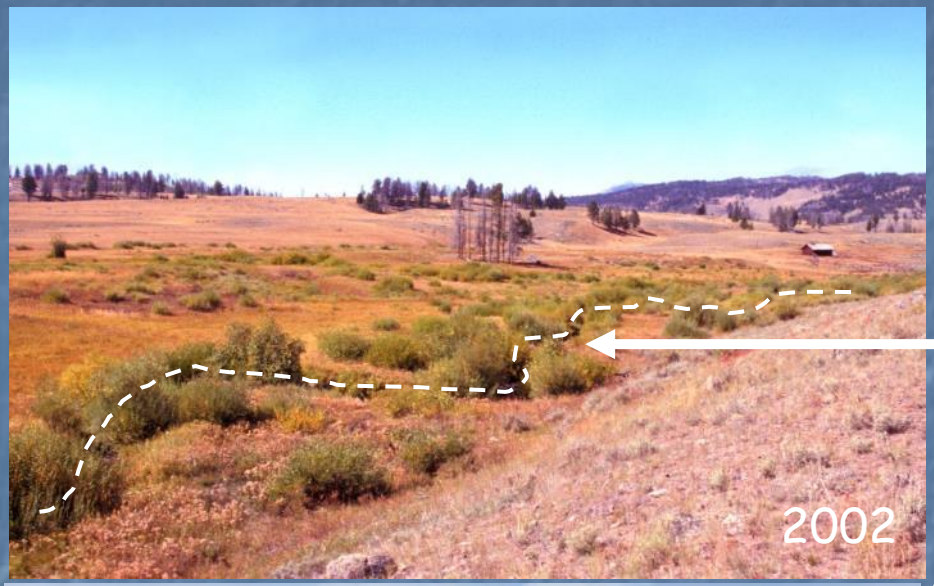
(Photo – RL Beschta)

However, riparian willows and herbaceous plants recovering, as shown here, a new floodplain or inset floodplain (IFP) has begun to develop within the oversized channel. Also, the return of well-vegetated overhanging banks are helping to stabilize and narrow this channel.

Note: Dashed line demarks the outer edge of the inset floodplain

Recovering Willows

West Fork of Blacktail Deer Creek



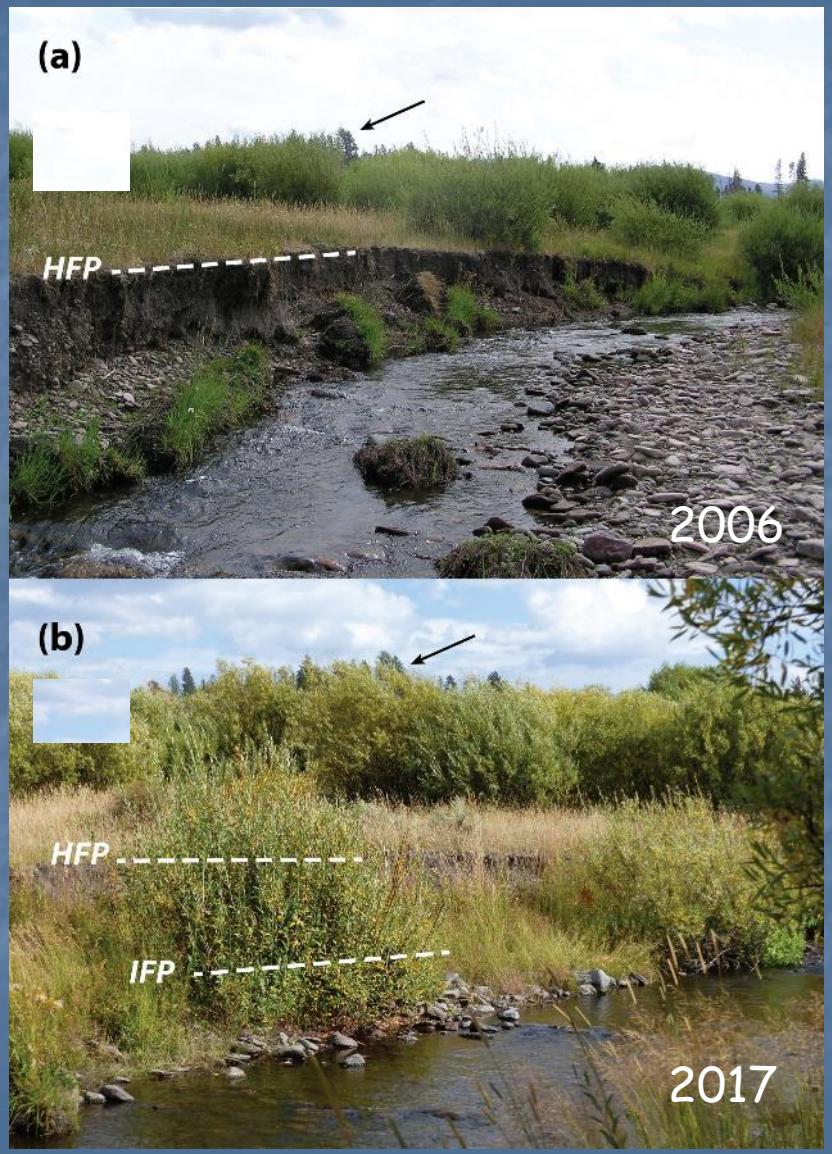
In 2002, willows along the West Fork were beginning to grow taller due to decreased elk browsing.

West Fork stream channel

By 2017, some 15 years later, willows in excess of 3 m (9.8 ft) tall have become relatively common across this valley bottom. This area now provides important habitat for birds, beaver, and other wildlife.

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

Stabilizing Streambanks
West Fork of Blacktail Deer Creek



HFP = edge of historical floodplain
IFP = edge of inset floodplain

Although willows on the historical floodplain (HFP) in 2006 were escaping the reach of elk (~ 2m or 6.5 ft), high rates of streambank erosion continued.

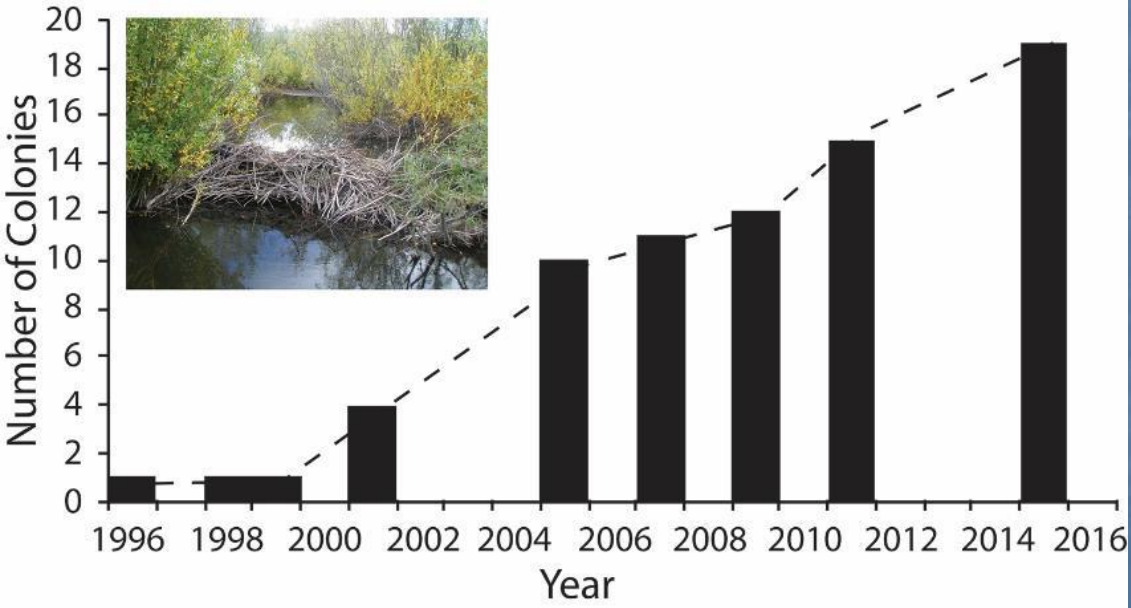
By 2017, willows and grasses have stabilized this streambank. In addition, a relatively small inset floodplain (IFP) had begun to form along the streambank.

Note: Arrow points to a conifer common to each photo.

(Photos – RL Beschta)

Beavers Return to the Northern Range

Beaver colonies were largely absent from the northern range for nearly the last half of the 20th century. However, with a resurgence of riparian vegetation in recent years, beaver colonies have begun to increase (see graph). While the number of colonies is nowhere near the many hundreds of colonies that likely existed across the northern range in the early 1900s, their increasing presence confirms the ongoing recovery of plant communities.



Beaver dams store water that helps to nurture riparian vegetation. In turn, these more diverse plant communities provide additional habitat benefits for terrestrial and aquatic wildlife species.

(Graph – Beschta & Ripple 2016)

Recolonizing Beavers
West Fork of Blacktail Deer Creek

By the 1990s, and likely earlier, the browsing-suppressed plant communities along Blacktail Deer Creek provided little food or dam-building materials for beaver.

However, with increased growth of willows and other plants in recent years, a beaver colony became established in 2015. Several of their dams, which averaged 0.95 m (3.1 ft) in height, began diverting water onto the historical floodplain, thus enhancing plant growth and diversity.

The occurrence of beaver along Blacktail Deer Creek may foreshadow a much broader recovery for this stream and its riparian ecosystems.

Beaver Dam
West Fork of
Blacktail Deer Creek

(Photo – RL Beschta)

The Bison Conundrum

Many streamside communities in the northern range have been recovering in recent years. However, this has not been the case along major valley bottoms where plant communities and their channels continue to be adversely affected by the feeding and trampling of a burgeoning bison population.

Below are two examples from the Lamar Valley, an area of high bison use, where riparian plant communities are largely absent and channel erosion is ongoing.

(Lower photos – RL Beschta; upper inset – CH James)

Riparian Vegetation in the Gallatin Winter Range

As in the northern range, wolves in the Gallatin winter range were extirpated in the early 1900s and willow communities were heavily impacted by increased elk browsing, eventually leading to increased widening and incision of the Gallatin River channel.*

With the mid-1990s return of wolves, willow communities have begun to recover, beaver have recolonized portions of the river, and over time the river channel may begin to narrow.

Gallatin Winter Range

The following photos show some of the dramatic changes in the Gallatin's willow communities. Recent photographs indicate that recovery of riparian vegetation is well underway.

* Ripple & Beschta 2004; Beschta & Ripple 2007, 2019

Willow Loss and Recovery

Gallatin Winter Range

In 1924, a dense stand of tall willows occurs along the Gallatin river. This is about the time when the last wolves were being extirpated from Yellowstone. Crown Butte is in the hill in the background.

By 1961, after several decades of heavy elk willow communities had been decimated and riverbanks were eroding.

Wolves soon occupied this portion of the winter range after their 1995-96 reintroduction into the park, and by 2003 willows were becoming established across the floodplain.

(Photos – Top & middle, Montana Fish, Wildlife, & Parks; bottom, RL Beschta)

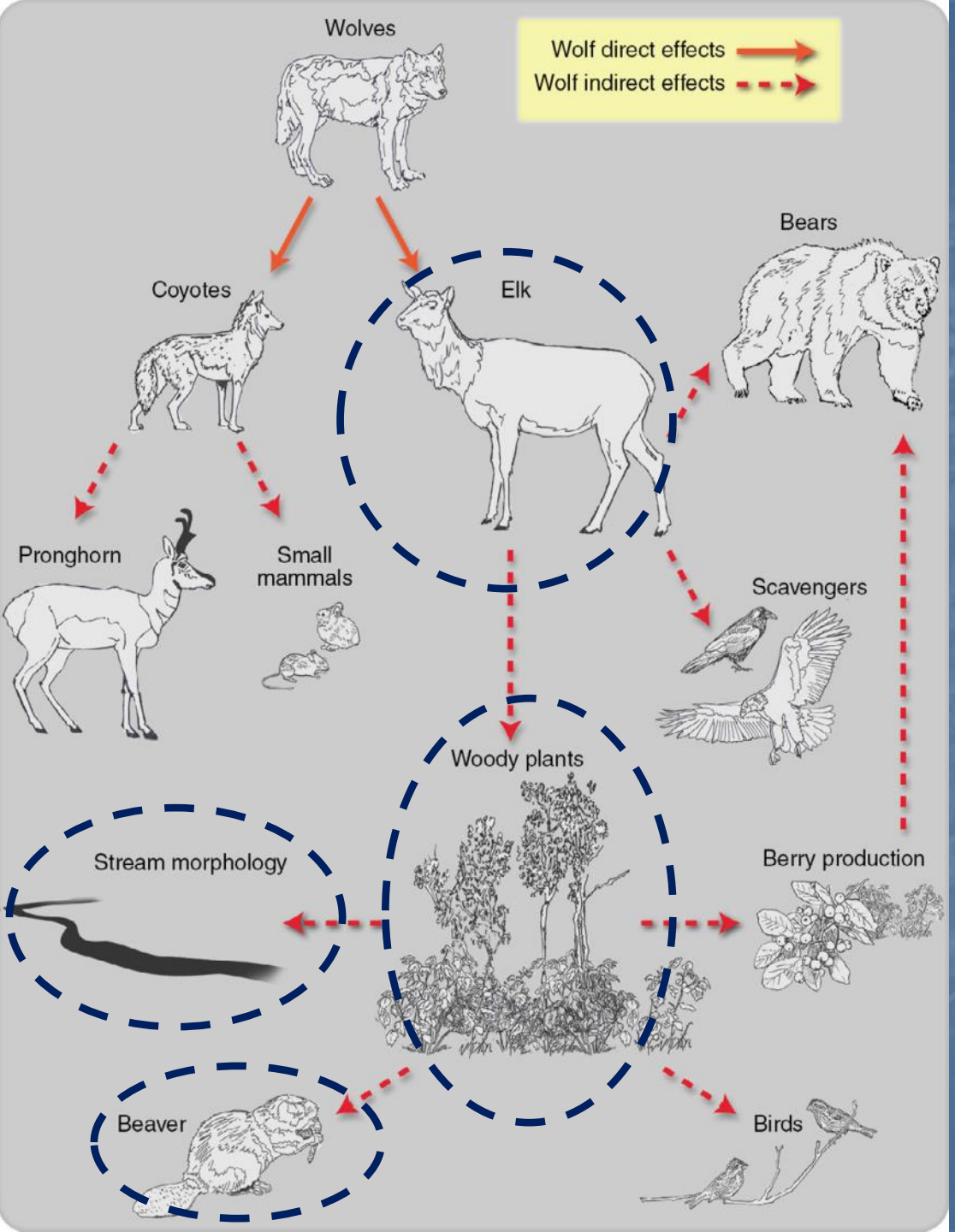
Recovering Willows
Gallatin Winter Range

(Photos – top, CE Kay; bottom, RL Beschta)

By 1983, willows had largely disappeared from banks along the Gallatin River and its floodplain. As a result, riverbank erosion increased and the river's channel began to widen and incise.

By 2018 willow communities had again become established along the river's floodplain (arrows). These plant communities have an important role in stabilizing riverbanks.

In contrast to Yellowstone's northern range where bison impacts are having major effects on riparian vegetation and channels, the Gallatin winter range does not have bison.



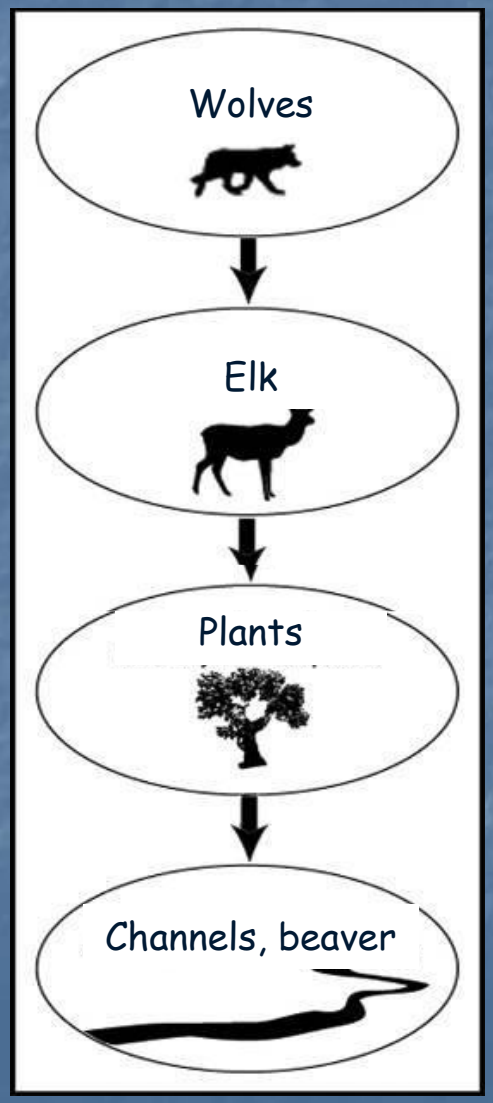
Beyond Plants and Streams: Wolves and Trophic Cascades Across Northern Yellowstone

In this document we have mostly focused on effects of reintroduced wolves upon elk, plants, streams, and beaver (dashed ovals).

However, the return of wolves has created additional direct and indirect effects, as indicated in the conceptual diagram.

(Graphic - Ripple et al., 2014)

Synthesis
Can Wolves Change Streams via a Trophic Cascade?



Following the return of wolves, which completed the park's large predator guild, various denuded riparian areas and eroded streams from across the northern range have begun to recover.

Results from studies of the East and West forks of Blacktail Deer Creek were consistent with a trophic cascade hypothesis. Here, reduced elk browsing following the return of wolves allowed riparian plant communities to begin recovering. In turn, this increased shade over the stream, stabilized banks, and began to provide habitat for beavers.

Can wolves change streams? The streams of Yellowstone affirm that they do.

(Figure – Beschta & Ripple 2008)

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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 of Plant and Animal Species

Plants

Cottonwoods – *Populus* spp.
Quaking aspen – *Populus tremuloides*
Sagebrush – *Artemesia* spp.
Sedges – *Carex* spp.
Thinleaf alder - *Alnus incana* spp. *tenuifolia*
Willows – *Salix* spp.

Animals

Black bear – *Ursus americanus*
Beaver – *Castor canadensis*
Cougar – *Puma concolor*
Gray wolf – *Canis lupus*
Grizzly bear – *Ursus arctos*
Moose – *Alces alces*
Mule deer - *Odocoileus hemionus*
Rocky Mountain elk – *Cervus canadensis*

Glossary of Selected Terms

Herbivory – The feeding or foraging of animals on living plants; browsing is used in reference 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 reach of ungulates. In northern Yellowstone, recruitment is assumed to occur when these plants exceed a height of ~2 m (6.5 ft), the normal upper browse level of elk.

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

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