Wolves, Elk, and Woody Plants of Yellowstone National Park: A Photographic History of a Trophic Cascade

Part 1 - The Removal of Wolves and the Reign of Elk

Once There Were Wolves

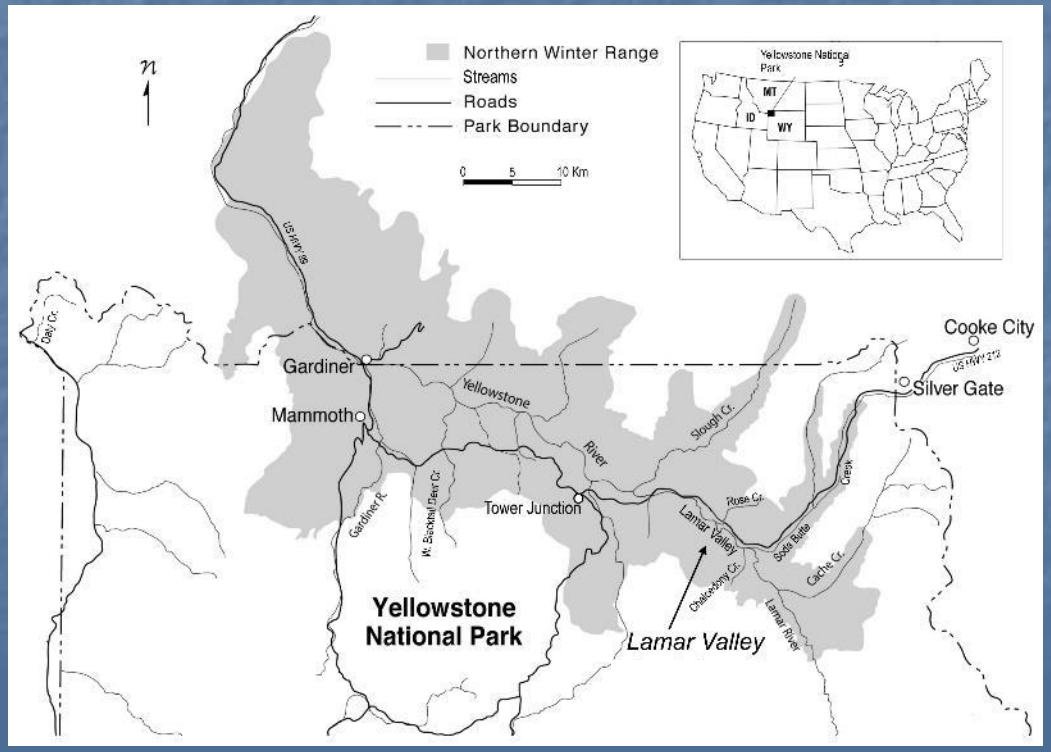
Yellowstone National Park was established in 1872 with a full complement of large predators--gray wolves, cougars, grizzly bears, and black bears) and their ungulate prey (Rocky Mountain elk, mule deer, moose, bighorn sheep, and bison). The park occupies nearly 9,000 km^2 (3,470 $mi^{2)}$ of terrain in the Rocky Mountains.

Gray wolf

(Photo – National Park Service)

Elk of Yellowstone's Northern Range

Elk are the primary prey of gray wolves and many of Yellowstone's elk are found in the north-central portion of the park. Here they spread across a mountainous landscape in summer but each fall thousands of them descend into the valleys of the park's northern range to forage throughout the winter. The northern range encompasses ~1,500 km^2 (580 mi^2), most of which occurs inside the park.



(Photo – WJ Ripple)

The Reign of Elk

Yellowstone's wolves—and its cougars—were hunted, trapped, and eventually extirpated by the mid-1920s. Soon after, heavier browsing of woody plants in the northern range became increasingly common. Over time, and despite Park Service efforts at reducing elk numbers *via* culling, young aspen, willow, cottonwood, thinleaf alder, and other woody species were increasingly stunted by the elk's intensive browsing.

In 1958 the Park Service indicated: "The cumulative effects of grazing and trampling by excessive numbers of elk for many decades are obvious today. Meadows once covered by lush thickets of willows now have a grass-type aspect; likewise former stands of aspen now have only a few trees that cannot be replaced while elk consume reproduction. Sagebrush has disappeared from ridges and other places where snow lies shallow, and even bunchgrasses, which comprises the bulk of the elk's diet, is in poor condition."

In 1968 the Park Service stopped culling elk and their numbers rapidly quadrupled, to nearly 20,000 elk by the early 1990s, with increasingly severe consequences for northern range plant communities.

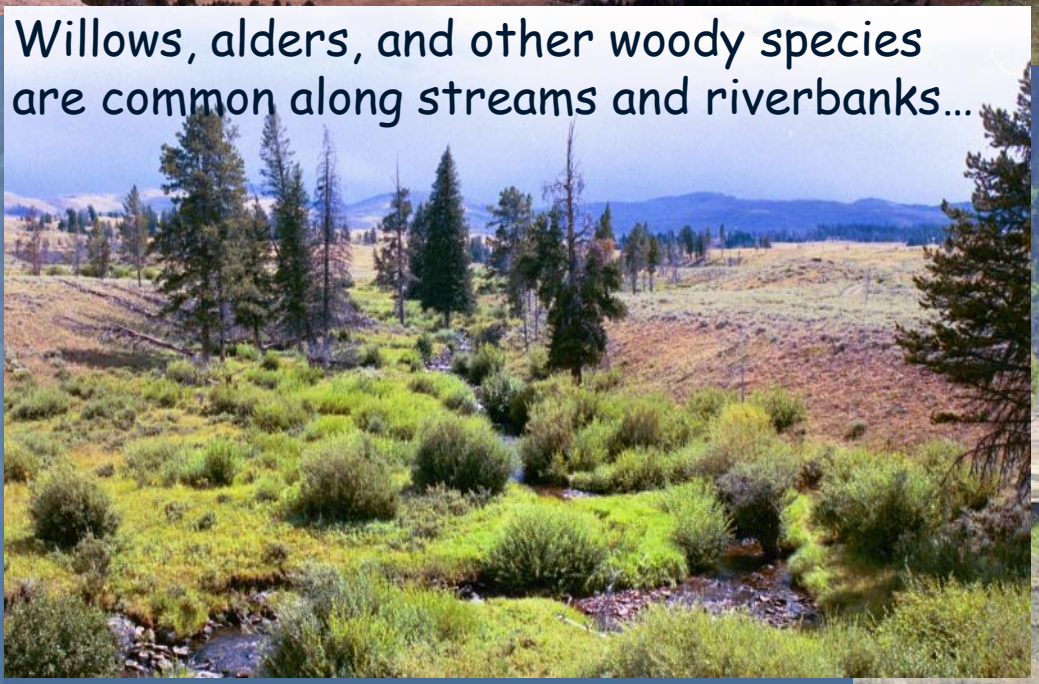
(Photo – National Park Service)

Northern Range Vegetation

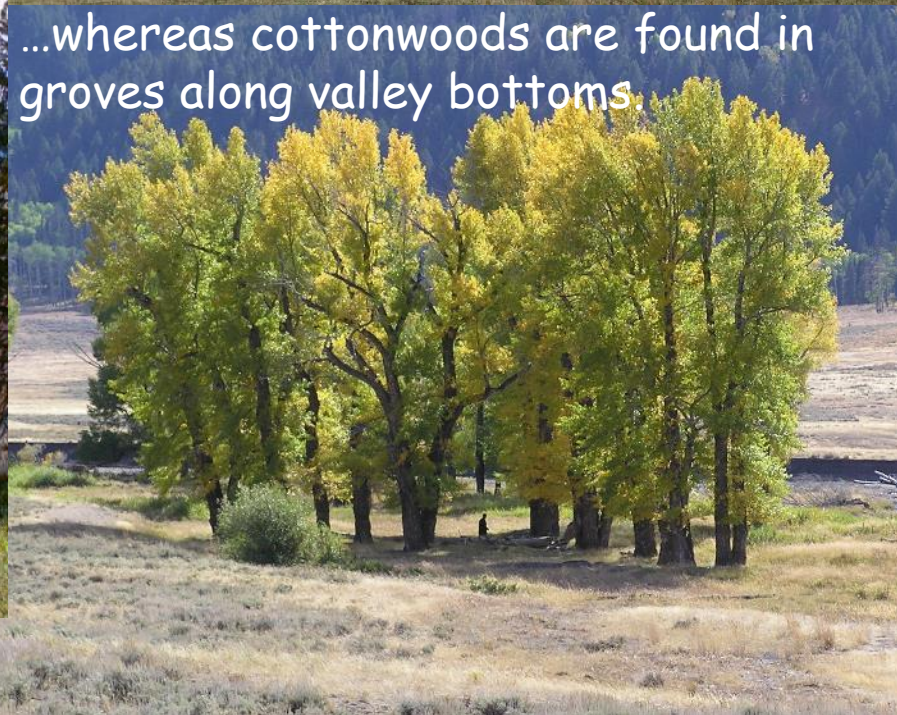
The northern range is vegetated primarily by sagebrush-grassland…

…with scattered aspen stands.

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

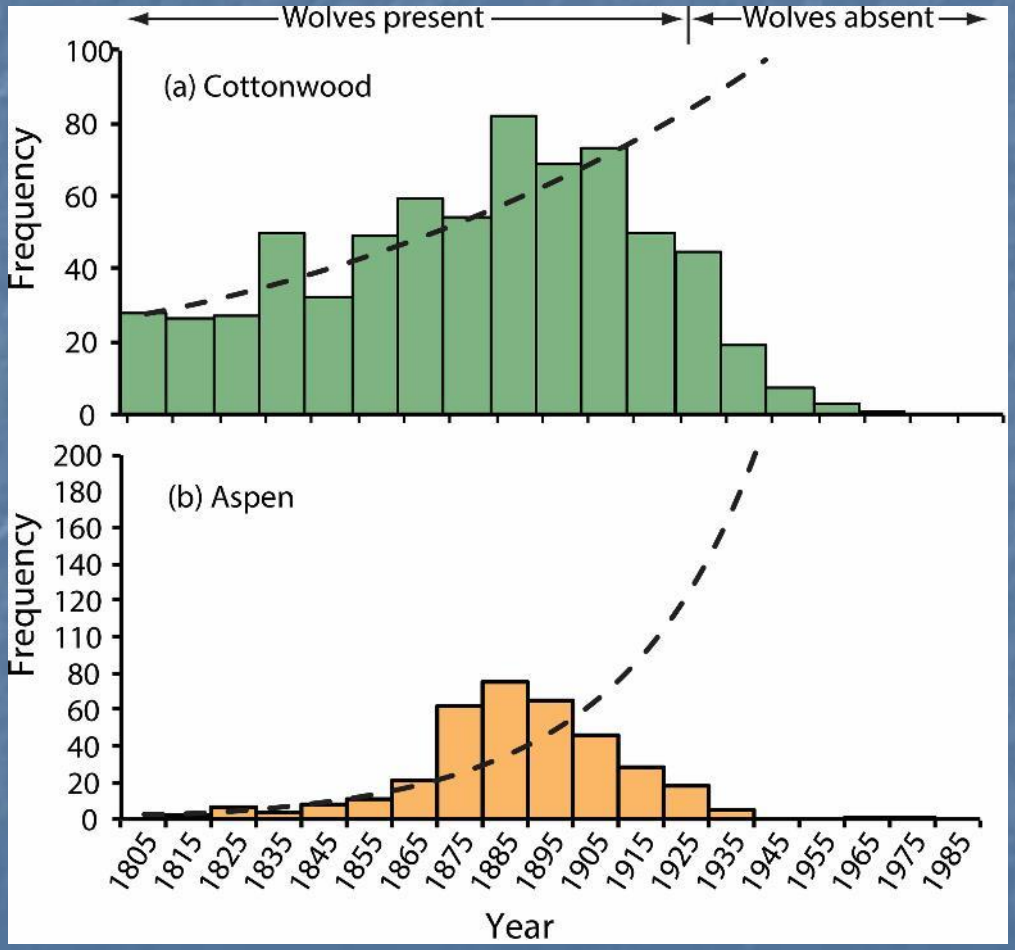


…whereas cottonwoods are found in groves along valley bottoms.



(Photos – RL Beschta)

Decline of Woody Species after Wolf Extirpation



When wolves were present the numbers of cottonwood and aspen increased over time throughout the 1800s (vertical bars), but declined dramatically following the removal of wolves, due to increased browsing by elk.

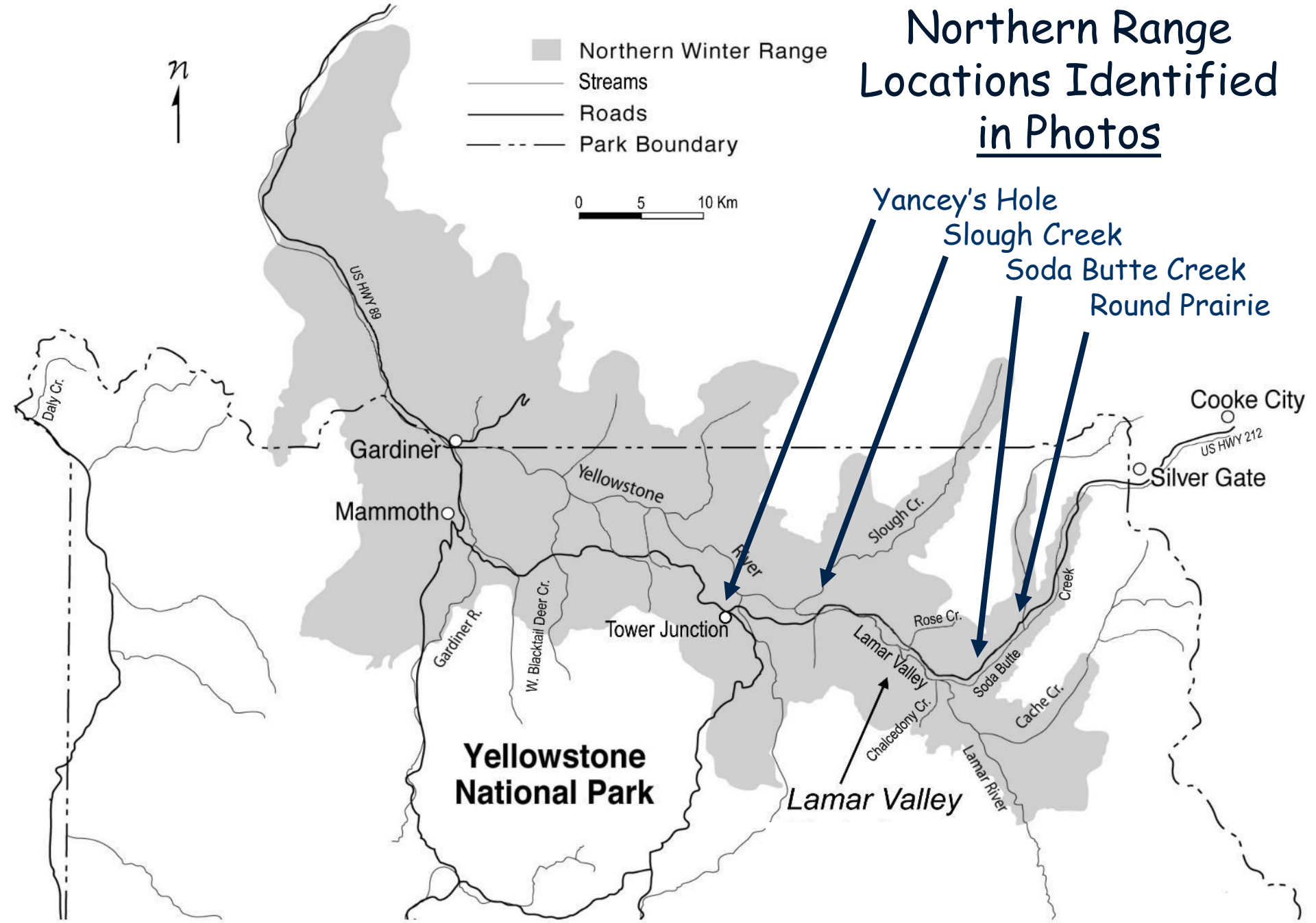
If the lack of tree recruitment in the late 1900s, as shown here for both cottonwood and aspen were to continue, these woody species could eventually be lost from the northern range.

(Beschta & Ripple 2016)

The Northern Range in the Absence of Wolves

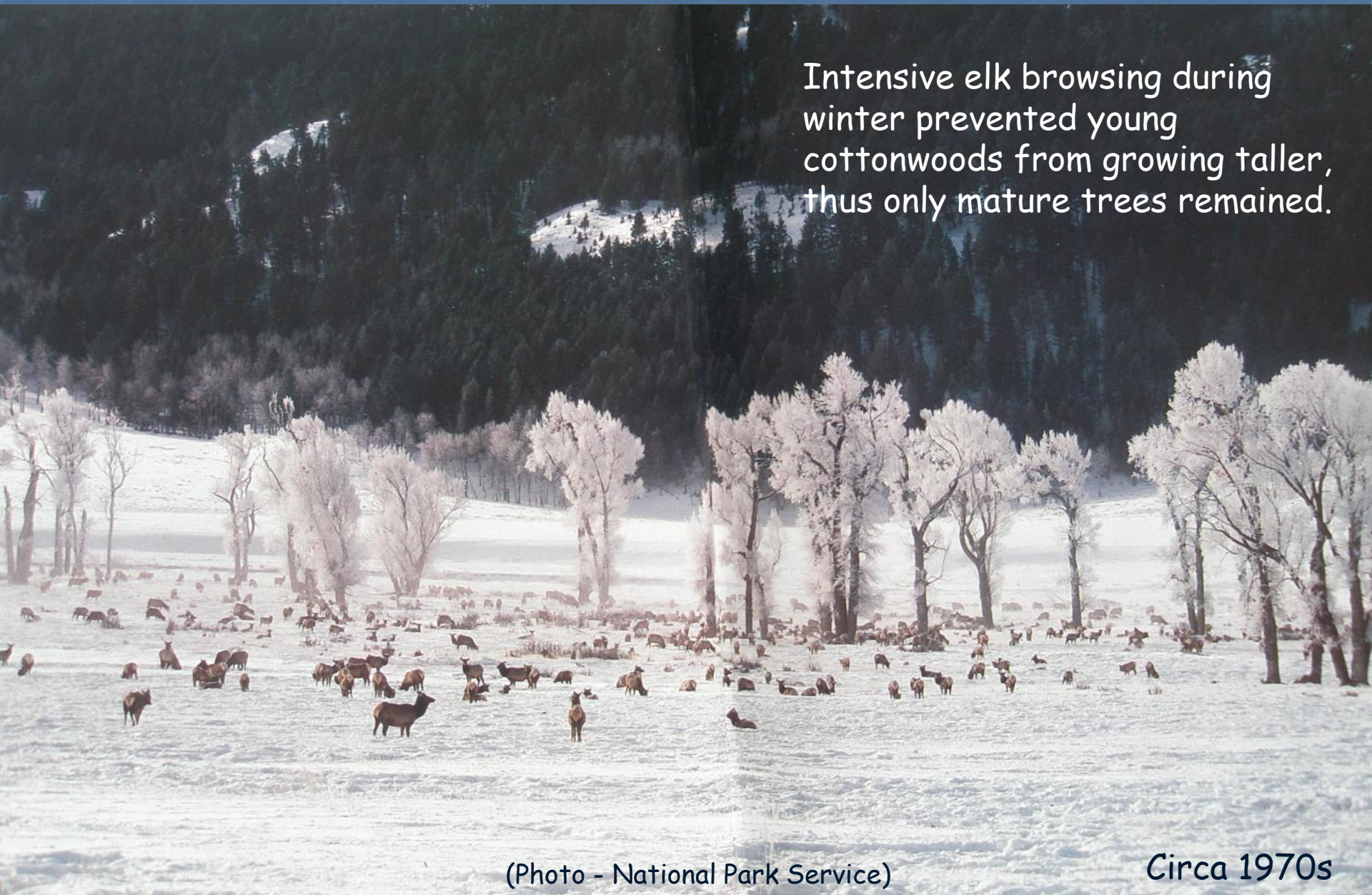
The following photographs, primarily from the 1970s, 1980s, and 1990s illustrate some of the long-term effects of intensive elk browsing on woody plant communities and rivers.

Northern Range Locations Identified in Photos



Wintering Elk among Cottonwoods

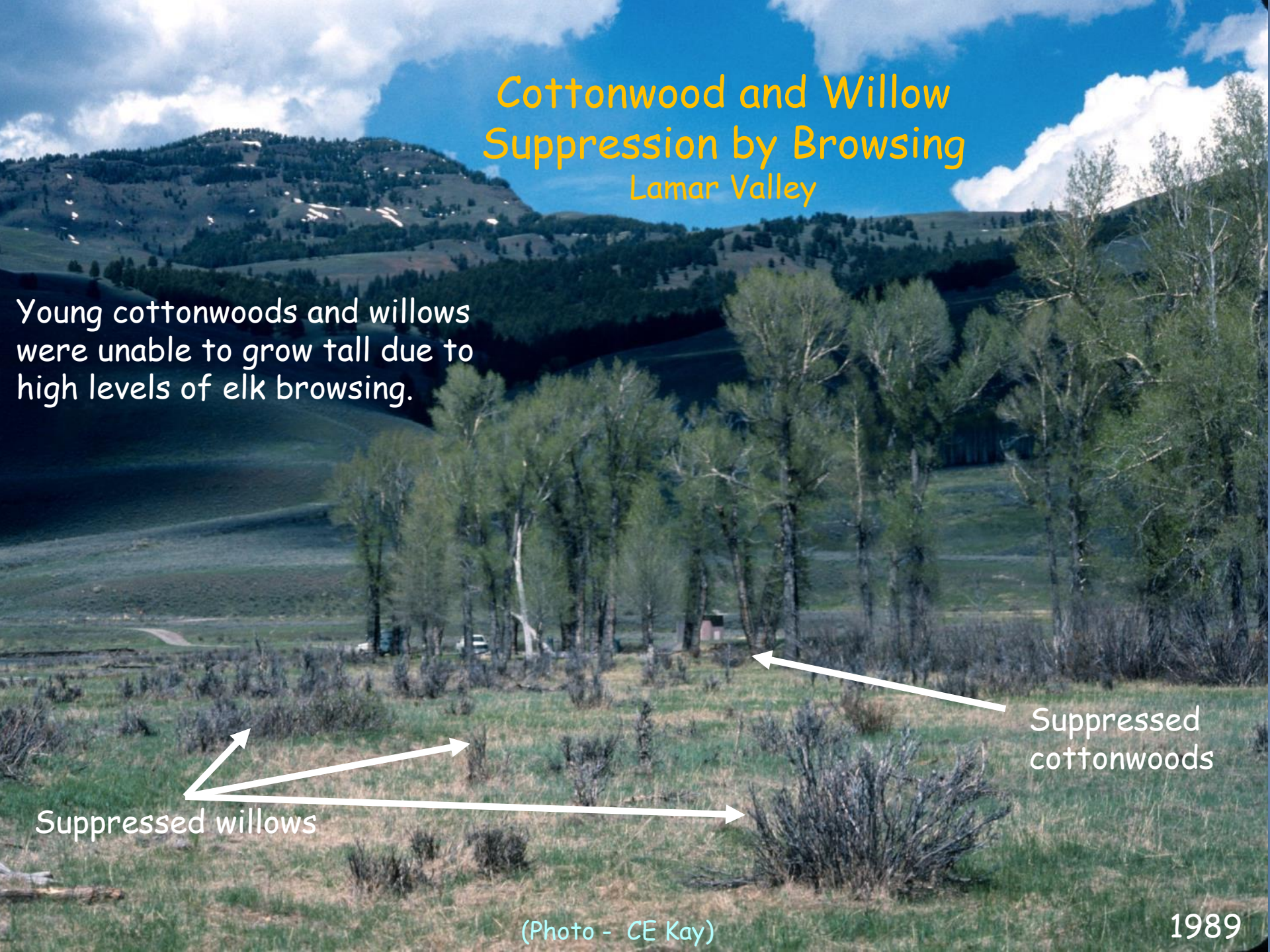
Lamar Valley



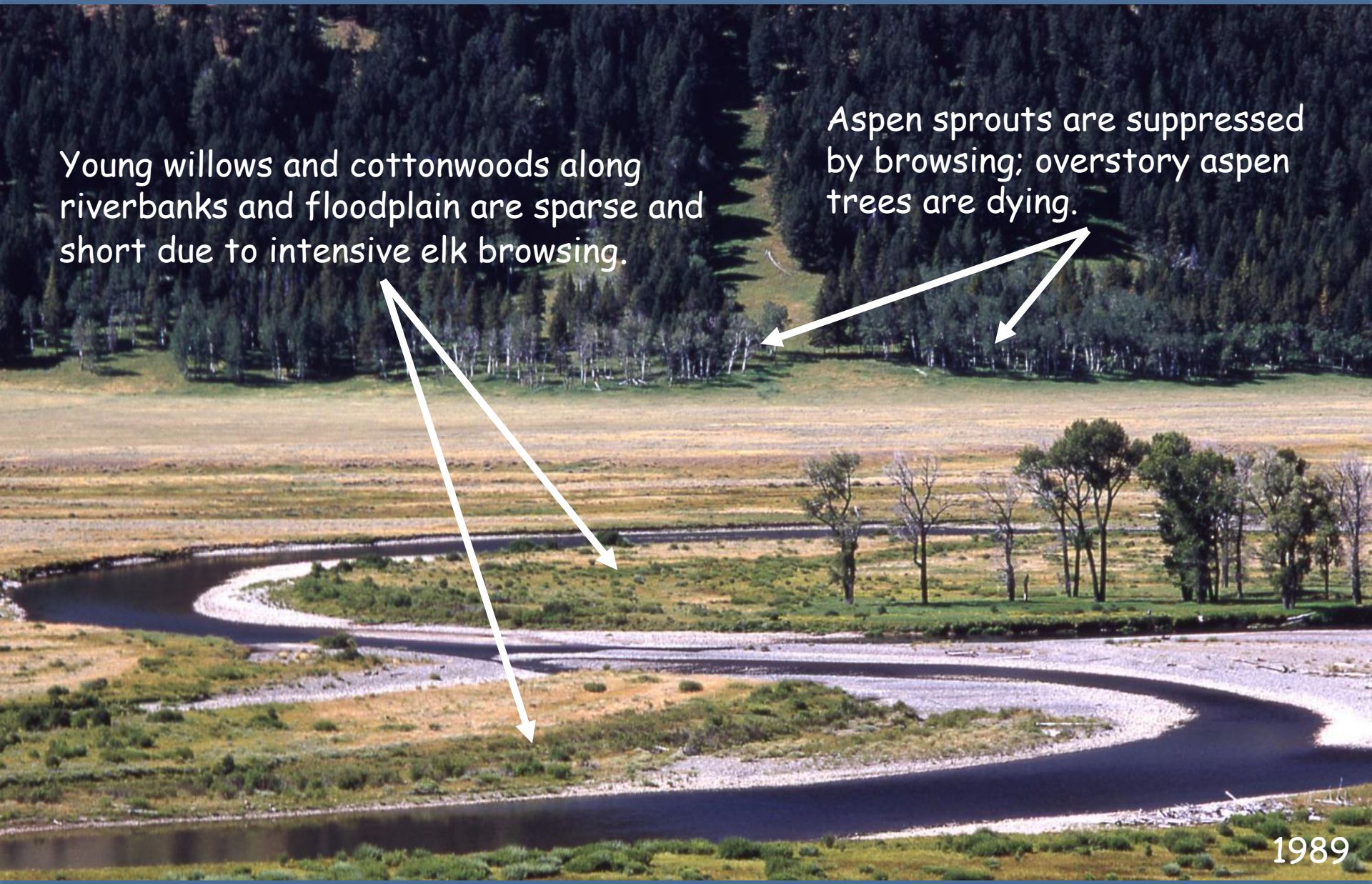
Intensive elk browsing during winter prevented young cottonwoods from growing taller, thus only mature trees remained.

(Photo - National Park Service)

Circa 1970s


Cottonwood and Willow Suppression by Browsing
Lamar Valley
Young cottonwoods and willows were unable to grow tall due to high levels of elk browsing.
Suppressed cottonwoods
Suppressed willows
(Photo - CE Kay)
1989

Depleted Plant Communities, Lamar Valley



(Photo - WW Dunmire)

Eroding Riverbanks
Lamar River

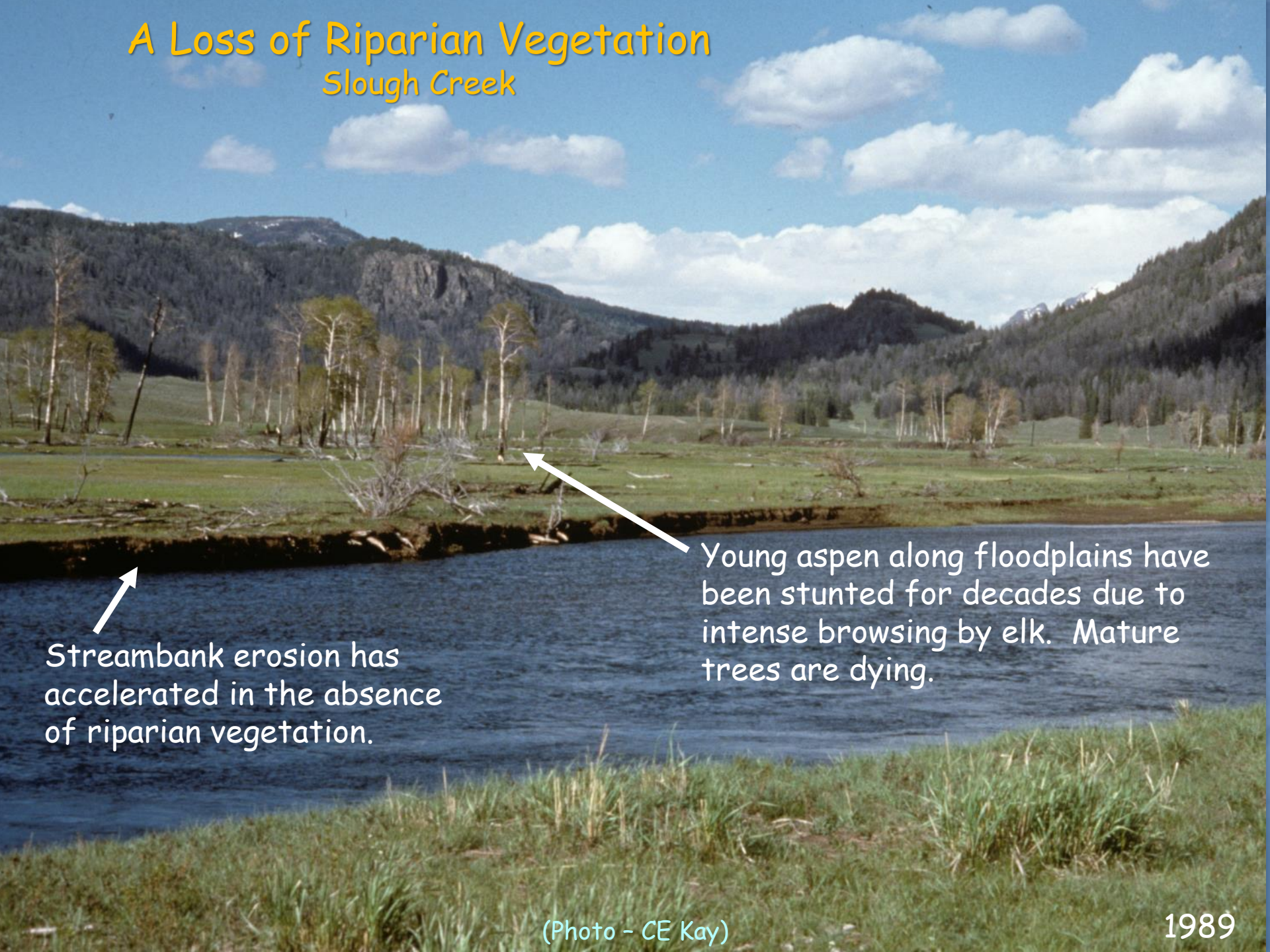
Following the loss of riparian vegetation, riverbank erosion accelerated.

Deep, carbon rich, floodplain soils that had been laid down over thousands of years were being washed downstream.

(Photos – RL Beschta)

A Loss of Riparian Vegetation

Slough Creek



(Photo – CE Kay)

1989

Quaking Aspen in a Land of Elk

Aspen stands are found scattered across the northern range in both riparian (streamside) and upland settings. As high rates of elk browsing increasingly suppressed aspen sprouts, following the extirpation of wolves, they were unable to grow into trees.

Browsing-suppressed young aspen

"Barked" aspen tree

(Photo - RL Beschta)

Mature aspen suffered as well. Hungry elk stripped bark along the base of trees with their teeth (a habit called 'barking'), creating potentially fatal entry sites for disease organisms. Barking also causes the tree's bark to turn black and rough (see photo).

The barking of aspen by elk has likely contributed to an accelerated die-off of overstory trees in many northern range aspen stands.

Repeat Photographs

The photographs that follow further chronicle the long-term effects of intensive elk browsing on northern range woody plant communities.

Willows in Decline

Round Prairie

By 1943, mature willows were being "hedged" due to intensive elk browsing.

In 1988, over four decades later, all tall willows in this meadow have been removed due to intensive browsing by elk.

Note also that mature aspen trees are barked and sprouts have been unable to grow tall, both effects due to elk.

(Photos – top, National Park Service; bottom, CE Kay)

Loss of Willows

Soda Butte Creek

1896 - Mature willows occur continuously along base of slope.

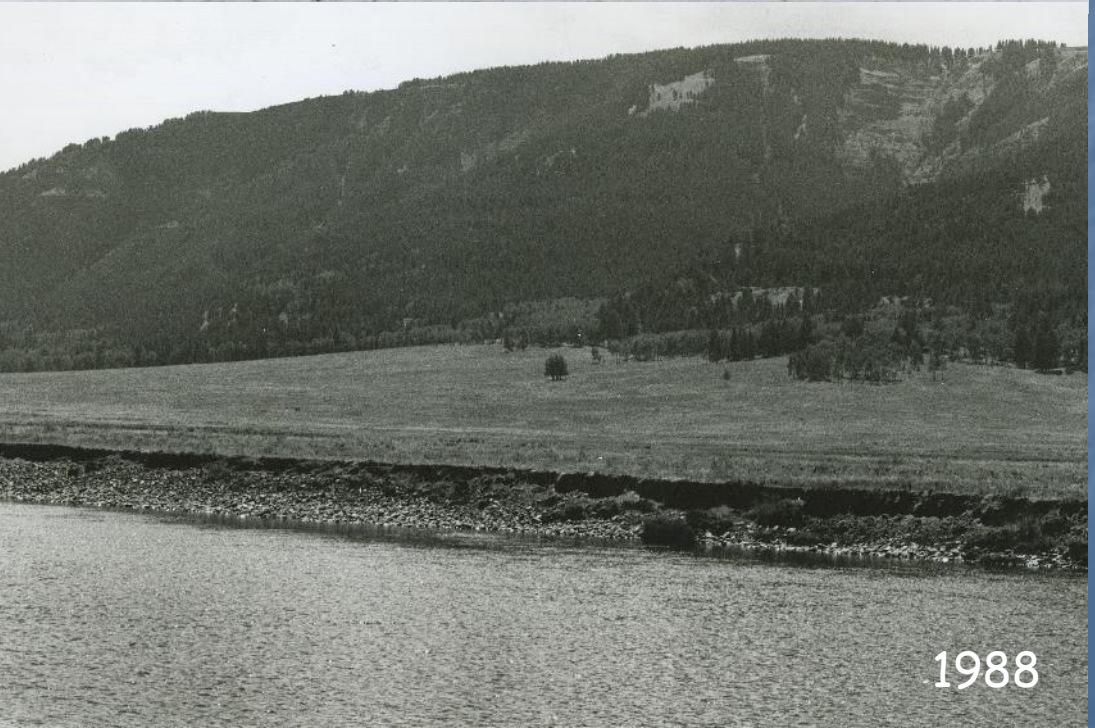
1988 - Willows have been eliminated by elk browsing.

(Photos –top, AE Bradley; bottom, CE Kay)

Riverbank Willows Vanish

Lamar Valley

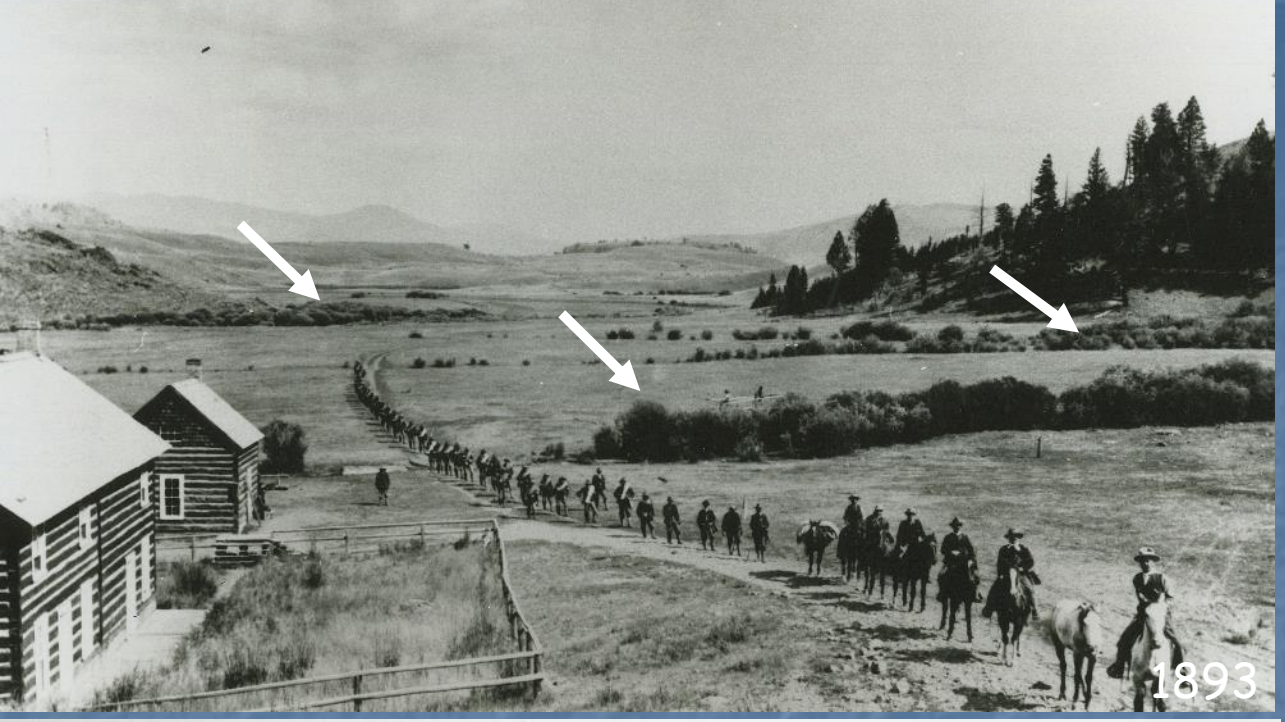
1921 - Willows and other woody species line the banks of the Lamar River, providing bank stability and protection during high flows.



1988 - Woody species have been eliminated by elk browsing and, as a result, bank erosion has increased.

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

Willows Lost
Yancy's Hole



1893 - In the early years of the park, small streams were lined with willows, alders, and other woody species.

1990 - Nearly a century later, intensive elk browsing had eliminated woody species from along these streams.

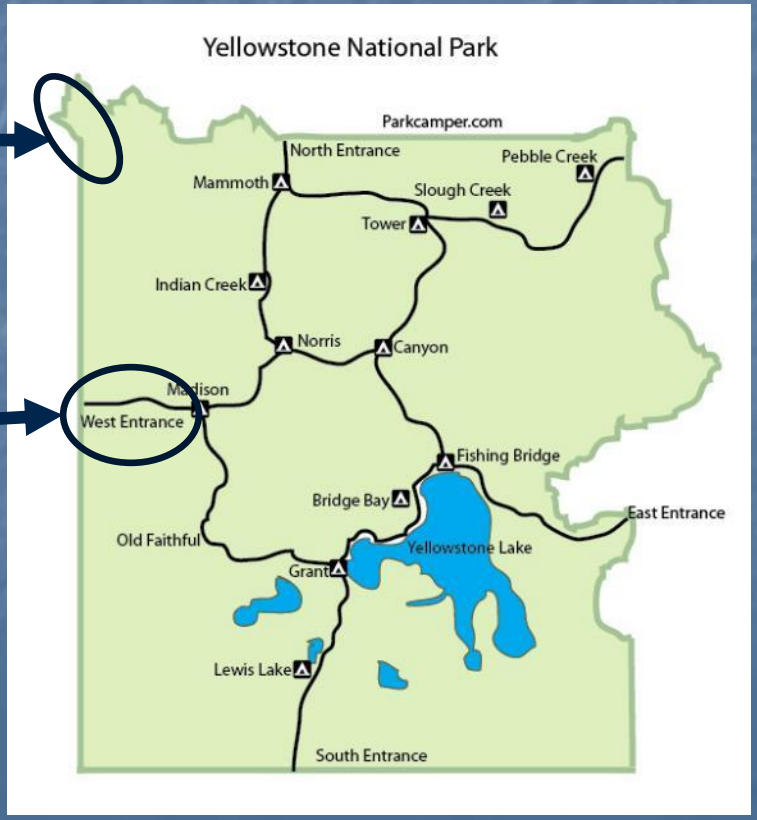
(Photos – top, FJ Haynes; bottom, CE Kay)

Elsewhere in the Park

While the effects of increased elk browsing during the 1900s have been most studied in the northern range of Yellowstone National Park, woody plant communities in other portions of the park also revealed significant changes have occurred, such as those along the Gallatin and Madison rivers.

Gallatin River

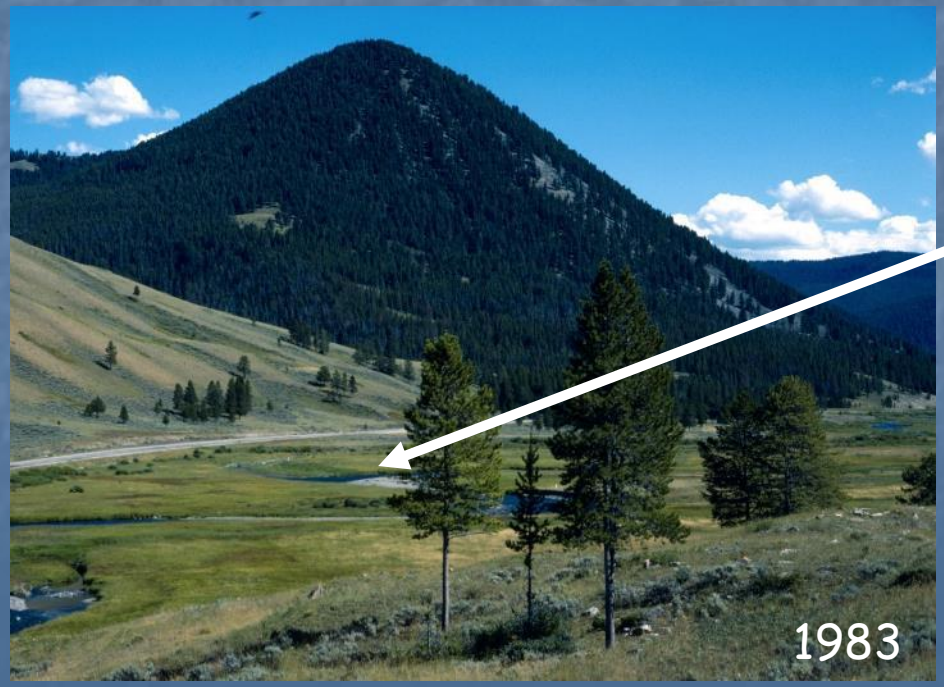
Madison River



Disappearing Floodplain Willows

Gallatin River Floodplain

1921 - An extensive willow community is present across the floodplain of the Gallatin River.

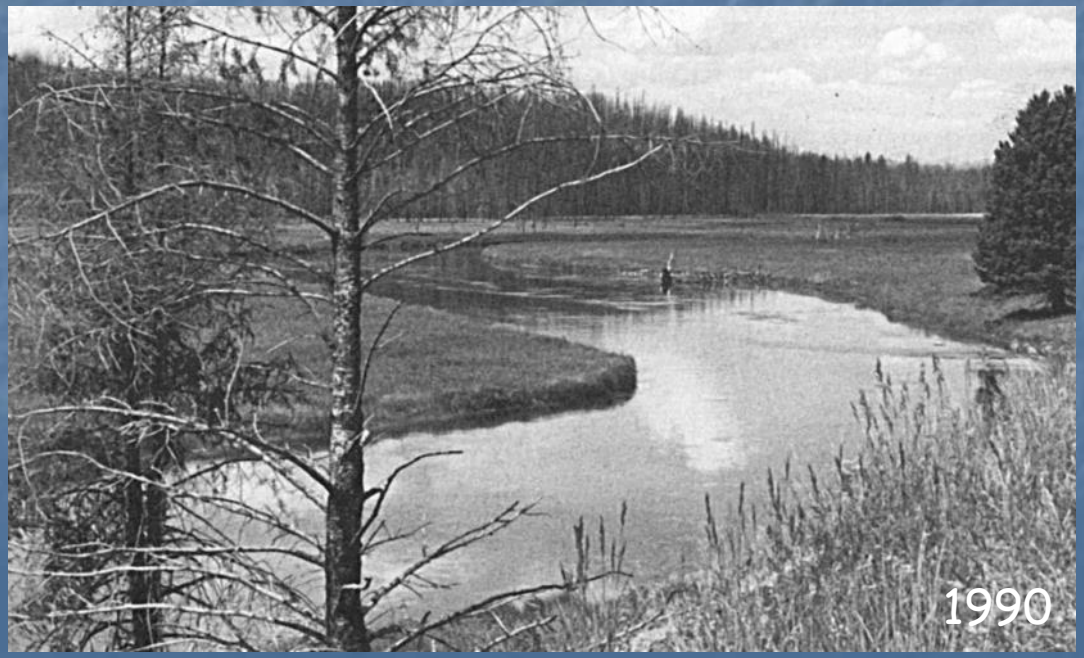


1983 - Increased elk browsing, following the extirpation of wolves in the 1920s, eliminated nearly all willows along this valley bottom.

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

Willows and Beaver
Madison River Floodplain

In 1912, tall willow communities were present across this Madison River floodplain, communities capable of supporting numerous colonies of beaver.



By 1990, decades of heavy elk browsing removed nearly all willows, effectively destroying food resources for beaver, as well as habitat for other wildlife species.

(Photos – top, US Army Engineers, bottom, M Meagher)

Missing Predators and Increased Browsing by Ungulate Prey: A Widespread Problem

The effects of large predator removal, followed by increased elk browsing, has had devastating consequences for woody plant communities in Yellowstone's winter ranges. But Yellowstone is not an isolated case.

Government efforts to rid the West of large predators in the early 1900s extended beyond Yellowstone to other national parks, such as Olympic, Rocky Mountain, Wind Cave, Yosemite, and Zion—resulting in similar patterns of drastic ecosystem changes: intensive browsing by elk or deer, loss of woody species, simplification of plant and animal communities, and increased erosion along rivers and streams.*

* Beschta & Ripple 2009

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Beschta RL, & Ripple WJ. 2009. Large predators and trophic cascades in terrestrial ecosystems of the western United States. Biological Conservation 142: 2401-2414.

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NPS (National Park Service). 1958. Management plan for northern elk herd, Yellowstone National Park. USDI, National Park Service, Yellowstone National Park, Mammoth, Wyoming.

Related Literature

Beschta RL. 2005. Reduced cottonwood recruitment following extirpation of wolves in Yellowstone's northern range. Ecology 86: 391-403.

Ripple WJ, & Larsen EJ. 2000. Historic aspen recruitment, elk, and wolves in northern Yellowstone National Park, USA.. Biological Conservation 95: 361-370.

Ripple WJ, & Beschta RL. 2004. Wolves and the Ecology of Fear: Can Predation Risk Structure Ecosystems? BioScience 54: 755-766.

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: aspen community, willow community, sagebrush community.

Recruitment – Growth of 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 for a wide range of aquatic and terrestrial biota.

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