

Ecosystem Services of the American Beaver: A Wetland Engineer



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**BUT FIRST,
AN INTRODUCTION TO THE BEAVER
AND ITS STATUS IN NEW MEXICO...**

North American Beaver (*Castor canadensis*)

- Rodent Family
 - Medium sized
 - adults 45 pounds
 - Body plan: chunky and short legged
 - slow movement on land
 - Teeth and digestive tract adapted for vegetarian diet



Diet

- Herbivore
 - Do not eat fish
 - Choosy generalist (only a few species make up bulk of diet)
- Seasonal shift
 - Summer—herbaceous
 - Herbaceous preferred in all seasons
 - Winter—woody
 - Inner bark of limbs
 - stored
- Inherent Problem
 - Plants have poor nutrition, so beaver must spent lots of time foraging, including on land
 - Makes beaver susceptible to predation



Vulnerable to Predation

Predators of Beaver

- Coyote**
- Wolf**
- Dog
- Black bear
- Brown bear
- Wolverine
- Mink (kits)
- Otter (kits)
- Bobcat
- Lynx
- Mt lion
- Golden eagle
- Humans

Pair coyotes prey on a beaver at
Mesilla Valley Bosque State Park, Las Cruces, NM



Friends of Mesilla Valley Bosque SP

Deep Water=Protection

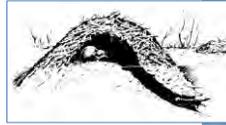
- Aquatic adaptations
 - Fusiform body
 - Water repellent fur
 - Webbed hindfeet
 - Sense organs high on head
 - Nose and ears seal to prevent entry of water
 - Clear eyelid to see under water
 - Large lungs
 - Flap prevents water from entering lungs when swimming with mouth open (carrying food)



http://www.art.com/products/p12598647117-sa-6373999/Aonrad_wothe_american_beaver_swimming_underwater_north_america.htm

How Deep Water Used

- “Deep” = ca > 3 ft
- Flee to deep water when alarmed
- Dens accessed by underwater entrance
 - Lodge--free standing
 - Lodge--on shore
 - Bank den—(no lodge)



<http://atowhee.wordpress.com/2009/10/17/more-malheur-then-homeward-bound/>



http://anecological.blogspot.com/2009_04_26_archive.html



Deep Water Habitats Used by Beaver

- Large waters
 - Types
 - Lakes
 - Reservoirs
 - Large rivers
 - Ecosystem services minor
 - primarily altered plant community
- Small streams
 - Ponds built by beaver
 - Ecosystem Services MAJOR and DIVERSE
 - Ecosystem Engineer & Keystone Species

Rio Grande, Bernalillo Co.

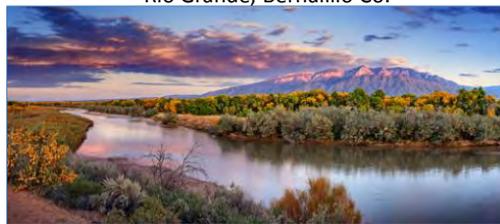


Photo Credit: Bill Tondreau

Willow Creek, San Miguel Co.



Photo Credit: James Stuart

The Beaver Pond

- Dam building
 - Stimulated by sound and feel of running water
- Dam material
 - Cut branches
 - Mud
 - Rocks
- Colony
 - Adult pair and offspring of 2 yrs
 - Usually have several ponds
- Maintenance
 - Continual
 - Multiple generations



Wildlife Conservation Society

Expansion of Beaver Ponded Area

- Dispersing offspring create new colonies
 - (if unmolested and adequate resources)
- Result
 - complex network of stair-stepped ponds occupying much of valley bottom



<http://www.mountwashington.org/forums/showthread.php?p=6433>-Exploring the Dickey-Notch Area (23-Oct-2010)

History of Beaver in New Mexico

Social-Political Context

- 1589-1821 (Spain)
 - 1589 Onate establishes first Spanish colony in NM
 - New Spain prohibited foreigners from entering territory
- 1803 Louisiana Purchase
- 1821
 - Mexico gains independence from Spain
 - Foreigners allowed in
 - Opens Santa Fe trail (commerce route to St. Louis)



Fur Industry

- 1820s-1840s beaver trapping heyday
 - Fashion: beaver felt hats
 - Opening of the West: Louisiana Purchase and Mexican independence



Beaver felt top hat



Fur Industry

- 1820's Rocky Mountain trapping system
 - Beaver was fur of choice (ca \$6/pound)
 - Valuable, light weight, and easily transportable
 - Kinds of trappers
 - "Engages" (supplied/salaried by fur company)
 - Usually worked in large brigades of 40-60 people
 - "Free-trapper" mountain men
 - Usually worked in small groups
- Fierce competition to find and exploit un-trapped streams



Mountain Man

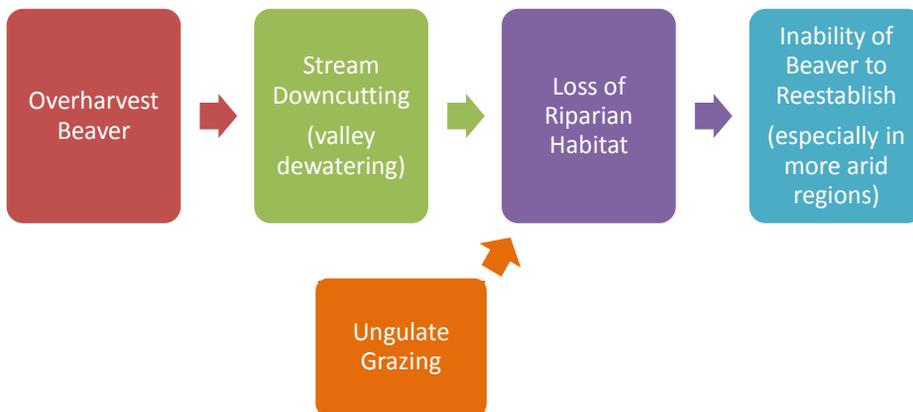
Examples

- Taos was trapping supply headquarters
- 1824 James Pattie party
 - Over ca 2 months trapped Gila & San Francisco rivers
 - Some areas already depleted by prior trappers
 - > 500 skins (250 on San Francisco in 2 weeks)
- 1830 Kit Carson brigade
 - Took 2000 pounds (=ca 3000 pelts) of beaver skin from Colorado River Arizona and Gila River New Mexico



Kit Carson home; Taos

Demise of Beaver



Beaver Status in New Mexico

- Pre-1800
 - all perennial waters
 - Population: 62,500 - 281,400 (Wild 2011)
- 1897 season closed; 1912 damage permits
- Bailey (1931), Ligon (1931)
 - Many areas entirely unoccupied
 - Call for restoration & more stringent laws
- 1932-1953 NMDGF transplant 630 nuisance beavers
- 1953 reopened beaver season
- Huey (1956)
 - only comprehensive assessment
 - 7,954 beaver (mostly in north)
- NMDGF (1967): 5,500-6,000 beaver
- NMDGF (2006): 5,254-11,676 beaver



Today:
 Many stream reaches lack beaver, and
 hence lack wetlands and provide few
 ecosystem services



Rio de las Vacas, Sandoval County

Synopsis of Ecosystem Services Provided by Dam-building Beaver

For references and more detail.....



Overview of Impacts

- Abiotic
 - Hydrology
 - Biogeochemical processes
 - Geomorphology
- Biotic
 - Plants
 - Animals



<http://earthjustice.org/sites/default/files/feature/2013/09/beaver-400a.jpg>

ABIOTIC ENVIRONMENT

Abiotic Environment

HYDROLOGY

Abiotic: Hydrology

- Altered Surface Water Flow Pattern
 - Ponds increase water volume & surface area
 - Increases water retention time (i.e., transient storage)
 - Allows more time for critical biogeochemical cycles that influence stream ecosystem



Abiotic: Hydrology

- Reduced stream energy
 - Controls flooding
 - Moderates high stream flow
 - Stream energy dissipated by ponds, dams, and riparian shrubs
 - Series of dams better than 1
 - Reduces loss of water to runoff
 - Retains debris that otherwise could cause downstream damage



Abiotic: Hydrology

- Altered Ground Water Flow
 - Increase recharge and retention
 - Sediments trap, hold, and slowly water
 - Promotes perennial flow
 - Enhance water table, especially in summer
 - Can cause INCREASE in stream flow during low-flow period
 - Promote more consistent and higher flow
 - Intermittent streams can become perennial with beaver



Abiotic Environment

GEOMORPHOLOGY

Abiotic: Geomorphology

- Beaver ponds control erosion
 - Reduce water velocity
 - Still water, riparian plants, and overbank flooding causes deposition of sediments (i.e., aggradation)
 - Can raise stream bed, which promotes larger riparian area



FIGURE 2. Strawberry River, August 2002. Eroding banks occur on 60-70% of stream length. Bank heights locally exceed 5 feet. The present active floodplain is at an elevation 3 or more feet lower than the high banks (USDA 2004).



FIGURE 3. Strawberry River Reach 30, October 2003. Beaver dam has raised water level to within 6-12 inches of 1938 water level. Wetted width has been expanded from 88 to 300 feet. Potential riparian area is expanded by 3-5 acres adjacent to the pond (USDA 2004).

Abiotic: Geomorphology

- Long-term aggradation in stream valleys
 - Beaver dams create and maintain low-gradient valley floors
 - Without beavers, streams may down-cut and altered hydrology dewater valley floor (can lose riparian system)



<http://twomomshohikeinalaska.files.wordpress.com/2011/07/eedlakesarearearcabin.jpg>



http://wildnews.cleanwebdesign.com/wp-content/uploads/2012/04/Pass_Creek_allotment_11_12_08-2.jpg

Abiotic Environment

BIOGEOCHEMICAL PROCESSES

Energy Flow

- Beaver alter energy flow pattern of stream
 - Organic matter (energy) accumulates in beaver ponds
- Beaver ponds function to retain energy in the system rather than exporting it downstream



<http://www.markpicard.com/portfolio/mammals/>

Nutrient Cycling

- Beaver ponds are focal points of nutrient cycling processes
- Beaver ponds are long-term storage areas for usable nitrogen
 - Bacteria in pond sediments convert nitrogen to useable forms
 - Streams lacking beaver lose nitrogen downstream
 - Nitrogen becomes most available to plants and animals when sediments exposed and pond converts to beaver meadow.



<http://www.flickr.com/photos/mouser-nerdbot/4717054349/sizes/m/in/photostream/>

Suspended Sediments

- Sediments = nonpoint source water pollution
 - Enter water through erosion processes
 - Turbidity: inhibits plant growth, clogs gills, entomb eggs, etc.
- Beaver dams improve water quality through aggradation of sediments



<http://www.nmenv.state.nm.us/swqb/SanJuan/description.html>

Water Purification

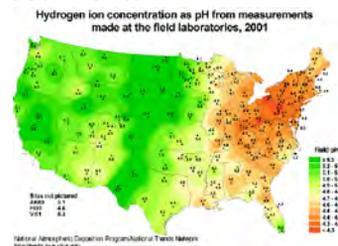
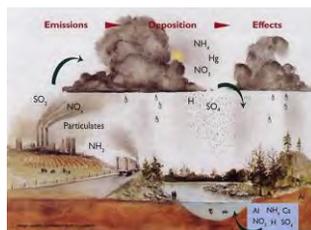
- Beaver ponds can clean water of pollution, excess nutrients, toxins, and bacteria
 - Pollutants attach to sediment particles which are removed from water as they accumulate in pond bottom
 - Purification capacity of stream with beaver is 10x stream without beaver



http://sustwatergmt.wikia.com/wiki/Livestock_Water_Management?file=Water_livestock.jpg

Acid Neutralization

- Acid Precipitation
 - Due to sulfur and nitrogen emissions from burning fossil fuels
 - Kills aquatic species, reducing diversity
- Stream waters are made less acidic after passing through beaver pond
 - Due to chemical reactions in sediments



BIOTIC ENVIRONMENT

Increase Wetland Zone

- In arid regions, shrubs at water edge expand outward 30-40 ft
- Productivity/pasturage can increase 25x-50x



Altered forest composition and succession

- Beaver cut trees
 - Increases openings in forested areas
 - Promotes growth of shade intolerant/early successional plants (e.g., willows, alders, grasses, forbs)



<http://www.methowconservancy.org/enews0810.html>



<http://www.sticksite.com/blog-2006/beavermess.jpg>

Pond Succession

- New pond
 - Cut and flood-killed trees create more open habitat; water table enhanced
 - Stimulates growth of riparian shrubs and herbaceous plants
- Aging pond
 - Shallows as fills with silt
- “Beaver Meadow”
 - Productive wet meadow
 - Slowly encroached by shrubs, then trees



Photo credit: Paul Kirtley



<http://www.commonweeder.com/2009/09/12/life-will-not-be-denied/>

http://meemointains.blogspot.com/2010_07_1_archive.html

Plant Diversity

- Maintain populations rare wetland plants
- Beaver ponds have higher plant diversity (e.g., 33% more) than streams without beaver
- Beaver negatively impact invasive salt cedar



Willow Mutualism

- Both species benefit from interaction
- Willow Benefits to Beaver
 - Primary food source
 - Building material
- Beaver Benefits to Willow
 - Beaver ponds promote willow growth
 - Willows more tolerant of flooding than other species
 - Willows are shade intolerant
 - Increased wetted area and ground water table (promote germination and seedling survival)
 - Sediments have enhanced nutrients



Willow Mutualism

- Beaver cutting promotes willow growth
 - When willow cut, responds by burst of growth in both numbers of stems and rate of elongation
- In natural conditions, beaver and willow can coexist indefinitely
- Ungulate browsing can disrupt the mutualism
 - Beaver primarily browse willow in fall when dormant
 - Ungulates primarily browse willows in growing season which inhibits subsequent growth
 - Results in feedback mechanism of loss of willow and loss of beaver



Colorado St. Univ. experimental plot Yellowstone northern range—willow need beaver to outgrow elk

Biotic: Aquatic Animals

- Invertebrates
 - Pond sediments increase diversity, density and biomass
- Fish
 - Beaver ponds enhance production in coldwater streams
 - More fish; larger size
 - Spawning habitat; habitat juveniles during low flow
 - Dams hinder Fall spawning non-native trout



<http://coloradomountainfishing.com/forum/MGalleryItem.php?id=1366>

Biotic: Aquatic Animals

- Amphibians and Reptiles
 - Beaver ponds are crucial for reproduction in some frogs
 - Beaver ponds promote higher diversity of herps



Chiricahua leopard frog-USFWS

Biotic: Terrestrial Animals

- Invertebrates
 - Endangered species of butterfly associated with beaver wetlands
- Birds
 - Higher abundance and diversity of birds at sites with beaver
 - Create habitat for scrub-shrub dependent birds (e.g., willow flycatcher, Bells vireo)
 - Increased waterfowl production



satyr butterfly



SW willow flycatcher-USFWS



Bell's vireo—Cornell Lab



Cinnamon teal

Biotic: Terrestrial Animals

- Large Mammals
 - Beaver ponds are key habitat for other semi-aquatic mammals (otter, mink, muskrat)
 - Otter & beaver are commensal; allows otter to occur on smaller streams
 - Alhambra Creek, Martinez CA– beaver colonized in 2006, steelhead & otter appeared in 2008, mink appeared in 2009; tule perch in 2010
 - Beaver create food and drinking water for large mammals (e.g., raccoon, bear, deer, elk, moose)
 - Are prey to carnivores



Photo credit: James Stuart



Biotic: Terrestrial Animals

- Small Mammals
 - Higher density and diversity of small mammals
 - drives higher density and diversity of carnivorous birds, reptiles, and mammals
 - Create ideal habitat for New Mexico meadow jumping mouse
 - Riparian wetland obligate
 - Will be proposed for ESA listing this spring



Spotted owl with vole



NM Meadow Jumping Mouse

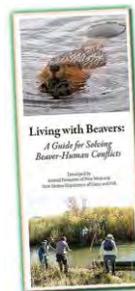
Conclusions

- Beaver can restore and maintain aquatic and riparian ecosystem functioning and resilience
- Problem: Current distribution and abundance of beaver in NM is much less than historical
- Solution: Beaver Restoration



Research Needs

- Understand, mitigate, and manage human conflicts and use
 - Current
 - Nuisance control: implemented by APNM, NMDGF, APHIS-WS, others
 - Harvest: regulated by NMDGF
 - APHIS-WS National Wildlife Research Center
 - Non-lethal control and ecology
 - Frey & Small will address some aspects of potential conflicts
 - Much more research needed



Research Needs

- **Current Distribution**
 - Need comprehensive study
- **Potential Distribution**
 - Model of potential beaver distribution (WildEarth Guardians)
- **Habitat Limitations**
 - Model of habitat requirements necessary for stream to support dam-building beaver (Frey & Small)
 - Thresholds for summer and winter food, and dam building material
 - Influence of ungulate competitors
 - Influence of sources of human conflict (irrigation, proximity)



Rio Tusas, Rio Arriba County



Rio San Antonio, Sandoval County



Beaver pond on Coyote Creek, Colfax County, NM
Home to endangered meadow jumping mouse