The articles have been organized into three categories, (1) Beaver Captive Habitat Preferences, (2) Beaver Release Location selection, (3) Both Captive Habitat and Release Location Selection. This is to help narrow down which articles are most relevant for creating captive environments for beavers or for selecting locations to release beavers back into the wild.

Beaver Captive Habitat Preferences:

Secondary Article:

Campbell-Palmer, R., & Rosell, F. (2015). Captive care and welfare considerations for beavers. *Zoo Biology*, *34*(2), 101–109. https://doi.org/10.1002/zoo.21200

Article Summary:

Beavers require very complex habitats in the wild and are therefore, very difficult to care for in captivity. The objective of this review article is to identify captive beaver care requirements, discuss husbandry and wellness, all relative to studies of wild beavers. The focus is on Eurasian beavers however, North American beavers are noted as being very similar, such that most of what is discussed still applies. The review breaks down the many factors of captive care for beavers into several sections relating to physical, social, and behavioral health, as well as sections relating to captive specific factors (e.g., tagging).

Beavers were shown to have very strong social connections, where separating minorly injured beavers from their family can result in death from stress. Beavers were also shown to not do well alone or do well with non-family members due to conflict. Keeping in mind juvenile dispersal occurs as soon as 20 months from which point, they should be separated from their original family group. Beavers were also described as generalist herbivores, having seasonal variation, feeding on a range of herbaceous, woody, terrestrial, emergent, and aquatic plants. Due to this the article stressed the dietary requirements of beavers including adding sufficient browse (i.e. twigs, saplings) to the diet to increase fibre and encourage a variety of natural behaviours. Wild beaver habitat construction behaviours were discussed including lodge maintenance, which can be a complicated behaviour to accommodate in captivity. The need for proper enclosure design was stressed with specifics like natural lodge temperature ranges (0-28^{o}C), substrate for burrowing, and access to deep fresh water (>1m) being important for many natural behaviours. Overall, the article does a great job of summarizing key captive care topics to ensure that captive beavers can exhibit natural behaviours, low stress, good health, and other important factors.

Article Contribution:

This article reviews many factors that are important for the captive care of beavers especially relating to mimicking the natural needs of the animal. Despite the low number of articles about beaver captive care, the article manages to accumulate a large amount of vital information and present it in a way that is needed for organizations to care for beavers in captivity. It is also important for the captive care of beavers with the purpose of releasing them, as it provides key information for keeping the animals healthy and in conditions close to nature assuring a more seamless release.

Primary Article:

Wang, G., McClintic, L. F., & Taylor, J. D. (2019). Habitat selection by American beaver at multiple spatial scales. *Animal Biotelemetry*, *7*(1), 10. https://doi.org/10.1186/s40317-019-0172-8

Article Summary:

Beavers require both aquatic and terrestrial habitats making it difficult to determine which habitat requirements are the most important to them when selecting a home. This article investigated which location type(s) North American beavers prefer on the second order (home range) and on the third order (within home range) scales. Wang et al. (2019) aimed to determine how food resource availability and how water bodies influenced second order habitat selection and how this compared to third order selection. To explore this, 21 beavers were monitored and their location was recorded every two weeks from May 2011 to April 2012. Only beavers with 30+ recorded locations were used. For the second order analysis locations were divided into twelve categories for the third order analysis they incorporated a total of 30 landscape variables.

Two different preexisting modeling methods were used to evaluate second and third order habitat selection. Both models were selected because they do not use pseudo-absence location data (randomly selected locations assigned to have absence of beavers due to lack of true absence data). The analysis found that second order habitat selection was not random and herbaceous wetlands were selected 3-4 times more than all other types (95% confidence Interval). Shrub, grassland, hardwood forest, and woody wetland fell into the 95% CI, but with a much lower preference index. Pastures, developed, agriculture, coniferous forest, and mixed forest were not preferred. The third order habitat selection intensity was not random and positively related to shrub and woody wetland edge distance, distance to crop field, and proportion of herbaceous wetland (95% CI). These results may suggest that when selecting a home range location, the area's available food resources (e.g., herbaceous wetlands) are more important for beavers than the areas water body, and same was found for within home range selection.

Article Contribution:

This article is important because it gives insight into beaver habitat preferences which are important for captive beaver care. The article suggests that beavers will prefer locations with herbaceous wetlands over areas with better open water habitats. Contrary to previous understandings that beavers would show preference for areas based on the water bodies present. This helps in designing better captive environments for beavers as less emphasis should be paid to the water body design/type and more focus put on the types of food resources that are growing nearby to keep the beavers happy with their new environment.

Beaver Release Location selection:

Secondary Article:

Johnson, C.A. (2012). Beaver Wetlands. In Batzer, D.P., Baldwin, A.H., and Baldwin, A. (Eds.), *Wetland Habitats of North America: Ecology and Conservation Concerns* (pp. 286-305). University of California Press.

Article Summary:

Beavers are ecosystem engineers who create and care for the many wetlands present in nature. Their impacts on these systems are numerous and at times very complex. This article reviews research about the impacts that beaver habitat building behaviour has on the environment. The objective of the article is to describe the negative and positive impacts that beaver-altered environments can have for environmental processes, humans, and other species. This is done by categorizing impacts of beavers into environmental impacts (e.g., how they impact geology) and impacts on plants and animals. The beaver's impact on the environment was largely positive, increasing sedimentation, reducing erosion, creating wetland areas, and changing the chemical composition of the water. However, indirect negative impacts were also observed including flooding from dam breaches and buildup of undesirable chemicals in the water (e.g., toxins).

Beavers were shown to have positive relationships with many plant and animal species by creating beaver meadows and ponds, adding to the heterogeneity of the landscape. This increases diversity for plants, especially herbaceous plants, which further leads to increased animal diversity. These beaver-created areas can however have indirect negatives on some plant and animal species as they provide ample conditions for invasive species to thrive. However, now that beavers have recovered in many areas they can become pests, flooding properties, destroying trees, and becoming invasive species themselves. Regardless, the author shows that beavers are an important part of wetland ecology and have been for thousands of years, their habitat building altering up to 15% of an area turning it into a much more fertile landscape. This article does a good overall job of showing which ecological factors result from beaver habitat building behaviour and how their introduction/decline can impact an ecosystem.

Article Contribution:

This article provides a condensed review of articles relating to the implications that beaver habitat building behaviour can have on the ecosystem. This includes how they change landscapes and what this means for the areas where beavers are present/absent, which is important to consider when releasing beavers into a new area. Before releasing beavers these many implications can be accessed to ensure that a new location can stand to benefit from the beaver's positive impact, and that their introduction will not damage other species in the area inadvertently.

Primary Article:

Scrafford, M. A., Nobert, B. R., & Boyce, M. S. (2020). Beaver (*Castor canadensis*) use of borrow pits in an industrial landscape in northwestern Alberta. *Journal of Environmental Management*, *269*, 110800. https://doi.org/10.1016/j.jenvman.2020.110800

Article Summary:

Alberta's boreal forests contain approximately 65,000 borrow pits (large often water-filled abandoned excavation holes) left from industrial digging. Beavers have been noted to inhabit these pits frequently and Scrafford et al. (2020) set out to model habitat associated beaver activity at borrow pits. Specifically, to investigate differences between pits with beaver lodges from pits with other beaver-activity. Of 1455 borrow pits in the boreal forests near Rainbow Lake, Alberta they randomly selected 90 for analysis. Each pit was categorized as active lodge and food storage, inactive lodge, beaver cutting, or no beaver use. They found beaver activity at 64% of the random borrow pits sampled. Pits with active beaver lodges had significantly different features from other beaver-activity categories. The proximity of borrow pits to streams, marshes, and swamps were the most consistent habitat features for pits supporting active colonies.

This has implications for wildlife management because if 64% of burrow pits contain beaver colonies then just in Rainbow Lake area there are some 1048–1571 beavers living in borrow pits. This suggests that borrow pits increase beaver populations by creating suitable habitats in areas that were not formerly occupied by beavers, markedly increasing beaver populations above their natural carrying capacity. These findings are also important because they suggest factors that can impact this increase like beavers prefer habitats that are close to streams, marshes, and swamps over other locations. Wildlife managers can use this model to control the population of beavers in borrow pits by either increasing or reducing the borrow-pit suitability. Reducing suitability can be achieved by removing vegetation around borrow pits, isolating new pits from natural wetlands, and filling in pits with substrate. The authors further suggest that long term research be conducted on borrow pits to more fully assess factors that promote long-term use by beavers.

Article Contribution:

This article suggests habitat features that are preferred by beavers, specifically in relation to borrow pits. It also suggests that these borrow pits provide increased ideal conditions for beavers that can increase the natural carrying capacity for beavers in an area. This is important when considering releasing beavers into areas with borrow pits as their presence in these areas will increase the beaver population of the area. This increase can be negative such as flooding roads, or positive by providing more food for struggling wolverine and wolf populations. Therefore, this article should be considered before releasing beavers into these areas.

Primary Article:

Scrafford, M. A., Tyers, D. B., Patten, D. T., & Sowell, B. F. (2018). Beaver habitat selection for 24 yr since reintroduction north of Yellowstone National Park. *Rangeland Ecology & Management*, *71*(2), 266–273. https://doi.org/10.1016/j.rama.2017.12.001

Article Summary:

Beavers disappeared north of Yellowstone Park in the 1950s due to a variety of factors, especially trapping and overgrazing of willows by moose. In 1986 they were reintroduced, and yearly inventories were taken of the population until 2010. The objective of the article was to evaluate the success of the beaver reintroduction and ability of a recovering willow community to support a population of reintroduced beaver. The study took place in the north boundary of Yellowstone National Park based on annual beaver structure inventories from 1986-2010.This inventory was used to calculate the annual activity of colonies and the annual density of active-beaver colonies was used to estimate population growth. The quantity of willow cover was estimated using aerial photography (1981 and 2010) as well as field surveys in 2010. Several variables were measured relative to specific beaver-colony locations. willow cover and height, stream depth and sinuosity, distance to secondary channel, stream width, and sandbar width.

Following reintroduction as the beaver population increased and the moose population decreased the willow cover increased from 32% in 1981 to 48% in 2011. This increase in willow was sustainable for the beavers even at carrying capacity was reached in 2000. They found that beaver colonies that settled soon after reintroduction had greater longevity than colonies settled later, which was suggested to be due to beavers first colonizing high-quality habitats. These long-lived beaver colonies were more likely to be located on or near secondary channels and were also associated with sinuous stream reaches. These findings showed that beavers can successfully be reintroduced into environments with sub-optimal food conditions but promising site-potential. These findings are important as they suggest that sinuous streams reaches and deep water on secondary channels may be important to the survival of reintroduced beavers before they can build dams.

Article Contribution:

This article is important because it shows other factors aside from food availability that are also important considerations for beaver reintroduction. The article shows how water body characteristics such as secondary channels and sinuosity can help support new beaver colonies even if the food availability is low but recovering. It also demonstrates that beavers can help aid recovery of certain species of vegetation despite expanding themselves. These findings should be considered before releasing beavers into previously uninhabited areas to assess the suitability of these reintroduction locations for long term beaver success.

Both Captive Habitat and Release Location Selection:

Primary Article:

Barela, I. A., & Frey, J. K. (2016). Habitat and forage selection by the American beaver (*Castor canadensis*) on a regulated river in the Chihuahuan Desert. *The Southwestern Naturalist*, *61*(4), 286–293. https://doi.org/10.1894/0038-4909-61.4.286

Article Summary:

Beavers consume large varieties of plant species but only a few make up the bulk of their diet, preferring herbaceous plants but also able to survive on woody plants. The article's objective was to determine how beavers select habitat and food during the winter in arid environments (New Mexico). The authors selected sites based on Google Earth imaging in areas with consistent water in the Chihuahuan Desert during winters of 2014-2015. Sites without evidence of beavers were declared beaver absent. For the 18 absent and 18 beaver present sites all cut plant species were recorded and listed as food, since no dams (one exception) were built in the study area. The overall vegetation characteristics of each site was measured using 32 plots to sample the vegetation along the shoreline and inland. The pool width for all 36 sites was also estimated.

Sites with beavers were found to have significantly wider pools, significantly more sedges, significantly more willow, and all woody species combined, and had greater woody stem richness than sites with water but lacking beavers. The study also found that beavers strongly selected cottonwood and Russian olive, weakly selected willow, and used mule-fat, screwbean mesquite, saltcedar, and broadleaf cattail less frequently than were available. The beavers did not cut skunkbush sumac or fourwing saltbush. Beavers were absent from 44.4% of sites where water was present, suggesting that water alone does not define a beaver's habitat. The findings demonstrate that beavers prefer areas with larger pools, more woody plants, more sedge and a greater abundance of willows and all species of woody plants. This means that beavers have strong preference for cottonwoods (*Populus*) and then willows when selecting an area. However, in areas with harsher winters beavers may be more dependent on willows.

Article Contribution:

This article provides further insight into beaver food and habitat selection specifically for arid environments. It concludes similarly to other researchers that *Populus* and willow are preferred food sources for beavers, only differing by finding *Populus* to be the preferred food over willow, likely due to differences in climate. It also further demonstrates that water bodies alone are not what determines beaver inhabitance at a site. The article is helpful in constructing a captive environment for beavers and determining ideal locations for release by demonstrating which types of food and which water characteristics are preferred by beavers.

Primary Article:

Gerwing, T. G., Johnson, C. J., & Alström-Rapaport, C. (2013). Factors influencing forage selection by the North American beaver (*Castor canadensis*). *Mammalian Biology*, *78*(2), 79–86. https://doi.org/10.1016/j.mambio.2012.07.157

Article Summary:

Beavers are central place foragers that harvest trees and bring them back to their central place (lodge) to use or consume. Beavers must select a central place with the appropriate necessities nearby in order to thrive. Gerwing et al. (2013) set out to investigate the effect that forage species, distance of forage from water, forage density, and site had on beaver foraging selection, and determine if these factors could be arranged hierarchically. The authors selected eight sites across central BC and used linear transects to describe the woody vegetation at each site. Each transect extended 50m perpendicular to the water's edge and all woody species were identified, the distance to water measured, and the number of plants cut were recorded.

On the fine-scale they observed that three species of *Salix* were actively selected for while 1 species was avoided and 5 more were neutral. This is in agreeance with other findings that beavers are picky generalists, preferring specific species but able to use many. On the medium-scale plant density had little influence on foraging behaviour while foraging intensity declined sharply after 25m from the water, although this was not significant. On the large-scale they found a significant difference in the probability that a stem would be cut among sites. This is supported by other studies that found that presence and cover of plants on the river bank, river flow speed, river width, bank slope, elevation, type of water body, water depth, and bank substrate all significantly influenced the activity of beavers. These findings are important as they suggests that large-scale factors are of primary importance, while medium-scale factors are influenced by a forage item's distance from water, and at the fine-scale plant species is a tertiary consideration. These findings can help to model the large scale distribution of beavers.

Article Contribution:

This article is important as is demonstrates that beaver foraging selection is based on a hierarchal set of variables. In this hierarchy large-scale factors like river bank slope have the largest impact on beaver selection while medium-scale factors like plant distance from water have a lesser impact on habitat selection. Fine-scale factors such as plant species had an even smaller importance on beaver foraging selection. These findings are important when creating captive beaver habitats or when considering locations for beaver release, as this article should be considered to ensure that the major foraging preferences are met on all scales.

Primary Article:

John, F., Baker, S., & Kostkan, V. (2010). Habitat selection of an expanding beaver (*Castor fiber*) population in central and upper Morava River basin. *European Journal of Wildlife Research*, *56*(4), 663–671. https://doi.org/10.1007/s10344-009-0361-5

Article Summary:

Background: Not much research is available for long term beaver habitat selection and less still in ideal habitat selection, just that of which habitats are suitable or not suitable for beavers. The objective of the article was to examine habitat selection by European beavers during colonization of previously unoccupied areas. The study took place in the Czech Republic during initial beaver reintroduction in 1991, until reaching carrying capacity in 2007. River channels were subdivided into 500m long sections and beaver inhabitancy was recorded every winter. Habitat variables includes 2 vegetation, and 7 physical variables that were assessed using Geographic Information System (GIS). Willow was noted as the main food source and most prominent plant species in the study area.

The beavers distributed in a spatially discontinuous dispersal pattern, where distant sites were colonized before close-by sites. In the early stages of the study, locations with wide river channels with a high-percentage canopy cover of willow were selected significantly more than random use. In the later part of the study beavers were more likely to select channels with a higher gradient, smaller watershed, and at a shorter distance to roads, railways, and urbanized areas. Beavers establish colonies in optimal habitat first before occupying suboptimal locations, with the power of the variables changing over time. These findings are significant because they show that beavers seek out optimal habits (areas rich in willow) when first introduced to an area, ignoring close by willow poor sites. During later phases of colonization, the optimal sites serve as sources for new colonies. Once optimal sites are colonized beavers then begin to colonize heavily human altered sites and suboptimal/marginal habitat.

Article Contribution:

Although the study focuses on European beavers this species is very similar to North American beavers and thus is still relevant to them. This paper is important as it outlines information on what an optimal habitat looks like for beavers over time, relating to their population density. It helps to select appropriate release sites based on existing nearby beaver density and based on the optimal conditions available. The article is also important for captive environment construction as it further shows what an optimal environment looks like for beavers.

Primary Article:

Raffel, T. R., Smith, N., Cortright, C., & Gatz, A. J. (2009). Central place foraging by beavers (*Castor canadensis*) in a complex lake habitat. *The American Midland Naturalist*, *162*(1), 62–73. https://doi.org/10.1674/0003-0031-162.1.62

Article Summary:

Beavers are central place foragers and previous models predict that beavers should become more selective of species and select larger trees the further they get from the central place. The objective of Raffel et al. (2009) was to investigate if beavers become more selective for size and species of tree as they foraged further from the lodge, both in terms of distance on land from the shore and distance through the water from the lodge. Secondly, they investigated whether beavers selected larger trees when either shore distance or lodge distance increased. The study took place in Ohio between May and July 2000. Sites were between 16-60 m wide, and all trees >1 cm in diameter were measured as far back as the last cut tree (20-30m from shore). They recorded the species, distance from shore, status (cut or uncut) and diameter of each tree. They then used a logistic regression model to test whether selectivity for preferred tree species or sizes changed with increasing distance from the lodge or from the shore. Tree species were then categorized as consistently preferred, neutral or avoided

Tree preferences varied significantly depending on the distance from the lodge or shore with preferred trees being selected significantly more at farther distances. Beavers also significantly cut less trees the further from shore or the lodge they were. Overall beavers preferred intermediate-sized trees (diameters 2.0-6.9cm) and were neutral to trees up to 9.9cm in diameter, avoiding trees under 2.0cm and larger than 9.9cm. These findings are important because they confirm other studies that found that beavers have higher selectivity both in size and species the further, they are from shore or the lodge, and they showed that beavers select intermediate sized trees clearing up previous conflicting studies suggesting large or small tree preferences.

Article Contribution:

This article is important because it sheds clarification into beaver foraging selection with relation to distance from shore or the lodge. They also show that aside from species and distance away beavers also show preference for specific sizes of tree. The study also sheds further light into preferred tree species, especially showing preferences when other known preferred species like aspen are absent. These findings are extremely useful when designing a captive beaver habitat and when selecting sites for release as they help design/select habitats with ideal foods both in relation to the species, size, and the distance from the lodge/shore.

Primary Article:

Salandre, J. A., Beil, R., Loehr, J. A., & Sundell, J. (2017). Foraging decisions of North American beaver (*Castor canadensis*) are shaped by energy constraints and predation risk. *Mammal Research*, *62*(3), 229–239. https://doi.org/10.1007/s13364-017-0312-6

Article Summary:

Most prey species will avoid areas with high predation risk and prey can assess these risks through chemical tracers left by predators. The aim of this study was to assess the effects of predation risk and energetic constraints on the foraging behavior of beavers. The study took place in Southern Finland, where six sites were analyzed over 20 days. Observationally the beavers' foraging behavior was studied by investigating the foraging distance from the shoreline of different sizes and species of tree. Secondly aspen sticks (preferred food) were experimentally placed at different distances from the shore in sites treated with control (water or vinegar) or wolf urine. Of note wolves are rare in this location which may affect responses.

The observational study found that aspen, downy birch, and speckled alder were the preferred tree species. More of these species were cut close to the shore (13-19m), and cut trees were smaller with increasing distance from the water, except for the energetically valuable aspen (cut >20m away) like previous studies. The experimental study found no strong evidence for predatory odors strongly affecting the distance from shore that sticks were taken. There was also no strong statistical difference between the effect of wolf urine and the effect of vinegar on foraging. Beavers did however bring all food back to the shoreline before consuming it despite the energy costs, presumably to increase safety while eating. The results of the present study may suggest that beavers use their sense of smell to assess the risk of predation when foraging. However, it seems that energetics plays a larger role in foraging than predation risk, as foraging farther away and selecting larger trees at distance are very costly. Suggesting that beavers would prefer locations with food species close to the water (<20m).

Article Contribution:

This article provides further insight into beaver foraging behaviours and how they may select habitats. It shows that beavers prefer to forage as close to the shore as possible, possibly to reduce the energy expenditure, and possibly predation risk. This is important to consider when selecting a location for releasing beavers or when constructing a habitat, since beavers will prefer locations with ample food supplies close to the water (<20m away). The article also provides more confirmation about preferred species of food (e.g., aspen) which is also important to consider for release locations and captive habitat construction.