Annotated Bibliography on the Ecology and Management of Invasive Species: Eastern Cottontail (*Sylvilagus floridanus*)

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Althoff, D. P., G. L. Storm and D. R. Dewalle. 1997. Daytime habitat selection by cottontails in central Pennsylvania. Journal of Wildlife Management 61 (2): 450-458.

Authors' abstract: Information on behavioral responses of wildlife to habitat alterations is needed to allow restoration and maintenance of suitable habitats for a variety of vertebrate species. We studied the use by radiotagged eastern cottontail rabbits (*Sylvilagus floridanus*) of habitats within a terrestrial ecosystem scheduled to be used for disposing secondarily-treated effluent (domestic wastewater) in central Pennsylvania. Cottontails selected old-fields and shrublands for daytime use, but croplands were used when oats and corn matured during summer and fall. Aboveground bedding sites (forms) were associated with relatively dense cover, indicating that cottontails recognized variations in microhabitat within habitat types. Females frequently used underground burrows when air temperature was less than 0 C, whereas males seldom use burrows except when air temperature was less than -5 C during winter. Cottontails encountered a wide range of microclimates at forms. Air temperature, net radiation, and wind speed extremes were -7.1 to 38 C, -21 to 70 W/m-2, and 0.0 to 11.3 cm/sec. Air temperature, net radiation, and wind speed were greater at open sites than those at forms used by cottontails during each season. Cottontails selected micro-environments in which the insulating effect of dense cover may allow conservation of metabolic energy or reduction of heat loss. Provision of dense herbaceous and shrub cover is essential to management of cottontail habitat because it allows the animal to maintain a positive energy balance as well as avoid predators. Typically, cottontails occupied a form from sunrise to sunset. Thus, the structure of vegetation associated with forms may be a key indicator of suitable cottontail habitat. Shrub-woodland habitat appeared to be especially important to cottontails during late winter and early spring because of increased cover associated with

early leaf-out of shrubs.

Banfield, A. W. F. 1974. The mammals of Canada. University of Toronto, Toronto, ON.

This comprehensive field guide provides detailed identification and life history information based on Canadian populations of eastern cottontails. Banfield provides useful background on the ecology of eastern cottontails which is necessary for understanding management of the species in Garry oak ecosystems. The dated range map does not show the introduced population on Vancouver Island. Eastern cottontails are described as small buff coloured rabbits with short hind feed and ears. The rump and flanks are grey and black and there is a red-brown patch between the shoulders and ears. The cottony tail is brown on top and white underneath. Cottontails measure 446 mm in length and weigh between 1.1 and 1.2 kg. Eastern cottontails are active in the evening and night and spend most of the day under cover in thickets or hollows. Home ranges are approximately 8 acres but vary with the habitat. Cottontails are not dormant during the winter. Summer diet consists of herbs and grasses. Winter diet includes the bark, twigs and buds of woody plants including the following native species which may occur in Garry oak ecosystems: oak, hawthorn, wild apple, mountain ash, red-osier dogwood, roses, snowberry, service berry and wild cherry. In Garry oak ecosystems, adult cottontails may be preyed on by hawks, owls, cats, dogs and humans. Juveniles may be preyed on by snakes and crows. Average life expectancy is 6 months. Cottontail habitat is described as "meadows, orchards, and fence rows and in weedy and shrubby areas and on the borders of woodlots". Reproductive details include gestation (26-32 days), nest structure (grass lined hollow hidden by tall grasses or shrubs), litter size (2-7), weaning age (16-22 days) and dispersal age of the young (7 weeks). Cottontails mate soon after a litter is born and can have 3 or more litters per year. Cottontail damage includes girdling trees, grazing plants and acting as a vector for parasites and diseases including Tularaemia which can infect humans. Barriers around target plants are usually an effective control method. The native distribution of cottontails ranges through eastern and central North America. Although there may have been historical native populations of cottontails in Canada, they were not present when early settlers arrived. The range naturally expanded into Ontario between 1867 and 1870.

Barnes, T. G. 1990. For-27, Kentucky Christmas tree production workbook: Pest control - animals. Website: www.ca.uky.edu/agc/pubs/for/for27/for27.htm Accessed: November 13, 2002.

This site is maintained by the University of Kentucky, College of Agriculture. The site describes how to identify damage caused by rabbits in Christmas tree plantations. The site also covers basic life history and a range of control options, many of which may be useful in Garry oak ecosystems. No references are provided for the information provided. The general description and reproductive biology of eastern cottontails is as described in other references. Cottontail damage in Christmas tree plantations includes tree girdling and browsing of buds and twigs. Rabbits usually leave tooth marks on remaining bark and cut twigs at a clean 45º angle. Tracks and droppings also help identify rabbit damage.

Hunting is recommended as the best long-term solution for controlling rabbits although other authors have suggested that adjacent populations will readily repopulate an area. In Kentucky, hunters may pay to be able to hunt rabbits in plantations. In plantations, habitat can be modified by removing all grass and weeds from between the trees by tilling or herbicide. This is not appropriate for Garry oak ecosystems although other types of habitat modification may be effective. Providing raptor perches helps control cottontails and the site provides directions for perch construction. Barriers (guard tubes, netting, fencing) placed around trees will prevent browse but this may be expensive. Deer fences can be made rabbit proof by placing a 2 foot strip of ¼ inch mesh along the bottom of the fence. At least 6 inches of the fence should be buried. Live traps will reduce cottontail numbers and are most effective when covered with dark cloth. Although the site mentions snap traps, these traps should not be used in Garry oak ecosystems since they may trap non-target species. Cottontails are not controlled by frightening devices. Chemical repellents applied directly to plants or to a general area will decrease but not eliminate cottontail damage. Repellents can be very expensive when used on a large scale. Repellents can contain bone tar oil, egg solids, ammonium soaps or capiscin. The site also discusses the use of pesticides for control of voles but not for cottontail control.

Biotechnology Australia. 2002. Control through birth. Website: www.biotechnology.gov.au/biotechnologyOnline/environment/PestSpecies/EuropeanRabbit/ControlThroughBirth/e_ControlThruBirth.htm Accessed: December 23, 2002.

Biotechnology Australia coordinates biotechnology issues for the Commonwealth governments. The site describes the current research on immuno-contraception of Australia's feral rabbit population. Immuno-contraception tricks the rabbits' immune system into attacking naturally occurring proteins on sperm and egg cells. Antibodies bind to the sperm or egg and prevent fertilisation. This response can be induced by introducing sperm or egg proteins into the rabbits' blood. The immune system then treats the sperm or egg protein as foreign. Scientists are hoping these proteins can be introduced by a genetically engineered myxoma virus. The site does not discuss any of the potential negative impacts of this process such as the infection of non-target species.

Bond, B. T., B. D. Leopold, L. W. Burger and K. D. Godwin. 2001. Movements and home range dynamics of cottontail rabbits in Mississippi. Journal of Wildlife Management 65 (4): 1004-1013.

Authors' abstract: Knowledge of movement rates with respect to habitat conditions is necessary to understand foraging strategies, breeding opportunities, and probability of predation. The cottontail (*Sylvilagus floridanus*) is an important small game animal, yet no previous study has simultaneously examined movement rates and home range dynamics with respect to gender, breeding season, diel period, and habitat use. We estimated home range (HR) and core use areas (CA) during the breeding seasons and diel periods for 94 cottontails. We determined breeding season, diel period, and habitat-specific movement rates for 103 cottontails in east-central Mississippi from 1 February 1997 to 31 January 1999. Overall movement rates (m/hr) did not differ between years (1997: x=28.81 m/hr, SE=1.67; 1998: x=26.26 m/hr, SE=2.34) or genders (male: x=28.81

m/hr, SE=2.24; female: x=23.06 m/hr, SE=1.49). However, diel period interacted with season to influence movements (diurnal breeding: x=8.99 m/hr, SE=0.83; diurnal nonbreeding: x=3.23 m/hr, SE=0.35; crepuscular breeding: =33.40 m/hr, SE=2.47; crepuscular nonbreeding: x=23.45 m/hr, SE=1.90; nocturnal breeding: x=43.12 m/hr, SE=3.27; nocturnal nonbreeding: x=29.12 m/hr, SE=1.71). Movement rates differed among habitat types (>1 habitat patch: x=41.7 m/hr, SE=2.3; open fields: x=35.5 m/hr, SE=6.1; rowcrops: x=25.5 m/hr, SE=3.1; grass fields: x=19.4 m/hr, SE=0.9; woody areas: x=15.7 m/hr, SE=1.7). These differences were associated with differences in plant species richness (woody areas: x=11.1 plant species/30 m, SE=0.7; grass fields: x=9.2 plant species/30 m, SE=0.3; open areas: x=8.5 plant species/30 m, SE=1.1; rowcrops: x=5.8 plant species/30 m, SE=1.1) and percentage cover within habitats (0.0-0.9 m in height: rowcrop, woody areas, and grass fields had significantly greater cover than open areas; 0.9-1.8 m in height: rowcrop and woody areas had greater cover than grass fields and open areas). A significant gender-by-season interaction occurred for HR (95% adaptive kernel) (male breeding: x=5.98 ha, SE=0.57; male nonbreeding: x=2.54 ha, SE=0.65; female breeding: x=3.04 ha, SE=0.33; female nonbreeding: x=2.11 ha, SE=0.51) and CA (50%) (male breeding: x=0.93 ha, SE=0.10; male nonbreeding: x=0.32 ha, SE=0.08; female breeding: x=0.41 ha, SE=0.05; female nonbreeding: x=0.26 ha, SE=0.05). Home range (diurnal: x=3.71 ha, SE=0.47; nocturnal/crepuscular: x=4.70 ha, SE=0.43) and CA (diurnal: x=0.52 ha, SE=0.07; nocturnal/crepuscular: x=0.69 ha, SE=0.06) size differed between diel periods. Habitat specific movement patterns may be a function of forage availability and may influence fitness, particularly predation risk. Selection of habitats or habitat conditions that result in reduced movement rates by cottontails should reduce vulnerability to predation.

Bond, B. T., L. W. Burger, B. D. Leopold and K. D. Godwin. 2001. Survival of cottontail rabbits (*Sylvilagus floridanus*) in Mississippi and an examination of latitudinal variation. American Midland Naturalist 145 (1): 127-136.

Authors' abstract: We estimated seasonal and annual survival and cause-specific mortality of 132 cottontail rabbits (*Sylvilagus floridanus*) in east-central Mississippi during 2 y. Daily survival did not differ between years for genders, but differed significantly between breeding (99.22%) and nonbreeding seasons (99.76%). Mammalian (54.8%) and avian (26.1%) cause-specific mortalities were major mortality agents. Mammalian predation was similar between genders during the breeding season (male: 51.8%; female: 59.4%). Males experienced greater avian predation during the breeding season (male: 33.7%; female: 18.8%). Mammalian predation (male: 12.8%; female: 25.1%) and harvest (male: 25.6%; female: 12.5%) did not differ between genders for the nonbreeding season. Daily mammalian (breeding: 0.45%; nonbreeding: 0.10%) and avian (breeding: 0.22%; nonbreeding: 0.03%) predation differed between seasons. Cottontails preyed upon had greater movement rates the week before death than those that survived the same week. Cottontails that experienced avian predation had larger core areas up to day of death than those that did not experience avian predation whereas home- range size did not differ. Home-range and core-area sizes did not differ between rabbits that experienced mammalian predation and those that did not. From four previous survival studies and ours, cottontails exhibited latitudinal variation in survival (possibly due to

climatic factors, mammalian or predator population levels). Southern (Mississippi and South Carolina) populations exhibited survival less than northern (Wisconsin and Illinois) populations in the breeding season and greater survival during the nonbreeding season than northern populations.

Bumann, G. B. and D. F. Stauffer. 2002. Scavenging of ruffed grouse in the Appalachians: Influences and implications. Wildlife Society Bulletin 30 (3): 853-860.

Authors' abstract: Scavenging is often neglected as a source of bias when determining causes of mortality and collecting mortality-related habitat information. The use of mortality-sensing radio-transmitters has greatly increased our understanding of animal survival. However, the potential of lag-time in recovery of carcasses and subsequent determinations of cause of death are seldom addressed. Motion created by feeding predators and scavengers can delay pulse switchover and prolong recovery. We determined the influence of temperature, forest stand type, overhead cover, and carcass condition on scavenging rates, displacement patterns, and habitat sampling biases at perceived kill sites for ruffed grouse (*Bonasa umbellus*). We documented carcass disturbance, scavenger species, and displacement distances for 64 carcasses. Mammalian scavengers disturbed 42 of 64 grouse carcasses. Scavenger species identified included mice (*Peromyscus* spp.), flying squirrel (*Glaucomys* spp.), cottontail rabbit (*Sylvilagus floridanus*), Virginia opossum (*Didelphis virginiana*), raccoon (*Procyon lotor*), long-tailed weasel (*Mustela frentata*), bobcat (*Lynx rufus*), eastern coyote (*Canis latrans*), and common raven (*Corvus corax*). Air temperature and carcass condition were the dominant factors associated with scavenger disturbance of grouse carcasses. Mammal scavenging activity increased during warmer temperatures, and mock avian kills were scavenged more frequently than whole carcasses. Potential overestimation of mammalian-caused mortality may result from scavenging, especially when ambient air temperature is warmer and carcasses have been previously fed upon.

Chapman, J. A., J. G. Hockman and W. R. Edwards. 1982. Chapter 5: Cottontails: *Sylvilagus floridanus* and Allies. Pp. 83-122 in: Wild mammals of North America: biology, management and economics (J. A. Chapman and G. A. Feldhamer, eds.). Johns Hopkins University Press, Baltimore, MA.

Chapman *et al.* provide a comprehensive account of the 8 *Sylvilagus* species found in North America with information based on extensive peer-reviewed literature. The chapter places information in a regional context and evaluates conflicting references. Eastern cottontails have the widest distribution of any of the cottontail species. The range of this species is expanding through emigration at the margins of the range and via introductions to new locations. Introduced populations occur in Washington, Oregon and British Columbia. Eastern cottontails are described as large brown to gray rabbits with white under the body and tail, sometimes with a white area on the forehead. The chapter provides detailed skull descriptions and photographs in addition to dental formulas. Different studies have indicated that breeding season is stimulated by available vegetation, temperature and/or daylength. The chapter also discusses weaning age (15 days), breeding season (January to September in Oregon), gestation (25-35 but averaging

28 days), litter size (average 3.1-5.6 depending on latitude, time of year, size of mother, soil fertility), breeding age (in Oregon, 54% of juveniles breed), fecundity (Oregon populations bear up to 39 young in 8 litters) and nest construction (slanting holes measuring approximately 18 x 13 x 12 cm). Population size is more closely correlated to changes in habitat than predator/prey cycles. Home ranges vary depending on habitat, age and sex of the individual, season, weather, competition and population density. An extensive list of plants consumed does not list any species native to Garry oak ecosystems although plants from the same genus do occur in these ecosystems. Soft fecal pellets are re-consumed. Cottontails are listed as r-selected species: they have high reproductive rates and populations are limited by dispersal and mortality. Cottontails prefer patchy habitat with a mix of open areas for foraging combined with brushpiles, herbaceous or shrubby vegetation for cover. An extensive list of predators, parasites and diseases is included (many of these are as listed in other references). The impacts of cottontails include consumption of crops and seedlings and debarking of trees. Many of the management options listed are designed to promote cottontails in their native range. Repellents and habitat manipulation are recommended when cottontail impacts are a problem. The chapter provides an extensive review of cottontail physiology, genetics, reproductive anatomy, demography, social behaviour, age determination and means of estimating population size. These factors are important for understanding the ecology of eastern cottontails, however, due to space constraints, these factors are not summarized here.

Connecticut Department of Environmental Protection, Wildlife Division. 1999. Wildlife in Connecticut Informational Series: cottontail rabbits. Website: dep.state.ct.us/burnatr/wildlife/factshts/ctntail.htm Accessed: November 15, 2002.

This two page brochure is designed to provide background information on New England and eastern cottontails. The brochure provides species descriptions and information on their habitat, diet, native range and reproduction as described in other references. Eastern cottontails were introduced to New England in the 1800s and they now compete with native New England cottontails for habitat. The eastern cottontails' range is expanding and they are now more abundant than the native species. Cottontail damage is similar to what could be expected in Garry oak ecosystems: they eat grasses and herbs, and browse woody plants. Rabbit browse is generally low to the ground (less than 2½ feet) and they nip twigs with a clean, angled cut. Cottontail control options listed in the brochure may be successful in Garry oak ecosystems. Exclusion recommendations include erecting a 3 foot high fence of 2 inch mesh and protecting individual plants with tubing or wire mesh. Chemical and odour repellents may limit damage but must be reapplied regularly, especially after rain. Live trapping and hunting may help control cottontails but adjacent populations will rapidly repopulate vacant habitat. Traps can be baited with apples, carrots and rabbit droppings and are most effective during the winter. Although the brochure suggests that trapped rabbits should be released in suitable habitat, trapped cottontails from Garry oak ecosystems should not be released when captured.

Cox, E. W., R. A. Garrott and J. R. Cary. 1997. Effect of supplemental cover on survival of snowshoe hares and cottontail rabbits in patchy habitat. Canadian Journal of

Zoology 75 (9): 1357-1363.

Authors' abstract: We examined mortality patterns of sympatric snowshoe hares (*Lepus americanus*) and cottontail rabbits (*Sylvilagus floridanus*) on sites with and without brush piles to evaluate the protective role of cover in the fragmented habitat typical at the range limits of both species. Treatment sites received gtoreq 2 oak brush piles per hectare in August and September 1994. Leporids used a minimum of 56% of created brush piles, but we failed to detect a difference in survivorship between animals occupying treatment and control sites, suggesting that brush piles may not have served as effective refugia to leporids of either species. Coyotes (*Canis latrans*) killed leporids in understory cover similar in mean density to that of study sites, whereas raptor kills occurred in areas with sparser understory than the average for the study sites or at coyote kills. We concluded that other methods of habitat alteration may be more effective means of increasing numbers of snowshoe hares and cottontail rabbits.

Crawley, M. J. 1990**.** Rabbit grazing plant competition and seedling recruitment in acid grassland. Journal of Applied Ecology 27 (3): 803-820.

Author's abstract: (1) Two experiments were done to determine the effects of grazing by rabbits on plant recruitment in mature grassland and on cultivated soil. The first was a factorial experiment, with and without rabbit fencing, and with and without soil cultivation, carried out between 1986 and 1989 in acid grassland with a long history of rabbit grazing. In the second, carried out between 1982 and 1985 in two contrasting arable fields, rabbits grazed crops of winter wheat, with fencing exclosures erected at different times and for different durations. (2) Rabbit grazing affected the stature and composition of the grassland throughout the year. Species that increased in cover in rabbit-grazed grassland included the grass *Anthoxanthum odoratum* and the forb *Rumex acetosella*. Species that decreased included the grasses *Festuca rubra* and *Agrostis capillaris* and the forbs *Vicia sativa* and *Trifolium repens*. There was negligible change in the total number of plant species with grazing. (3) The cultivated treatments showed that the seed bank under the acid grassland was extremely heterogeneous. (4) Eight of the twenty-three commonest ruderal species beneath acid grassland decreased in cover significantly (e.g. *Capsella bursa-pastoris* and *Papaver dubium*), and none increased significantly. In contrast, most of the ruderal species in the seed bank of nearby arable soils increased under grazing. (5) Most plants species on cultivated grassland soils regenerated from vegetative fragments (e.g. *Holcus mollis, Stellaria graminea, Rumex acetosa* and *R. acetosella*), rather than by germination of seed. Regrowth shoots outnumbered seedlings by a factor of between 1.3 and 23.3. (6) The extent of spatial heterogeneity within and between plots in both the composition of the buried seed bank, and in recruitment by vegetative regrowth, highlights the need for large sample size in this kind of study. (7) The mechanisms that determine whether a plant species increases or decreases under grazing are discussed.

Dunwiddie, P. 2002. *Personal communication*. Restoration ecologist, The Nature Conservancy, Seattle, WA. November 13, 2002.

Although there are no mammals on Yellow Island where Dunwiddie has been conducting extensive restoration work, he is familiar with rabbit problems in other Garry oak ecosystems. In Garry oak ecosystems, on Whitby Island, Washington, extensive rabbit browse has been one of the top two threats facing *Castellija levisecta.* Rabbit browse has also been a major problem at American Camp on San Juan Island.

Durant, P. and R. Perez. 1995. Population and reproductive ecology of the northwestern Venezuelan cottontail rabbit, *Sylvilagus floridanus continentis* Osgood, 1912 (Lagomorpha: Leporidae). Caribbean Journal of Science 31 (1-2): 95-103.

Authors' abstract: The northwestern Venezuelan rabbit (*S. floridanus continentis*) inhabits xerophytic and subxerophytic regions of western Venezuela. A population of this subspecies was studied at "La Sabana" (9 degree 33'NL, 70 degree 28'WL, 272 masl), a cattle ranch about 35 km NW from the city of Valera, State Trujillo. A monthly capture program was conducted in five "pasture grounds" or "potreros" in this area during 1983. Seventy-eight percent of the sample were adults. Adult males were more common (53.8%) than females. Adult females were heavier (t = 6.21; P lt 0.005), and larger (BL) than adult males (t = 4.38, P lt 0.005). A pregnancy rate of thirty-five percent was recorded during April-May, and 23.5% in November. There was a positive and significant correlation between pregnancy percentage and precipitation (r = 0.63, t = 2.57, P lt 0.001). Ovarian and testicular index fluctuations, and concentration of mobil espermatozoa were also correlated to the rainy and dry seasons of the region. An average of 1.74 embryos in the left horn (n = 17), and 2.21 embryos in the right one (t = 2.89, 33 df; P lt 0.005) were recorded. Intrauterine litter size was 3.12 young/female, and an ovulation rate of 6.3. According to these records, intrauterine mortality and/or reabsorption would be about 50%. Similarities and differences found are compared with those of other groups of *Sylvilagus*, and discussed in function of habitat and some climatic parameters.

Ennis, T. 2002. *Personal communication.* The Nature Conservancy of Canada, Victoria, BC.

Ennis is involved with restoration of the Cowichan Garry Oak Preserve (CGOP). He has observed that eastern cottontails have been largely inadvertently controlled by the removal of invasive shrubs. Cottontails were abundant on the site when there was abundant scotch broom. When the Nature Conservancy removed all of the mature scotch broom and hawthorn plants in the CGOP, there was a period of time when there was high rabbit mortality from raptors. Although cottontails are still at the site, they are rarely seen. Ennis also notes that pellet rifles are very effective against both rabbits and squirrels.

Erickson, W. R. 1993. A wildlife habitat classification for Garry oak ecosystems. unpublished paper for BIOL 550 (Dr. D.S. Eastman). Department of Biology, University of Victoria, Victoria, BC.

Erickson monitored vegetation use by herbivores in 138 plots in Garry oak ecosystems.

He noted grazing on oak, Douglas-fir and arbutus, in 9 shrub species and in 13 herbaceous species. Heavy browse killed oak (one plot), Douglas fir (one plot), and *Symphoricarpos albus* (4 plots). Oak was the most frequently grazed in about 25% of the total plots. *Cytisus scoparius* was the next most frequently utilized, with 13 plot observations, followed by *Camassia quamash* with 12. The other herbaceous species grazed were *Brodiaea coronaria* (9), *Camassia leichtlinii* (8), *Sanicula crassicaulis* (6); *Plantago lanceolata* (2), *Vicia sativa* (2), *Elymus glaucus* (2), *Allium acuminatum* (2), *Allium cernuum* (1), *Bromus sterilis* (1), *Carex pensylvanica inops* (1), *Danthonia californica* (1), *Melica subulata* (1), and *Montia perfoliata* (1). The following shrubs were also grazed *Symphoricarpos albus* (4), *Amelanchier alnifolia* (2), *Lonicera hispidula* (2), Arbutus (1), Douglas-fir (1), *Holodiscus discolor* (1), *Mahonia aquifolia* (1), *Rosa* spp. (1) and *Rubus ursinus* (1). Browsing was mainly from deer and cottontail rabbits, as well as feral sheep and goats. Cottontail rabbits lightly browsed plants in 13 plots and moderately browsed plants in 3 plots. Cottontails heavily browsed oak, Douglas-fir, and an unspecified shrub in 3 plots. Cottontail rabbit scat was observed in 9 plots second only to deer scat.

Fraker, M. A. and W. J. Gazey. 2001. Standard inventory methods for components of British Columbia's biodiversity: hares and cottontails. Website maintained by Terrestrial Ecosystems Task Force of the Ministry of Environment, Lands and Parks. Website: srmwww.gov.bc.ca/risc/pubs/tebiodiv/hares/hacoml20-01.htm. Accessed: November 7, 2002.

The site lists which species of leporids occur in British Columbia and provides detailed range and distribution information for each species. The eastern cottontail population in British Columbia is a range expansion of cottontails introduced to Washington State in 1927 and 1931. Eastern cottontails were introduced to Sooke on Vancouver Island in 1964. Cottontails have since spread north along the eastern portion of Vancouver Island as far north as Campbell River with a few individuals as far as Sayward.

Fraser, D. 2002. *Personal communication.* Ministry of Water, Land and Air Protection, Victoria, BC.

Fraser has noticed eastern cottontail rabbits feeding heavily on *Viola praemorsa.* Cottontails have chewed adult plants to the roots and have prevented the plants from flowering.

Giuliano, W. M., C. L. Elliott and J. D. Sole. 1997. Relationships among habitat, cover, and eastern cottontails (*Sylvilagus floridanus*) in Kentucky. Transactions of the Kentucky Academy of Science 58 (1): 1-3.

Authors' abstract: We examined relationships among habitat, cover, and eastern cottontails (*Sylvilagus floridanus*) on five wildlife management areas in Kentucky in 1989. The pellet plot technique was used to determine habitat-use patterns and preferences, and a vegetation profile board was used to determine foliage cover. Old fields and fencerows contained the greatest foliage cover and were preferred by

cottontails year-round. Forested areas and agricultural fields were not high-use areas and were typically avoided.

Harestad, A. S., F. L. Bunnell, T. P. Sullivan and L. Andrusiak. 1986. Key to injury of conifer trees by wildlife in British Columbia. Research Branch, Ministry of Forests, WHR-23, Victoria, BC.

This report details the damage to conifer trees caused by mammals and one bird species. Damage can include bark removal, foliage removal and twig, stem and root cutting. The report provides a dichotomous key to identify which species has caused the damage based on an examination of the damaged vegetation. Pikas, rabbits, hares and rodents gnaw twigs and branches with clean, angled cuts. Seedling damage caused by cottontails is similar to the damage caused by mountain beavers. Cottontails gnaw the bark on the trunk and lower branches of trees and leave 2 mm wide toothmarks. Cottontail droppings are 9 mm in diameter and are slightly flattened.

Harestad, A. 2002. *Personal communication.* Simon Fraser University, Vancouver, BC.

During revisions of the eastern cottontail fact sheet, Harestad noted that both rodent and rabbit browse can be identified by a clean, 45º cut on twigs. In contrast, deer browse cuts twigs at 90º across the stem and leaves frayed edges.

Hygnstrom, S. E. and D. R. Virchow. 2000. NebGuide: Prevention and control of rabbit damage. Website maintained by Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln. Website: www.ianr.unl.edu/pubs/wildlife/g1401.htm. Accessed: November 6, 2002.

This site is designed to help identify damage caused by both eastern cottontails and jackrabbits and to recommend control options. The site does not provide references but refers the reader to "Prevention and Control of Wildlife Damage" by Timm (ed.) for further information. Hygnstrom and Virchow provide details on rabbit life history as described in other references. Cottontail damage is similar to what could be expected in Garry oak ecosystems; cottontails eat the new growth and flowers of plants during the growing season and they chew the bark and remove the small branches of woody plants during the winter. Rabbits can damage or kill the plants they eat. Rabbit damage can be identified by the presence of rabbit tracks, characteristic pellets and clean 45º cuts on twigs. Rabbits will also chew the roots of plants and will leave tooth marks on the wood. Excluding rabbits from an area is recommended as a long-term control. Rabbits can be excluded with a 1 inch mesh fence that is 3 feet high and buried at least 4 inches below the ground. An electric fence with two strands (one at 3-4 inches, the second at 8-12 inches high) is also effective. Individual plants can be protected with wire, plastic or fabric cylinders. In Gary oak ecosystems, fencing may be most appropriate for protecting new plantings and/or species at risk. Removing cover such as brush piles, tall vegetation and debris will help decrease cottontail habitat. Providing alternative food may deter cottontails from sensitive plants in the short-term; however, providing food may attract

more rabbits to the area. Rabbits quickly become accustomed to frightening devices and odour repellents. Taste and odour repellents are most effective when applied in the spring and they must be reapplied regularly. Trapping and shooting are effective short-term controls but adjacent cottontail populations will rapidly repopulate an area. Live traps are most effective in the winter and when covered with canvas. Although Hygnstrom and Virchow suggest that trapped rabbits should be released in suitable habitat, trapped rabbits from Garry oak ecosystems should not be released when captured. No chemical controls are available for cottontails.

Izakovic. 2001. Vertebrate bio control (and human?). Website: vertebratebiocontrol.htm Accessed: December 23, 2002.

The website documents recent research by CSIRO Wildlife Ecology, an Australian research agency, to develop immuno-contraceptives for invasive species including rabbits. The vaccine will be delivered by a virus that will spread through the pest population and will cause the animal's immune system to attack the eggs or sperm. There is concern that the virus may spread outside of Australia and kill non-target mammal populations in other countries. Further research is needed to determine the potential side effects and effectiveness of a vaccine of this kind.

Kollars, T. M., J. H. Oliver, P. G. Kollars and L. A. Durden. 1999. Seasonal activity and host associations of *Ixodes scapularis* (Acari: Ixodidae) in southeastern Missouri. Journal of Medical Entomology 36 (6): 720-726.

Authors' abstract: Based on tick collections recovered from wild vertebrates and by dragging, the seasonal occurrence of adult blacklegged ticks, *Ixodes scapularis* Say, extended from October through May in southeastern Missouri. Adult activity was bimodal with the higher peak occurring in November followed by a lower peak in February. The activity of immature *I. scapularis* had the general pattern of that found in the Northeast where Lyme disease is hyperendemic, with larval activity (July) peaking after that of nymphs (May and June). Vertebrates varied in their importance as hosts of *I. scapularis*. White-tailed deer, *Odocoileus virginanus* (Zimmerman), and coyotes, *Canis latrans* Say, were the primary hosts of adult *I. scapularis*. Broad- headed skinks, *Eumeces laticeps* (Schneider), and eastern fence lizards, *Sceloporus undulatus* (Latreille), were the primary hosts of nymphal *I. scapularis*. The broad-headed skink, 5-lined skink, *Eumeces fasciatus* (L.), and Carolina wren, *Thryothorus ludovicianus* (Latham), were the primary hosts of larval *I. scapularis*. Homeotherms were important hosts of immature *I. scapularis*, accounting for 30% of nymphs and 39% of larvae collected. The eastern cottontail rabbit, *Sylvilagus floridanus* (Allen), may play an important role in the epidemiology of Lyme disease in Missouri. Isolates of *Borrelia burgdorferi* Johnson, Schmid, Hyde, Steigerwalt & Brenner were made from ticks recovered from rabbits, making the cottontail rabbit a key species for further study of the epidemiology of Lyme borreliosis in Missouri.

Lochmiller, R. L., D. G. Peitz, D. M. Leslie and D. M. Engle. 1995. Habitat-induced changes in essential amino-acid nutrition in populations of eastern cottontails. Journal of

Mammalogy 76 (4): 1164-1177.

Authors' abstract: Previous studies have indicated that populations of eastern cottontails (*Sylvilagus floridanus*) respond favorably to habitat disturbance. Protein quality of vegetation has been implicated as one of the most important reasons for such demographic changes in herbivore populations. We explored the hypothesis that vegetation in upland hardwood forest-tallgrass prairie provided resources of higher-quality protein 4-5 years postdisturbance, as measured by the concentrations of essential amino acids in stomach contents, than did vegetation 79 years postdisturbance. Composition of nutrients in diets was not influenced by intensity of disturbance, but was influenced by time since disturbance and season. Habitats 4-5 years postdisturbance provided diets higher in essential amino acids and crude protein and lower in fat than those 7-9 years postdisturbance. Winter diets were higher in essential amino acids and crude protein than summer diets. Sulfur-containing amino acids, methionine and cystine, were the most limiting (histidine = second most limiting) of the essential amino acids in all years and seasons of study. Calculated biological values of protein in diets of cottontail rabbits suggested that rabbits may have had more difficulty meeting requirements for optimum growth in summer than during winter and in habitats 7-9 years compared with 4-5 years postdisturbance. The nutritional value of diets for essential amino acids declined as grasses replaced forbs on disturbed habitats which coincided with declines in other populations of small herbivores.

MacDonald, A. 2002. *Personal communication.* Birder, Victoria, BC. November 13, 2002.

MacDonald suggests that native raptors feed on eastern cottontails. The introduction of cottontails and other small mammals to Garry oak ecosystems may have caused increases in the populations of some native raptors and aided the range extension of barred owls into these areas. Maintaining habitat for hawks and owls, installing raptor perches and maintaining standing, dead trees, also known as wildlife trees, will also encourage the presence of birds of prey and may help control cottontail populations.

Mankin, P. C. and R. E. Warner. 1999. Responses of eastern cottontails to intensive row-crop farming. Journal of Mammalogy 80 (3): 940-949.

Authors' abstract: We studied responses of 25 transmitter-equipped eastern cottontails (*Sylvilagus floridanus*) to intensive farming disturbances in Illinois from June 1990 to April 1993. Home ranges during the row-crop growing season (June-October) averaged 2.3 times larger than during the nongrowing season and 7-8 times larger than those reported in previous studies. There were no differences between sexes in size of home ranges or use of cover in either season. Habitat composition within home ranges of cottontails was not different than from the entire study area during the growing season. During the nongrowing season, cover type of the farmstead was a key element in home ranges of rabbits; it represented <2% of the study area but comprised 23% of home ranges and 40% of locations of rabbits. Fifty-five percent of rabbit locations during the nongrowing season were located in harvested row crop fields. Our study demonstrated how rabbits respond to spatial and temporal environmental changes caused by intensive

agriculture where expansive row crops is the primary cover type.

Mankin, P. C. and R. E. Warner. 1999. A regional model of the eastern cottontail and land-use changes in Illinois. Journal of Wildlife Management 63 (3): 956-963.

Authors' abstract: The eastern cottontail (*Sylvilagus floridanus*) is important in ecological food webs as a prey species for a wide variety of predators throughout its range, and is also a popular game animal. From 1956 to 1978, the eastern cottontail is estimated to have declined at least 70% in Illinois and more than 90% in the most intensively farmed regions of the state. We describe long-term changes in the index of relative abundance for the eastern cottontail in Illinois in relation to regional patterns of land use. Classification and regression trees (CART) analysis was used to analyze county-level changes in 6 land-use variables (row crops, hay, diverted cropland, woodland, small grains, pasture) in relation to the number of cottontails harvested per hunter per day, 1956-69 versus 1982-89. In the early period (1956-69), 78% of the counties had an index of at least 1.50 cottontails cntdot hunter-1 cntdot day-1, compared to only 28% of the counties in the recent period (1982-89). The amounts of pasture, hay, and small grains were positively correlated (P ltoreq 0.01) with the change in cottontail index, and 2 response regions were identified with the change in pasture. The region with the least decline in cottontail index had more pasture, hay, and woodland. The stable amount of woodland during recent decades may have moderated the decline in cottontails, despite the negative influences of the other land-use changes. Long-term changes in the cottontail index in Illinois predictably track changes in farming and geomorphic factors that modify agriculture. Our analyses underscore the influence of agriculture on upland wildlife over expansive temporal and spatial scales in North America, influences that are not necessarily apparent in finer-scale studies.

Mason, J. R., J. Hollick, B. A. Kimball and J. J. Johnston. 1999. Repellency of Deer Away Big Game Repellent(R) to eastern cottontail rabbits. Journal of Wildlife Management 63 (1): 309-314.

Authors' abstract: Deer Away Big Game Repellent(R) (BGR) effectively deters browsing deer, most likely by the release of sulfur odors and volatile fatty acids. Because many herbivores avoid these odors, a logical inference is that BGR may repel herbivores other than deer. To address this possibility, we tested whether BGR was repellent to eastern cottontail rabbits (*Sylvilagus floridanus*). During fall-winter of 1994-95, we located 4 test sites (0.42.0 ha) in commercial nurseries in southern New Jersey. Different sites were planted to flowering pear (*Pyrus calleryana*), dogwood (*Cornus florida*), firebush (*Pyracantha coccinea*), and crab apple (*Malus* spp.). We split each site into 2 plots (0.2-1.0 ha), and plots then were randomly assigned to the treatment or control condition. After recording the number of damaged plants in each plot, we applied a 32.4% (mass/volume) solution of BGR to treated plots at the labelled rate of 3.8 L/400 plants. We applied water alone to plants in control plots. During a 21-day posttreatment period, we reassessed damage at 7-day intervals. During fall-winter of 1995-96, we repeated treatment and control applications, except that conditions were reversed (i.e., former control plots were treated with BGR and vice versa). We estimated rabbit numbers at

each site during both years of the study and chemically evaluated the environmental persistence of BGR during the first year. Big Game Repellent was an effective repellent at all sites during both years of the study. These findings are consistent with the possibility that BGR represents an omnibus repellent for problem herbivores.

Mikita, K. 1996. *Sylvilagus floridanus*: eastern cottontail. Website maintained by the University of Michigan. Website: animaldiversity.ummz.umich.edu/accounts/sylvilagus/s._floridanus$narrative.html Accessed: November 7, 2002.

The website provides background information on the range, description and life history of eastern cottontails. The site is designed to be used for college students and uses mammal guides as references. The site provides useful background on the ecology of cottontails which is necessary for understanding management of the species in Garry oak ecosystems. The native distribution of eastern cottontails is described as west of the Great Plains from South America to southern Manitoba and Quebec. Eastern cottontails are described as having a brown coat with coarser guard hairs, grey rump and flanks, a red-brown patch between the shoulders, a white belly and white on the underside of the tail. Cottontails are able to digest the complex carbohydrates and cellulose that make up their diet through caecal fermentation combined with reingestion of their droppings to maximise nutrient absorption. In the summer, cottontails eat a range of plant material and ½ of their diet is from grasses. In the winter, cottontails eat the twigs, bark and buds of trees and shrubs. Cottontails can reproduce at 2-3 months of age. Breeding is controlled by temperature, photoperiod and food availability. Cottontails can have 3-4 litters per year of 2-8 young. The shallow nests are hidden by shrubs, logs or tall grasses. Gestation is 26-32 days. Cottontails are weaned after 16-22 days. Other details include home range (5-8 acres depending on season, food and terrain), running speed (18 miles per hour) and habitat (edge habitat between open areas and places with cover of trees and shrubs). The site also provides photographs of shrub damage caused by cottontails and a comparison of deer and cottontail droppings.

Nagorsen, D. W. 2002. An identification manual to the small mammals of British Columbia. Ministry of Sustainable Resource Management, Ministry of Water, Land and Air Protection, Royal BC Museum, Victoria, BC.

The field guide is designed for lay identification of mammals and provides detailed body measurements, dental formulas and skull illustrations. Eastern cottontails are described as brown medium-sized rabbits with red-brown patches between the shoulders, black-tipped ears and white bellies. Cottontails could be confused with snowshoe hares (which do not occur in Garry oak habitat) and brown forms of the European rabbit. A range maps shows the two introduced populations in the lower Fraser Valley (a range expansion from introductions in Washington) and Vancouver Island (recent introduction). Unfortunately, there are no habitat descriptions in this guide.

Novak, M., J. A. Baker, M. E. Obbard and B. Malloch (eds.). 1987. Wild furbearer management and conservation in North America. Ministry of Natural Resources, Ontario

Trappers Association, Toronto, ON.

This book provides information on the ecology and management of furbearing species in North America. Cottontails are only briefly mentioned but some of the general information is useful for this species in Garry oak ecosystems. The book provides extensive information and illustrations showing different snare and trap designs. Snares and kill traps are not recommended in Garry oak ecosystems because they can trap and kill non-target species. A chapter entitled "Nuisance furbearer management programs for urban areas" does not specifically discuss eastern cottontails but does provide guidelines for developing policy, goals and evaluation of control programs in addition to management strategies and information about legal jurisdictions. The chapter suggests that there is a need for increased public education on wildlife habits and species identification. The chapter also suggests that public perception is a key component of any urban wildlife management. Habitat modification is recommended as the best control option, where applicable. Scare tactics and repellents, live trapping and catch poles are other options that are briefly discussed but the response of cottontails to these management techniques is not provided.

Oregon Department of Fish and Wildlife. 2001. Backgrounder: Nonnative wildlife in Oregon. Website: www.dfw.state.or.us/ODFWhtml/Nonnative_1.pdf Accessed: November 11, 2002.

This public education brochure provides information on the impacts of invasive species and control measures that can be used to prevent their spread and minimize their impacts. The brochure describes the native range of eastern cottontails as "eastern United States, west into New Mexico and Arizona, and south through much of Central America". Cottontails were first introduced to Oregon in the 1930's for hunting. Eastern cottontails may be negatively impacting Oregon's native brush rabbit (*Sylvilagus bachmani*) and desert cottontail (*Sylvilagus nuttalli*). Neither of these native species occurs in Garry oak ecosystems in Canada. The brochure outlines how to ecologically and humanely dispose of trapped invasive mammals. Humane euthanasia options listed are carbon dioxide, cervical dislocation, decapitation, gunshot to the head and barbiturates administered by veterinarians.

Pakeman, R. J., J. P. Attwood and J. Engelen. 1998. Sources of plants colonizing experimentally disturbed patches in an acidic grassland, in eastern England. Journal of Ecology 86 (6): 1032-1041.

Authors' abstract: 1. The sources of propagules for regeneration in an acidic grassland were identified from analysis of differences in colonization between plots subject to surface (0-5 cm) soil disturbance and plots where surface soil had been replaced by 'seed-free' soil from deeper soil horizons (30-35 cm), and between plots with and without the removal of rabbit pellets. 2. After 1 year, 10 species had a significantly higher cover on plots where the seed bank had been left intact. These included *Agrostis capillaris* (the dominant species prior to disturbance), *Myosotis arvensis* and *Veronica arvensis*. 3. Five species, including *Sagina apetala*, *Senecio jacobaea* and *Veronica arvensis*, showed

significantly higher cover on plots where rabbit pellets were left in situ. 4. From calculations it appeared that rabbit-dispersed seeds accounted for 15% of the developing higher plant cover, other means of dispersal from outside the plot accounted for 40%, and regeneration from the seed bank accounted for 45%. 5. Similar calculations suggested that three higher plant species, *Geranium molle*, *Myosotis arvensis* and *Senecio jacobaea*, appeared to depend most on non- rabbit dispersed seed for colonization of bare ground. 6. High concentrations of *Urtica dioica* in pellets contrasted with its poor establishment in the experiment. However, the other common species in the pellets, *Sagina apetala*, *Senecio jacobaea* and *Veronica arvensis*, all established in greater numbers on the plots where the pellets were not removed. 7. Seed bank content correlated well with the pattern of regeneration for *Agrostis capillaris*, *Holcus lanatus*, *Myosotis arvensis* and *Veronica arvensis*. However, removal of the seed bank did not have a significant effect on the regeneration of either of the most common species in the seed bank, *Rumex acetosella* and *Sagina apetala*. 8. No species appeared to be reliant on only one mechanism for regeneration from seed in disturbed areas in this community.

Roemer, H. 2001. *Personal communication*. Botanist, Victoria, BC. November 13, 2002.

Roemer has observed eastern cottontails feeding heavily on camas, shooting stars and *Erythronium* spp. leaving the remains of flowers and buds on the ground next to the plants. Cottontails are not likely to cause permanent damage to these plant populations. Either deer or cottontails also graze *Aster curtus* (= *Sericocarpus rigidus*).

Roseberry, J. L. 1998. Landscape characteristics and spatial patterns of eastern cottontail abundance in Illinois. Transactions of the Illinois State Academy of Science 91 (3-4): 167-178.

Author's abstract: I quantified landscape composition and pattern throughout Illinois from classified satellite imagery and compared them to abundance indexes of the eastern cottontail (*Sylvilagus floridanus*). Rabbits were most abundant in diverse, patchy landscapes that contained moderate amounts of row crops and grassland, and abundant woody edge. These findings were incorporated into a PATREC habitat model to identify and map Illinois landscapes potentially suitable for cottontails. Such landscapes were primarily associated with poorer quality soils and/or areas too hilly for extensive row cropping.

Shoemaker, D., A. Woolf, R. Kirkpatrick and M. Cooper. 1997. Humoral immune response of cottontail rabbits naturally infected with *Francisella tularensis* in southern Illinois. Journal of Wildlife Diseases 33 (4): 733-737.

Authors' abstract: Cottontail rabbits (*Sylvilagus floridanus*) usually are thought to succumb to infection with *Francisella tularensis*. Reports of a rabbit population from southern Illinois (USA) with a high prevalence of *F. tularensis* antibodies suggested that some cottontails survived infection with this typically fatal bacterium. Our goal was to examine the humoral response of cottontails from a study area in southern Illinois for

which multiple serum samples existed. Multiple sera were collected from 79 cottontails from 1986 to 1990 and 63% gained, lost, or maintained ELISA titers of IgM and IgG isotype antibodies. The typical pattern of antibody response appeared to be IgM isotype antibodies first, followed by IgG isotype antibodies, with both generally increasing to high titers. Negative culture attempts of liver tissue from 51 cottontails with varying antibody responses suggested that chronic infection did not occur in rabbits that developed antibody. The significance of the cottontail antibody response in resolution or prevention of tularemia infection remains unclear.

Smith, D. F. and J. A. Litvaitis. 2000. Foraging strategies of sympatric lagomorphs: Implications for differential success in fragmented landscapes. Canadian Journal of Zoology 78 (12): 2134-2141.

Authors' abstract: In recent decades, the distribution of New England cottontails (*Sylvilagus transitionalis*) has declined substantially in response to forest maturation and fragmentation. Populations of eastern cottontails (*Sylvilagus floridanus*) have expanded into the range of *S. transitionalis*, since they are apparently less affected by the consequences of habitat modifications. We suspected that *S. floridanus* was able to exploit small patches of habitat where *S. transitionalis* was vulnerable to intense predation and we evaluated this explanation using large enclosures within which we manipulated the quality and distribution of food in relation to escape cover. In trials with low-quality food in cover and high- quality food in open areas, *S. transitionalis* sacrificed food quality for safety by remaining in close proximity to cover. *Sylvilagus floridanus* avoided low-quality food in cover and foraged at sites containing high-quality food away from cover. When food was removed from cover, *S. transitionalis* was reluctant to forage in the open and lost a greater proportion of body mass and succumbed to higher rates of predation than did *S. floridanus*. We applied these results to patterns of foraging by free-ranging rabbits in a fragmented landscape and estimated that *S. transitionalis* could successfully exploit only 32% of the available habitat without experiencing elevated rates of predation, whereas *S. floridanus* could exploit 99% of the habitat. Thus, the consequences of habitat fragmentation (especially higher predation risk) may not be as detrimental to *S. floridanus*, and this species will likely persist, whereas populations of *S. transitionalis* will continue to decline.

Stirling, D. 2002. *Personal communication*. Birder, Victoria, BC. November 13, 2002.

Stirling has noticed a connection between the introduction of small mammals to southern Vancouver Island and the increase in owl and hawk populations. In the early 1960s, before there were large populations of introduced house mice, rats, grey squirrels and rabbits, there were very few small mammals on Vancouver Island (only Townsend's voles, deer mice and red squirrels). When there were few small mammals, there were also very few great horned and barred owls. Now, great horned and barred owls are very common and the introduced mammals make good prey. Both red tailed hawks and great horned owls like to eat rabbits.

Sullivan, T. P., A. R. Harestad and B. M. Wikeem. 1990. Chapter 22: Control of

mammal damage. Pp. 302-318 in: Regenerating British Columbia's Forests (D. P. Lavender, R. Parish, C. M. Johnson, G. Montgomery, A. Vyse, R. A. Willis and D. Winston, eds.). UBC Press, Vancouver, BC.

Sullivan *et al.*, discuss the impact of herbivorous mammals in coniferous forests. Although eastern cottontails are not specifically mentioned, damage caused by snowshoe hares may be similar to the impacts caused by eastern cottontails. Snowshoe hares damage conifers by browsing the leader and lateral shoots. Damage to trees is most severe in areas with suitable habitat and in years when the cyclical hare populations peak. Although the management suggestions were developed to control snowshoe hare damage in conifer plantations, some of the general principals may be applicable to Garry oak ecosystems suffering from cottontail herbivory. Management recommendations include planting larger stock, using less fertilizer with plantings, planting less palatable species, modifying habitat to remove cover and using repellents during times when rabbit populations are at their highest levels. Poisoning, trapping and shooting have not been found to be effective because hares rapidly emigrate from adjacent populations. Snowshoe hares also remove bark from the trunks and low branches of young trees and may completely girdle the trees. Bark damage can reduce growth and/or kill the tree. Most bark damage occurs from November to April. Management recommendations for bark damage are related to stand spacing and are not relevant to Garry oak ecosystems.

Sullivan, J. 1995. FEIS Wildlife species: *Sylvilagus floridanus.* Website: www.fs.fed.us/database/feis/animals/mammal/syfl/all.html. Accessed: November 12, 2002.

The website uses extensive peer-reviewed references to document the distribution, life history and management of eastern cottontails throughout the United States. Sullivan states where primary research was conducted so that different results can be related to local conditions. The native distribution of eastern cottontails is described in addition to the introduced breeding populations in Washington and Oregon (British Columbia is not mentioned). Cottontails have been identified in oak dominated habitats throughout the United States. General habitat and reproductive biology is as detailed in other references. Cottontails in Oregon breed from January to September. A list of cottontail parasites and diseases are included. Preferred habitat is described as a patchy mix of open areas and hiding cover. Specific habitat details are given for many states but not for the introduced populations in Washington and Oregon that may be most similar to cottontail populations in Garry oak ecosystems in Canada. Home range details are not listed for Washington or Oregon. Sullivan refers to studies that have identified up to 145 plant species in the diet of cottontails. Cottontails prefer small woody vegetation with stems less than 0.6 cm. Predators listed that may also be found in Garry oak ecosystems include domestic cats and dogs, raccoons, barred owls, great horned owls, hawks and snakes. The management considerations discuss ways to maintain cottontail populations in their native range. Exclosures and repellents are recommended as the most effective controls for pest populations. Reducing cover is also an effective control because cottontails will choose habitat with good cover rather than good food resources if both are in short supply. Trapping and shooting are only effective in the short-term. The impact of fire depends on

the intensity of the burn, fire interval and the habitat. Fire can be an effective tool for changing the structure of the habitat although further research is needed to determine how fires in Garry oak ecosystems may affect cottontail populations.

Timm, R. M. (ed.). 1986. Prevention and control of wildlife damage. Great Plains Agricultural Council Wildlife Resources Committee and Cooperative Extension Service, Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln, NE.

This reference provides extensive information on identifying wildlife damage, wildlife diseases and their human connections, vertebrate pesticides, and supplies and materials for wildlife control (including a list of manufacturers and suppliers). The reference also provides a thorough species by species account of different wildlife pests from an agricultural perspective. The section on cottontail rabbits by S. R. Craven of the University of Wisconsin uses primarily mammalian field guides as references. Craven provides background information on the identification, range, habitat, diet and reproductive biology of cottontails as detailed in other references. The section also covers a range of control options, many of which may be useful in Garry oak ecosystems. Cottontail damage can be identified by the presence of gnawed woody plants, cleanly nipped twigs, round droppings and characteristic tracks. Exclusion is recommended as a control option. Cottontails can be excluded from an area by a 0.7 m high fence made with a mesh of 2.5 cm or smaller. Protective barriers of wire hardware cloth and commercial tree wrap will help prevent damage to individual plants. Removing suitable cover will also help limit cottontail populations and control their damage. Contact or taste repellents will protect the portions of the plant they are directly applied to but are not effective on the new shoots that emerge after the repellent is applied. Taste repellents must be reapplied regularly, especially after rain. Mothballs and dried blood meal act as odour repellents and may keep rabbits from feeding in an area. No pesticides are recommended for use on cottontails. Live traps are recommended for removing rabbits, especially in urban areas and the reference provides detailed plans for building a wooden box trap. However, Craven does not address the issue of emigration from adjacent populations. Traps should be placed in areas where rabbits feed and rest. Traps can be baited with corn cobs, dried apples, carrots, cabbage and alfalfa. Covering wire traps in the winter makes the trap more enticing to cottontails. Although the reference recommends releasing trapped cottontails in other locations, this is not recommended in Garry oak ecosystems where they are an invasive species. Shooting cottontails may limit their populations but only if done regularly. Encouraging natural predators such as hawks, owls and snakes may help limit rabbit populations. Feeding cottontails may divert attention from sensitive species.

Wilson, D. E. and S. Ruff. 1999. The Smithsonian book of North American mammals. UBC Press, Vancouver, BC.

This field guide gives a two page description of eastern cottontails including basic life history information. Only one reference is provided with the text. The guide lists eastern cottontails as having the largest distribution within the genus. Eastern cottontails' range overlaps with 7 other cottontail and 6 hare species. The range map does not show the

introduced population on Vancouver Island. Cottontails range in length from 395-477 mm and weigh between 801-1,533 g. Eastern cottontails are described as large brown to grey rabbits with white under the body and tail. Habitat is described as agricultural areas and hedgerows. Historically, cottontails have lived in a broader range of habitat including deserts, swamps and a diversity of forest types. Cottontails use brush piles or dense vegetation as cover. Home range varies between 1-2 hectares depending on season and habitat. Cottontails are only territorial during the breeding season and good habitat can support up to 10 cottontails per hectare. Diet consists of grasses and herbs in the summer and woody species during the autumn and winter. Cottontails can produce up to 35 young per year with litters ranging from 3-6. Average gestation is 30 days.

Young, J. G. and S. E. Henke. 1999. Effect of domestic rabbit urine on trap response in cottontail rabbits. Wildlife Society Bulletin 27 (2): 306-309.

Authors' abstract: Low capture rates of cottontail rabbits (*Sylvilagus floridanus*) are common. We hypothesized that urine as an olfactory attractant would increase trapping success because rabbits scent-mark their territories with urine. We assessed trap response in cottontail rabbits using clean traps (control), traps baited with food, traps baited with block salt and minerals, and traps baited with urine from non-pregnant domestic rabbit does. We caught 314 cottontail rabbits during 2,000 trap-nights conducted from July through August, 1996. We captured more cottontails in traps baited with rabbit urine ($P<0.001$) than in the others, suggesting that olfactory cues are important in the behavior of cottontail rabbits. Capture frequencies were 2.8, 13.4, 17.0, and 29.6% for control traps and traps baited with food, salt, and urine, respectively. Sex ratios of captured rabbits did not deviate from a 1:1 relationship for each bait or for all baits combined.

Young, K. E., P. J. Zwank, R. Valdez, J. L. Dye and L. A. Tarango. 1997. Diet of Mexican Spotted Owls in Chihuahua and Aguascalientes, Mexico. Journal of Raptor Research 31 (4): 376-380.

Authors' abstract: We analyzed pellets of Mexican Spotted Owls (*Strix occidentalis lucida*) collected at roost and nest sites in Chihuahua from 1992-94, and Aguascalientes, Mexico from 1994-95 to determine diet composition. We identified 647 prey items from 13 owl territories in Chihuahua and four owl territories in Aguascalientes. Vertebrates constituted 64% of all prey items and 99% of total prey biomass. Woodrats (*Neotoma* spp.), mice (*Peromyscus* spp.) and cottontail rabbits (*Sylvilagus floridanus*) comprised 82% of total prey biomass in Chihuahua and 89% of total prey biomass in Aguascalientes.