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Byron Williams
Director
Public Interest law Centre
300-287 Broadway
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Dear Mr. Williams;

In response to a request from Manitoba Hydro for reference materials on vegetation management related to the Bipole III project, Aura (Jill Gunn) is please to provide your office with the following:

- a brief literature review summarizing progress in vegetation management strategies for wildlife habitat management on electric utility transmission rights-of-way from the 1950s to the late-1990s, with related reference list (**Attachment 1**);
- an overview of vegetation management strategies for wildlife habitat enhancement on electric utility transmission rights-of-way (**Attachment 2**); and
- a supplemental bibliography of works on vegetation management strategies for wildlife habitat management on electric utility transmission rights-of-way from 2000 to the present (**Attachment 3**).

Aura will invoice separately for this work. Please do not hesitate to contact me should you have any questions. Thank-you.

Sincerely,

Jill A.E. Gunn, Ph.D., M.C.I.P.

cc: Jackie Bronson, Bram Noble

Aura

PROGRESS IN VEGETATION MANAGEMENT STRATGIES FOR WILDLIFE HABITAT MANAGEMENT ON ELECTRIC UTILITY TRANSMISSION RIGHTS-OF-WAY: 1950s TO LATE-1990s[1]

In Canada and the Unites States, literature connecting wildlife habitat and right-of-way (ROW) management first began to appear in the early 1950s. At that time, researchers began to explore (i) the effects of various maintenance techniques on ROW vegetation (Ibberson and Egler 1951), as well as (ii) the potential of ROWs as wildlife habitat (Arner 1951; Bramble and Byrnes 1955; Egler 1952; Egler 1953; Egler 1954). The majority of studies published on both topics over the next four decades originated almost exclusively from utilities located in the Northeastern United States. Very little information in that period was contributed by Canadian utilities, save for a significant body of research developed by Hydro Québec.

Prior to the use of herbicides, electric utilities relied upon frequent cutting to manage vegetation in ROW corridors (Barnhart, et al. 1975; Abbott 1982). After World War II, brush axes, hand saws and horses were replaced by chainsaws and bulldozers as the primary tools used in clearing and maintaining the ROW (Abbott 1982). By the late 20th century, frequent cutting was generally not recommended for use on its own (Luken, et al. 1991) because it was proven not to be a successful method of inhibiting tree regeneration (Luken, et al 1993). Frequent cutting can be effective, however, if used in combination with other management techniques (Luken, et al. 1994) such as herbicide applications.

Herbicides have subsequently become an integral component of most vegetation maintenance programs, and have been the subject of many research initiatives over the years. Applying herbicides such as 2,4-D, Tordon 101, and 2,4,5-T, to the ROW in a blanket-spray was the original industry norm (Asplundh Environmental Services 1979; Barnhart, et al. 1975; Niering and Goodwin 1974; Abbott 1982) until scientists (Carvell 1975), and public bodies (Johns 1979), began to realize the detrimental effects on repeated blanket-spraying on ROW plant communities.

[1] Between 1997 and 2002, Dr. Gunn (neé Harriman) conducted research on integrated resource management strategies for electric utility transmission rights-of-way in northern British Columbia. This material is adapted from two of several works produced during this period: (1) Harriman, Jill. 1999. Toward A Conceptual Framework for Integrated Resource Management on Electric Utility Transmission Rights-of-Way. Masters thesis. University of Northern British Columbia: Prince George, BC. (2) Harriman, Jill. 1998. Wildlife Habitat Management on British Columbia Hydro's Northern Transmission Rights-of-Way. BC Hydro Northern Region: Prince George, BC.

Scientists in the late 20th century began to advocate selective herbicide treatments because (a) they greatly reduce negative impacts on desirable plant species (Mercier and Laliberte 1993); (b) they assist in maintaining habitat diversity (Niering and Goodwin 1974); and (c) environmental sensitivities often necessitate herbicide applications that are very precise (Turbide 1997). Even more importantly, selective herbicide applications can be used to cultivate dense, low-growing shrub communities that are resistant to tree invasion and less costly to maintain over the long-run (Dreyer and Niering 1986; Johnstone 1990).

Manual and mechanical methods have been successfully combined with herbicides to produce even more specialized and flexible vegetation maintenance techniques (Rowell, et al. 1997a; Rowell, et al. 1997b; Porteck, et al. 1995; Garant, et al. 1997; Luken, et al. 1994; Luken, et al. 1993). Various herbicides are usually combined with specific cutting regimes to establish the most effective treatment(s) for the purpose intended in a localized area on the ROW. Results of these initiatives vary, depending upon the combination of methods used and the types of tree species involved.

In addition to manual, mechanical, and herbicide vegetation management techniques, researchers have experimented with prescribed burning (Olson, et al. 1982); jellied fuel (Arner, et al. 1982); hand-held torches (Olson, et al. 1979; Arner et al. 1982); herbivory by wild animals (Ostfeld and Canham 1993); allelopathy (Varfalvy 1993); livestock grazing (Stacey 1997: pers. comm.); special plantings (Brown 1995; Seguin 1993; Meilleur, et al. 1994; Harper-Lore 1996; Bramble, et al. 1990); and multiple vegetation zones (Bramble, et al. 1985) to manage undesirable vegetation on ROWs.

Prescribed burning, jellied fuel, hand-held torches, wild herbivory, and allelopathy are not widely used in the electric utility industry because they can be difficult to direct or control, and often produce variable results. Livestock grazing (cattle, sheep) can be an effective form of vegetation control and habitat enhancement (Urness 1990; Guthery et al. 1990; Anderson, et al. 1990), but is little discussed in the literature pertaining to electric utility ROWs. Special plantings using highly competitive species may help the utility to establish dense, stable vegetative communities (Brown 1995), control erosion (Harper-Lore 1996), and benefit wildlife (Woodhouse and Baynes 1976), but are often costly (Egler 1975) and tend not to fare well in the long run if seed species are not native to the region (Harper-Lore 1996).

The idea of cultivating multiple vegetation zones on transmission ROWs, is another progressive vegetation management strategy on ROWs. Bramble, et al. (1985) suggested cultivating a “wire

zone" directly beneath transmission wires, and two "border zones" between the wire zone and either ROW edge. Vegetation in the wire zone is kept short, and free of undesirable tree species. Vegetation in the border zones is also kept free of target species, but allowed to grow taller, creating a "U-shaped" cross-section of vegetation on the ROW. This technique is intended to "feather" ROW edges (Bramble, et al. 1985) and help further diversify the vegetative community.

In summary, research produced in the late 20th century strongly recommends the development of flexible, site-specific vegetation maintenance programs which depend heavily on selective herbicide applications in order to minimize long-term maintenance costs (Reason, et al. 1997; Abrahamson, et al. 1992; Abrahamson, et al. 1993; Lowrey 1998; Johnson 1996; Spangler 1979).

Also in the mid- to late-20th century, a small body of literature emerged that specifically addresses wildlife management on electric utility ROWs. A number of papers explored the utility of various maintenance techniques in enhancing wildlife habitat. For example, selective herbicide applications have been used quite extensively to cultivate food and cover for various wildlife species on ROWs (Hanson 1988; Brown and Irwin 1996; Geier, et al. 1992; Bramble and Byrnes 1972; Bramble and Byrnes 1983; Hartley, et al. 1982). Selective cutting (as opposed to clear cutting) has also been found to improve wildlife habitat (Cavanagh, et al. 1976). Special plantings of small trees, low-growing shrubs, and various perennials have been used to improve wildlife habitat on electric utility ROWs, but with varying degrees of success (Farrish, et al. 1997; Arner 1951; Zuck 1973).

Studies involving simultaneous maintenance techniques have been executed as well. Herbicides, prescribed burning, and mechanical manipulation have been combined with seeding and fertilizing to produce food for wildlife (Arner 1960), and habitat for upland game (Arner 1997). Huntley and Arner (1982) compared the effectiveness of winter and spring prescribed burning, selective spring mowing, and selective summer basal spraying in wildlife habitat improvement. Huntley and Arner (1982) recommend timing maintenance activities to ensure that brushy habitat is available throughout the year. They also recommend performing as much maintenance during winter months as possible to protect sensitive soils and ground vegetation.

A number of other papers explore the response of certain animal species to the presence and maintenance of transmission ROWs. White-tailed deer, in particular, are often chosen for study because they are quite ubiquitous and are relatively important as a big game species in Canada and the United States (Bramble, et al. 1985). Studies of white-tailed deer focus mainly

upon improving forage quality (Harlow, et al. 1993a; Harlow, et al. 1993b); maximizing the supply of available browse (Krefting, et al. 1969; Garant and Doucet 1993; Harlow, et al. 1993a.); and studying ROWs as potential habitat (Bramble, et al. 1985; Loft and Menke 1984; Eaton and Gates 1979; Doucet, et at. 1979; Jackson and Hecklau 1993).

Innovative deer habitat enhancement techniques include raising transmission towers in ‘deer yards’ (Doucet and Garant 1997; Lamothe and Dupuy 1982); developing ‘travel lanes’ for ease of species movement (Lamothe and Dupuy 1982; Doucet and Garant 1997); scheduling maintaining activities on ROWs during winter (Garant and Doucet 1993; Lamothe and Dupuy 1982); and "selective thinning" of dense vegetation (Eaton and Gates 1979) to leave as much cover and browse in place as possible. Travel lanes are wide forested corridors that stretch from one side of the ROW to the other, in between tower bases. Transmission towers are sometimes raised to ensure line clearance over these lanes. Selective thinning is used when travel lanes, or other forage areas, have become too thick for deer and other animals to utilize. The difference between selective thinning and selective cutting of vegetation is the type and amount of tree species removed from the ROS. Selective thinning removes target, as well as non-target species, in order to open an area to sunlight or create ease of access whereas selective cutting involves target species only. Selective thinning has also been recommended for maintaining songbird habitat (Burger 1973).

Small mammals such as rabbits and squirrels, ground-dwelling rodents and insectivores, have also been the subjects of several studies. Betsil, et al. (1979) evaluated a seeded and mechanically maintained ROW for its importance as habitat to cottontail rabbits before and after habitat manipulation, but found no significant difference in population levels between control and test areas. Doucet and Brown (1997) found that hares did not cross the ROW at all in winter in areas lacking cover. Squirrels were found to cross open ROWs, but preferred more heavily forested areas (Doucet and Brown 1996). Schreiber and Graves (1976) studied shrews and mice to see if either species would return home, across a ROW, when released. Both species did return, but shrews took longer and were less successful (Schreiber and Graves 1979). Ladino and Gates (1979) evaluated animal activity patterns within and bordering a ROW and found that significantly more animals were active just inside the forest edge, as opposed to on the ROW itself.

Johnson et al. (1979) concluded that small mammal diversity after construction and maintenance activities was higher in edge and ROW communities than in adjacent hardwood forests. Schreiber, et al. (1976) found that ROWs seriously affect species in forested regions with small ‘life areas’ due to gene pool fragmentation. The results of these two studies were used to identify and assess

potential regional impacts of ROWs on ecosystem operation and stability (Johnson, et al. 1979; Schreiber, et al. 1979).

Endangered species on ROWs received relatively little attention in the literature well into the 1990s. The few articles addressing endangered species of plants and animals on ROWs up until that time focus on woodpeckers (Jackson 1976), butterflies (Smallidge, et al. 1993), gnatcatchers (Stevens 1996), and endangered species generally (St. Clair and McFarlane 1979; Johnstone 1993). Although valuable in themselves, these studies do little to suggest how endangered species may be broadly addressed during regular ROW maintenance activities. More information may be available from Hydro Québec which in the 1990s developed a complete conservation program to address endangered species on ROWs in response to a governmental decree in the (Belzile and Cohen 1997). BC Hydro also initiated a robust research program to address wildlife species-at-risk on transmission ROWs in its northern region between 1997 and 2003 (Harriman 1999). When a utility cannot avoid endangered species' habitat during route selection, construction and maintenance, mitigation of damaged habitat should be performed (Belzile and Cohen 1997).

The US Fish and Wildlife Service published a major three volume document in 1979 to assist ROW managers and biologists in developing fish and wildlife habitat management plans for transmission ROWs (Galvin, et al. 1979; Hoover and Galvin 1979). Up until the late 1990s, this document remained unparalleled as a information source and a management tool for vegetation management strategies benefitting wildlife, however, it was not put to great use because it was adopted by utilities only a voluntary basis (DeCicco, et al. 1992).

In addition to the above research, surveys on wildlife, biodiversity, and ROWs began to appear in the mid-1970s. Lancia and McConnell (1976) consulted 312 electric and gas utility companies to determine whether or not they managed their ROWs for wildlife (note: not wildlife habitat). Twenty-four percent of the companies reported having a wildlife plan, and cited "vegetation maintenance to create wildlife habitat" as the most common initiative.

Asplundh Environmental Services conducted a US national survey of 269 utilities in order to review the ecological effects of overhead power transmission ROWs from the standpoint of middle-level managers (Cupit 1979). Part of this survey queried respondents on the importance of wildlife management objectives: “Responses indicated that vegetation control was the most important ROW management objective of the four we tested (soil conditions, water quality, vegetation control, wildlife enhancement); wildlife management was the least” (Cupit 1979: 52-8). This result might

have been expected, however, considering that one of a ROW manager's primary concerns is maintaining the reliability of the power supply.

A later survey of power utility biologists in the 1990s found that terrestrial biodiversity "is considered a major issue" by only a few utilities in Canada and the United States (Breece and Ward 1996: 799). In the opinion of Breece and Ward (1996), biodiversity on ROWs hadn't received much attention by that decade for several reasons:

> (1) There has not been a concentrated effort to promote biodiversity management on private lands; (2) many utility land managers think they have always managed for biodiversity, and it is just a new way of looking at the same thing; and (3) it is a new idea (p. 799).

However, nearly all respondents to this survey felt that biodiversity should be a goal for resource management (Breece and Ward 1996). Two other surveys administered by the US Power Plant Research Program support the results obtained in 1996 by Ward and Breece (Shaw Patty, et al. 1997). US and Canadian utility biologists indicated that:

> ...few states or utilities are directly addressing the biodiversity issue. Both surveys indicated that more than three-quarters of the utilities and state agencies (surveyed) feel that biodiversity will be an important issue in the future (Shaw Patty, et al. 1997: 409).

In summary, studies of wildlife habitat management on ROWs from the 1950s to the late 1990s primarily originated from the northeastern United States and focused mainly on: (i) finding vegetation maintenance technique(s) that produce desirable wildlife habitat; (ii) studying the effect of ROWs and maintenance activities on certain species of animals (particularly white-tailed deer); (iii) the standardization of wildlife habitat management on transmission ROWs; and (iv) and the extent to which utilities consider wildlife/ biodiversity in their management plans.

Beyond the literature explored here, there is a wide range of related literature published by scientists in disciplines such as forestry, biology, geography, zoology, ecology, and natural resource management that would be useful to explore. Additional information on biodiversity, soil structure, plant succession, restoration ecology, species-habitat relationships, and wealth of other subjects, is necessary to a better understanding of wildlife habitat management through vegetation management on transmission ROWs.

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Aura

WILDLIFE HABITAT MANAGEMENT STRATEGIES ON ELECTRIC UTILITY TRANSMISSION RIGHTS-OF-WAY IN NORTHERN BRITISH COLUMBIA[2]

All animals require food, water, cover and space in order to survive and reproduce. Habitat enhancement initiatives on transmission ROWs involve improving the quantity and/ or quality of these essential elements in some way. By altering traditional vegetation management activities, it is possible to provide supplemental sources of food and cover for local wildlife where it would be most beneficial. According to preferences for food and shelter, each animal species tends to occupy a distinct type of habitat. For example, moose divide their time between shrubby meadows and bogs during the summer and aspen stands with edge in the winter, cottontail rabbits favour 'living' brush piles, coyotes frequent open fields abundant in small prey, and black bears den in naturally occurring shelters.

Knowledge of wildlife species' preferred habitat features, as well as basic features needed for survival is key to constructing a useful habitat enhancement plan on any ROW. This knowledge ideally comes from personal interactions with the host landscape by ROW vegetation managers and local contractors, combined with additional appropriate advice from trained biologists and ecologists. It is important to note that contractors performing vegetation management to benefit wildlife should be well trained: poorly executed mowing, cutting, or spraying in the field can easily negate the potential benefits of a wildlife-sensitive prescription. A highly knowledgeable, well-trained team ensures vegetation maintenance prescriptions not only benefit the suite of species intended, but also ensure the integrity of the power supply while meeting budget objectives. The wildlife habitat enhancement techniques described below were observed over a 10-year period to consistently reduce the cost of vegetation management while still meeting budgetary, safety, and service standards.

Wildlife Habitat Enhancement Techniques

Wildlife habitat enhancement plans on transmission ROWs should take into account (1) the composition of local plant and animal life; (2) the characteristics of the chosen site including soil type; (3) the utility's regional management objectives; and (4) line clearance standards. With this in

[2] Between 1997 and 2002, Dr. Gunn (neé Harriman) conducted research on integrated resource management strategies for electric utility transmission rights-of-way in northern British Columbia. This material is adapted from: Harriman, Jill. 1999. Toward A Conceptual Framework for Integrated Resource Management on Electric Utility Transmission Rights-of-Way. Masters thesis. University of Northern British Columbia: Prince George, BC.

mind, vegetation management prescriptions can be altered in ways to produce a vegetative community that is (a) suitable as wildlife habitat; (b) biologically diverse; (c) free of undesirable tree species; and (d) non-threatening to the reliability of the power supply. Cost–efficient options for wildlife habitat enhancement techniques include selective herbicide application; selective and non-selective mowing; high-table mowing; selective hand-cutting; topping; seeding; windrows; woodpiles; preserving wildlife trees; nest management; special timing/ seasonal considerations; and no treatment. Most commonly, a combination of these techniques is used to enhance habitat for the range of species that are known to or are likely to use a specific section of a transmission ROW corridor. What follows is a brief description of the wildlife habitat enhancement techniques used extensively on transmission ROWs in BC Hydro's Northern Region between the late-1980s and late-1990s.[3]

Selective Herbicide Applications

Herbicide is applied to undesirable woody vegetation using a basal streamline, basal thinline, or backpack foliar method. Selective herbicide applications translocate chemicals into the root system to kill target tree species, but leave them standing until they fall naturally. These three application methods boast a high degree of precision and are designed to disturb only targeted tree species, therefore, they allow more food and cover to remain on the ROW and help to cultivate useful wildlife habitat. In a basal streamline and thinline applications, a solution containing Garlon is applied to the base of the targeted tree using hand-held equipment. These methods offer a high degree of precision, and are especially useful in environmentally sensitive areas. In a backpack foliar application, a herbicide solution is sprayed onto the foliage of the targeted tree using hand-held equipment. This method of vegetation control is less precise than basal bark treatments, and may cause drift, but it still allows targeted trees to remain as cover on the ROW. It is important to note that both the herbicide and the application method can be selective by nature. A selective herbicide combined with a selective application method is recommended. Selective herbicide applications have been successfully used to benefit ungulates, bears, small fur-bearers, birds, rodents, and canids.

Selective Mowing

Selective mowing is performed by wheel or track-mounted heavy-duty mowers equipped with a cutter blade and is used when target tree species are too large or too dense to be treated with herbicides. Mowing becomes "selective" when it is used in time and/ or space intervals, allowing a

[3] See Figure 4-6 on page 106 in Harriman (1999) for a detailed listing of the pros and cons, seasonal considerations, and other special notes associated with each technique. Illustrative photos with captions of wildlife enhancement techniques are also included in Appendix F on page 274 (Harriman 1999).

substantial amount of ROW vegetation to remain intact. Selective mowing may be performed in late winter, just before the frost has left the ground. This helps to minimize soil disruption and maximize the amount of browse left on the ROW during winter months. Mowing treatments are often followed with a selective herbicide application after a couple of growing seasons have passed. Selective mowing helps to create a mosaic of vegetative cover types for wildlife and prevents large sections of ROW from standing entirely bare (especially important for browsing ungulates). Even on the widest transmission ROWs (with as many as three 500kV lines), a vegetative mosaic may be achieved. Selective mowing has been successfully used to benefit ungulates, small fur-bearers, and rodents.

Non-Selective Mowing

Non-selective mowing is generally restricted to areas of the ROW that have not been treated since the line was built, or where a vast, dense, mature vegetation community persists. Where tree trunks are numerous and closely interspersed, the vegetation is completely mowed. This act may be used to rejuvenate early successional vegetation in the area. Non-selective mowing can quickly and dramatically increase an area's abundance in wildlife food plants and open the ROW floor to sunlight, however, it may also promote aggressive second generational species such as aspen and birch. Thus, a maintenance program involving seeding, selective herbicides and selective cutting should then be implemented to carefully treat the re-sprout and eventually transition the site to a stable, diverse mid-successional vegetative community. Non-selective mowing has been successfully used to benefit ungulates, bears, and small fur-bearers.

High-Table Mowing

This technique is performed using an excavator mower or by chainsaw and is done by cutting the trunks of selected conifers or willows that have exceeded clearance standards at approximately waist height. As most of the tree's lower branches remain intact, the tree has a good chance to survive this treatment.[4] Conifers cut at waist level continue to grow horizontally and become quite bushy as multiple leaders compete to direct growth vertically. As rainwater collects in the conifer's exposed cut, wood decay fungi develop and cause the cut surface to rot. As the new leader and the old branches grow larger and heavier, combined weight strains the rotting area and eventually breaks the tree off, negating the need for further trimming or cutting. Conifers that die after high-table mowing are potentially as beneficial to wildlife as those that do not survive. A dead, waist-high

[4] A variation on this technique is to create "living" brush piles by cutting part way through the stems of five or six smaller deciduous trees and bending their tops toward a common center, allowing the butt to remain attached to the stump. This is called “hinge-cutting” and is done to ensure that the tree does not die immediately. Cuts should be made after sap has risen and leaves have fully matured. For further information, see: Payne, N. and F. Bryant (1994) Techniques for Wildlife Habitat Management of Uplands. McGraw-Hill, Inc.: USA.

conifer still offers cover to wildlife and does not interfere with the growth of other vegetation. In addition, dead or fallen conifers eventually fill with ants, which is a favourite snack for bears. Willows cut at waist level provide an excellent source of browse for moose, as they are cut to a height that is readily accessible to ungulates throughout the spring and summer. The more heavily a willow stand is browsed, the more shoots it will produce which retards vertical growth and reduces the need for continuous maintenance. High-table mowing especially helps to keep willow browse above snow-level during winter months. High-table mowing has been successfully used to benefit ungulates, bears, small fur-bearers, rodents, birds, insects, and canids.

Selective Hand-Cutting

Selective hand-cutting is performed by chainsaw, brush saw or other hand-held equipment, and is one of the most selective methods of removing trees. Hand-cutting is generally performed by a small crew over a short period of time, and is minimally disruptive to local wildlife habitat. It is often used to treat target species in riparian zones and other environmentally sensitive areas. If desirable, selective cutting may be followed by a small herbicide application to the tree's cut surface in order to prevent re-sprout. Selective cutting and "cut and treat" (i.e. selective cutting followed up with selective herbicide treatment to the stump) leaves the ground unbroken, uses a minimal amount of herbicide, effectively opens the ROW floor to sunlight, and further develops a mosaic of vegetative cover types. Selective hand cutting and “cut and treat” have been successfully used to benefit bears, ungulates, small fur-bearers, rodents, and birds.

Tailored Seeding

Seeding the ROW is performed by attaching a seed distributor to an all-terrain vehicle or by using a belly-grinder, which is a seed drum strapped to a worker who operates a hand-crank. Either method is used to spread a seed mix directly onto the exposed soil after being disturbed by heavy machinery, road maintenance, or by other means. Seeding the ROW as soon as possible after disturbance generally acts to stabilize the ground and return the area to a more natural state. Standard seed mixes can, for example, can be altered to include more clover for bears or more crested wheat grass for birds and rodents. Virtually any seed mix may be applied to the ROW as long as it is an effective soil stabilizer and is compatible with the local bio-geo-climatic zone. The seed mix should include or be entirely composed of native species if possible. Seeding represents an excellent opportunity to create an additional source of food and cover for wildlife on the ROW and should be done in consultation with knowledgeable professionals. Tailored seeding has been successfully used to benefit deer, elk, small fur-bearers, rodents, birds, and insects.

Windrows

After undesirable tree species have been cut or mowed on the ROW, they are often chipped, mulched, burned, or hauled away. Another option is to pile cut debris into windrows. Windrows are linear piles of slashed trees that run either parallel to the ROW (for movement down slopes) or perpendicular to the ROW (for movement across). Most windrows are built approximately half a meter high and ideally are spaced about one meter apart from one another. Windrows are quickly overgrown by native grass communities and make excellent "living" brush piles. After several seasons, every other windrow may be burned to reduce fuel loading. Windrows are designed to (i) aid the movement of animals when crossing the ROW; (ii) provide a windbreak; (iii) encourage the growth of small animal populations by providing alternative nesting and burrowing opportunities; and (iv) stabilize loose soil and grass communities. Windrows have been successfully used to benefit deer, small fur-bearers, rabbits, rodents, ground-nesting birds, raptors, and canids.

Woodpiles

When it is necessary to fell full-grown trees, refuse may be hauled to a place where it can be cut and piled into one or more large mounds. Woodpiles can be constructed on level ground or in a slight depression and are especially attractive to wildlife when situated near the edge of the ROW. Mounds should be large enough to allow small animals to create tunnels within. Like chipping and mulching, woodpiling keeps the ROW clear of large, unorganized debris that may cause future access problems. However, unlike chipping and mulching, woodpiles create excellent habitat for small animals, snakes and reptiles (where they occur). Woodpiles that remain in place over several seasons quickly become an integral part of the surrounding wildlife habitat. Many of the same beneficial effects can also be achieved by constructing rock piles. Woodpiles have been successfully used to benefit rodents, small fur-bearers, snakes, reptiles, birds, and canids.

Nest Management

During vegetation management activities, crews on foot or operating mowers often encounter active birds' nests in risk trees targeted for removal. Provided that such a tree does not present any immediate danger to power reliability, it may be flagged and left standing at least for the remainder of the season. Ideally, trees that have nests would be removed after the young birds have successfully fledged. Timing of treatment is important to avoid disturbance of nest building, nesting, and fledging. Some raptors, such as osprey, build nests on top of transmission towers. Because osprey tend to build onto the same nest year after year, some nests eventually pose a risk to the power supply. Although not a vegetation management technique, oversized nests can be trimmed back by maintenance crews, instead of being removed. Making a special effort not to destroy the

nests of birds is one of the simpler ways to create ROWs that are more suitable as wildlife habitat. Nest management has been successfully used to benefit osprey, songbirds, ground-nesting and other birds.

Preserving Wildlife Trees

Wildlife trees, also referred to as snags, are mature standing trees that have died or are dying and are of value to birds, small animals, and insects. Wildlife trees are usually created through natural processes, but may also be created by maintenance crews by first topping and then girdling or chaining the tree. Snags are a common feature of wildlife habitat in any forested area, and help to maintain biodiversity on the ROW. Wildlife trees should be identified and preserved during maintenance activities whenever possible. Wildlife trees have been successfully used to benefit birds, small fur-bearers, insects, and bears.

Cattle Grazing and Farming

Cattle grazing and farming, as secondary uses of a ROW, are helpful to establish low-growing ground cover, which prevents vegetation from contacting overhead power lines. Grazing cattle are somewhat compatible with browsing ungulates because they do not compete directly for food found on the ROW. Being grazers, cattle do not feed on many of the small trees and shrubs that are attractive to moose, elk, and deer (unless the ROW becomes over grazed, which should be avoided). Grazing cattle also require a sufficient water supply on the ROW. Dugouts installed for cattle may provide an additional source of water for local wildlife, but ideally should be surrounded by taller vegetation in order to conceal its users from predators and poachers. As well, to ensure food for elk and deer on the ROW during winter, grazing activities should be stopped in enough time to establish a good grass cover before the snow falls each season. In grassland areas on ROWs, some level of tree maintenance will still be required. Farming does not directly benefit many larger wildlife species, but grain crops still help to provide cover and some food for smaller animals and insects on the ROW and reduce tree maintenance required by the utility to an absolute minimum. Field stubble is often utilized for food by deer and elk during the winter. Cattle grazing and farming have been successfully used to benefit moose, elk, deer, small birds, rodents, raptors, and canids.

Timing/Seasonal Considerations

Timing of maintenance activities on transmission ROWs is critical. Each season holds a different meaning to different species of wildlife. If at all possible, maintenance activities should be timed to minimize disturbance to wildlife during calving, nesting, mating, and other periods of special need. Especially, maintenance activities should not remove food and cover from the ROW in late fall, in

order to avoid shortages during winter. The additional supply of food and cover provided by ROW vegetation can be critical to wildlife in a hard winter. Each season also holds different opportunities for vegetation maintenance activities. For example, when snow conditions are favourable, mowing is best performed in late winter when the ground is still frozen (ideal when treating marshy areas) and ungulates are past their greatest time of need. Timing and seasonal considerations should play a major role in the design of a proper maintenance prescription. Careful timing of maintenance activities is known to benefit a wide range of wildlife species.

No Treatment

For some areas on the ROW, no treatment is the most desirable form of wildlife habitat enhancement. In areas where ground-to-line clearance is greater than usual (eg. in a valley, or at a river crossing), ROW vegetation need not be removed or disturbed in any way, except to top the few trees that may rise above the canopy. This situation is not usually predicated on habitat values, however. More often, "no treatment" zones are established as such simply because the vegetation no longer threatens power reliability and doing so reduces annual maintenance costs. Regardless, "no treatment" zones offer some sanctuary on the ROW for many wildlife species. Conversely, there are areas on the ROW where it is best to keep the vegetation (including desirable species) clipped short. This technique, generally used near road crossings, is intended to reduce the number of accidents caused when animals feed near the roadside. Sheared vegetation improves the driver's line of sight and attracts fewer animals, but also removes the screening required to reduce poaching. This trade-off must be considered on a case-by-case basis to ensure the greatest benefit to wildlife possible. Prescribing no treatment in certain areas can benefit a wide range of wildlife species.

As mentioned earlier, the habitat enhancement techniques outlined above will be most successful if they are applied in the proper context. For example, some areas of the ROW are naturally suited to grizzly bears, while others make excellent moose range. A maintenance prescription to enhance deer habitat will be somewhat futile if deer do not usually frequent that area. This is why an understanding of wildlife habitat preferences (and the seasonal needs of wildlife) is so important when designing habitat enhancement prescriptions. Before a program is developed, each section of the ROW should be carefully scrutinized in order to assess its potential as wildlife habitat. Often, clues are provided by the animals themselves and these should be very closely regarded. Tracks, trails, and droppings may be found throughout the year, and are especially visible during winter.

Ultimately, the goal of vegetation management on ROWs is to minimize the need for regular maintenance, and maximize the density and diversity of desirable plant species. The techniques described above, among others, are tools that can enable the ROW manager to achieve this goal and simultaneously benefit local wildlife species.

Aura

BIBLIOGRAPHY OF RECENT LITERATURE ON VEGETATION MANAGEMENT TO BENEFIT WILDLIFE HABITAT ON ELECTRIC UTILITY TRANSMISSION RIGHTS-OF-WAY: 2000 – PRESENT

Since 2000, four more International Symposia on Environmental Concerns in Right-of-Way Management have occurred:

- 7th Symposium took place in Calgary, Alberta in 2000. See: http://www.rights-of-way.org/17symp.htm for more information
- 8th Symposium took place in Saratoga Springs, New York in 2004. See: http://www.rights-of-way.org/18symp.htm for more information
- 9th Symposium took place in Portland, Orgeon in 2009. See: http://www.rights-of-way.org/19symp.htm for more information
- 10th Symposium took place in Phoenix, Arizona in 2012. See: http://www.rights-of-way.org/19symp.htm for more information (proceedings not yet released).

The proceedings for these symposia, while not addressed here, will be a rich source of relevant information. Below are citations and abstracts for 22 additional works with information on vegetation management to benefit wildlife habitat on transmission ROWs.

• AMEC Americas Limited (2010). *Environmental Overview Assessment: Merritt Area Transmission Project*. Submitted to: B.C. Hydro.

Executive Summary: The Merritt area is currently supplied by a single 69 kV transmission line from Highland Substation and load growth in the Merritt area is approaching the maximum supply capability of the system. BC Hydro is proposing to upgrade the power distribution system to increase the transmission power supply to the municipality of Merritt, BC, through the upgrade of an existing transmission line or the construction of a new 138 kV transmission line from either Highland substation or Nicola substation. This report provides an overview environmental assessment of the Merritt Area Transmission Reinforcement Project ('the Project') which investigates three alternative means to increase the electrical supply to the Merritt area.
The Project is not expected to require an environmental assessment under the British Columbia Environmental Assessment Act or the Canadian Environmental Assessment Act. However, this overview environmental assessment was conducted so BC Hydro could consider the environmental and socio-economic impacts of each alternative during the planning stage of the Project to help select the best corridor route. The environmental overview assessment identifies potential impacts of the Project on fish and aquatics, wildlife, vegetation, human environment, heritage resources and contaminants. It is based on information from a desktop review and field reconnaissance of the route alternatives conducted in August 2010. Mitigations are identified and discussed in order to minimize or avoid residual impacts of the Project. Potential effects of the Project include loss of habitat for

fish, vegetation and wildlife. However, if Best Management Practices are implemented, and work windows applied the majority of Project impacts can be reduced or eliminated for all disciplines. From a fish and fish habitat and socio-economic baseline and impact perspective, there is no measurable difference of impacts among the alternative power transmission line routes under consideration. Further, there are no differences between the socio-economic effects assessment of the transmission line and the substations. Vegetation losses generally include localized species loss and rare ecosystem alteration, primarily in alternative 2. Wildlife impacts have been identified as generally low to nil for each alternative if BMPs are implemented. However, the choice of alternative is important for species at risk as alternative 2 has the highest potential to impact rare species and their habitats. For non-traditional land use, the overall impacts are expected to be minimal with the exception of moderate potential impacts to agriculture and the private land base in alternative 2. The number of crown tenures (dispositions) affected is expected to be highest in alternative 1A.From an archaeology perspective, both alternatives 1A and 2 have the highest diversity of site types, and alternative 2 has the highest number of areas with moderate-high archaeological potential. The highest number of archaeological sites potentially impacted by the Project activities is expected to be associated with alternative 1B. Once a final route alignment has been selected, BC Hydro will develop an Environmental Management Plan (EMP) prior to the start of construction. The EMP will detail the permitting requirements, mitigation procedures and Best Management Practices (BMP) to be implemented during Project construction to ensure that potential impacts of the Project.

• Askins, R. A., Folsom-O'Keefe, C. M., Hardy, M. C., & Hayward, M. (2012). "Effects of vegetation, corridor width and regional land use on early successional birds on powerline corridors." *PLoS ONE*, *7(2)*, e31520.

Abstract: Powerline rights-of-way (ROWs) often provide habitat for early successional bird species that have suffered long-term population declines in eastern North America. To determine how the abundance of shrubland birds varies with habitat within ROW corridors and with land use patterns surrounding corridors, we ran Poisson regression models on data from 93 plots on ROWs and compared regression coefficients. We also determined nest success rates on a 1-km stretch of ROW. Seven species of shrubland birds were common in powerline corridors. However, the nest success rates for prairie warbler (*Dendroica discolor*) and field sparrow (*Spizella pusilla*) were <21%, which is too low to compensate for estimated annual mortality. Some shrubland bird species were more abundant on narrower ROWs or at sites with lower vegetation or particular types of vegetation, indicating that vegetation management could be refined to favor species of high conservation priority. Also, several species were more abundant in ROWs traversing unfragmented forest than those near residential areas or farmland, indicating that corridors in heavily forested regions may provide better habitat for these species. In the area where we monitored nests, brood parasitism by brown-headed cowbirds (*Molothrus ater*) occurred more frequently close to a residential area. Although ROWs support dense populations of shrubland birds, those in more heavily developed landscapes may constitute sink habitat. ROWs in extensive forests may contribute more to sustaining populations of early successional birds, and thus may be the best targets for habitat management.

• Bulluck, L. P., & Buehler, D. A. (2006). "Avian use of early successional habitats: Are regenerating forests, utility right-of-ways and reclaimed surface mines the same?" *Forest Ecology and Management*, *236(1)*, 76-84.

Abstract: The importance of early successional habitats for breeding and post-breeding birds has received recent attention. Common early successional habitats in the eastern United States are

regeneration after timber harvests, utility right-of ways and reclaimed surface mines. Few studies, however, have compared the characteristics of these with regard to avian habitat use. We conducted a passive mist-netting study to assess the breeding and post-breeding avian communities associated with these land uses in the Cumberland Mountains of eastern Tennessee. We used analysis of variance to compare the vegetation structure among these habitat types and discriminant function analyses to illustrate differences in vegetation structure and bird abundance among habitats. We banded 1562 individuals of 40 species (1.08 birds/net-hour). The percent cover of saplings, forbs and grass differed among habitat types, but there was no detectable difference in shrub cover. Vegetation structure allowed good discrimination between habitat types (Wilks' $\lambda = 0.16$), specifically in differentiating clearcuts from surface mines and right-of-ways. Although the three habitat types had several avian species in common, the abundance of 12 species differed substantially among habitat types, and their species abundance patterns allowed for excellent discrimination between these habitat types (Wilks' $\lambda = 0.08$). We conclude that these three early successional habitat types are different with regard to vegetation structure and avian community assemblage. These differences are important for local and landscape-scale conservation planning for both early and late successional avian species.

• Cogliastro, A., Benjamin, K., & Bouchard, A. (2006). "Effects of full and partial clearing, with and without herbicide, on weed cover, light availability, and establishment success of white ash in shrub communities of abandoned pastureland in southwestern Quebec, Canada." *New Forests*, *32(2),* 197-210.

Abstract: Shrub communities established on former pasture land are currently under-used and their forestry potential is of interest to land owners wishing to increase valuable hardwood regeneration on their properties. The comparative effects of strip clearing and total clearing, both treatments applied with or without herbicide, on competing vegetation cover, light availability, and survival and growth of planted white ash (*Fraxinus americana* L.) were examined in two different shrub dominated sites for 3 years in southwestern Québec, Canada. Survival was high in all treatments. At the site with the richest soil and in comparison to total clearing, strip clearing produced the lowest light level in the third year, which induced lower total herbaceous weed cover. These combined effects produced the same growth results for white ash seedlings in all treatments. At the second site, with the highest woody vegetation regrowth, strip clearing has promoted seedling height growth and produced the highest height: diameter ratio for white ash. This ratio was also superior at this site in the absence of herbicide. Treatment effects were soil/site dependant. Because partial clearing in strips has never reduced tree growth in comparison to total clearing, it represents a promising method for the establishment of valuable hardwoods in shrubby vegetation, with lower management intensity and lower landscape impact than total clearing.

• Courbin, N., Fortin, D., Dussault, C., & Courtois, R. (2009). "Landscape management for woodland caribou: the protection of forest blocks influences wolf-caribou co-occurrence." *Landscape Ecology, 24(10)*, 1375-1388.

Abstract: Various management plans have been developed to mitigate the effects of human activities on threatened woodland caribou (Rangifer tarandus caribou) populations. Most plans do not account for the behavior of wolves (Canis lupus), their main predator. The success of caribou recovery plans may nonetheless depend on how landscape management shapes wolf-caribou interactions. We evaluated the species-specific responses of caribou and wolves to a management plan in Que´bec, and assessed its impact on the probability of wolf-caribou co-occurrence. Landscape management consisted of the protection of large forest blocks, and the spatial aggregation

of cutblocks. Based on telemetry data, we modeled animal-habitat spatial relationships with resource selection functions, and then estimate the relative probability of wolf-caribou co-occurrence. We found that caribou selected mature conifer forests with lichen. Wolves selected mixed and deciduous stands. Caribou avoided roads and cutblocks, while wolves selected them, which resulted in a relatively low probability of co-occurrence in harvested areas. Concurrent habitat selection by the two species was such that the highest probability of wolf-caribou co-occurrence took place in protected forest blocks (PB) from December to May. For efficient mitigation measures, the location of PBs should be selected while accounting for differences in habitat selection between wolf and caribou. The blocks should include mature conifer forests with lichen, minimize the abundance of mixed and deciduous stands, and be far from roads and cutblocks. Consideration of predator behavior can improve suitability of landscape management plans for the long-term persistence of threatened prey populations under top-down control.

• de Blois, S., Brisson, J., & Bouchard, A. (2004). "Herbaceous Covers to Control Tree Invasion in Rights-of-Way: Ecological Concepts and Applications." *Environmental Management, 33(5),* 606-619.

Abstract: In northeastern America, thousands of kilometers of utility rights-of-way (ROWs) have to be managed to prevent the establishment of a tall vegetation cover that does not comply with safety and maintenance regulations. Recent decades have seen the emergence of ecologically based vegetation control strategies to reduce environmental impacts as well as maintenance costs. One such strategy is to take advantage of competitive herbaceous covers to limit tree invasion. This approach, however, as well as its fundamental underlying principles, has been little scrutinized. In this article, (1) we present the main ecological concepts supporting the use of a herbaceous cover to limit tree invasion, emphasizing naturally forested ecosystems of northeastern America. They include reported evidence of stable plant communities and an overview of potential underlying mechanisms of inhibition. (2) We then review field applications, specifically testing the ability of seeded herbaceous covers to control tree invasion in ROWs. (3) We discuss unresolved issues relevant to management and research. The available evidence suggests that seeding herbaceous covers in ROWs can help control tree invasion, but many issues still limit broad-scale applications. The various interactions that govern plant community dynamics are far from being fully understood, so selecting species still largely depends on an empirical approach. Patterns of resistance to tree invasion must be investigated over a wide range of spatial, historical, and environmental contexts to determine effective management and seeding practices that will lead to broad-scale applications. We suggest establishing communities rather than single dominant species and using as much as possible native species to limit risks of invasion.

• Guggenmoos, S. (n.d.). *Herbicides: Not a Silver Bullet.* Ecological Solutions Inc.

Abstract: Over decades research has shown herbicides not only to be a cost effective brush control tool but in many circumstances a superior environmental choice to brush cutting. Too often, however, vegetation managers build unrealistic expectations about the durability of results based on constrained budgets necessitating a magic bullet or enthusiasm generated when assessing a first time herbicide application. This article seeks to build an understanding of why herbicides provide effective brush control; what should be expected to occur on the right of way in the future; data verifying the expectations; and, the origins of economic gains. Discussion is restricted to right of way brush control.

• Johnstone, R. (2008). Integrated Vegetation Management. 5-17. (Note: unable to locate complete citation details)

Description: The science of integrated vegetation management (IVM) can trace its roots to the invention of modern herbicides following World War II. Dr. William C. Bramble and Dr. William R. Byrnes started research on electric transmission rights-of-way (ROW) in 1952 in the hills of central Pennsylvania because of a concern by that state's deer hunters that herbicides were harming their largest game animal. The two researchers were able to show that the deer hunters' fears were unfounded because herbicides proved to be a valuable tool in developing plant cover diversity for deer and a number of other animals and plants (Bramble and Byrnes 1976, 1983). The studies continue to monitor plant community changes following various vegetation maintenance procedures (hand cutting, mowing, broadcast and selective herbicide applications, or a combination of treatments) and their relative effect on a multitude of plants and animals. Small mammals (Bramble et al. 1992), birds (Bramble et al. 1994), butterflies (Bramble et al. 1997; Bramble et al. 1999), and reptiles and amphibians (Yahner et al. 2001) have all been shown to benefit from the proper use of herbicides in developing and maintaining habitat diversity. While the Bramble and Byrnes scientific studies are well known by utility arborists, they have received little attention within federal and state land management agencies. A cultural divide seems to have originated in the 1960s, when the environmental movement grew up, along with a belief that, during the unpopular Vietnam War, the military abused herbicides in jungle warfare. Any mention of chemical control by a utility was equated with wanting to use "Agent Orange." This bias against herbicides continued to cloud natural resource management decisions for the next 40 years. Some utilities chose to abandon herbicide use altogether in order to appear more environmentally conscious (Electrical World 1991).

• King, D. I., Chandler, R. B., Collins, J. M., Petersen, W. R., & Lautzenheiser, T. E. (2009). "Effects of width, edge and habitat on the abundance and nesting success of scrub–shrub birds in powerline corridors." *Biological Conservation, 142(11),* 2672-2680.

Abstract: Concern about declines in scrub–shrub bird populations has resulted in efforts to create and maintain habitat for these species. Vegetation within powerline corridors is managed to prevent contact of vegetation with transmission lines, and comprises approximately 2% of all of habitat for scrub–shrub birds in southern New England. Although previous studies have documented the use of powerline corridors by scrub–shrub birds, important questions remain about the factors affecting the quality of corridors as habitat for these species. We surveyed birds and monitored nests on 15 corridors in western Massachusetts during 2002 and 2003 to determine whether scrub–shrub birds occupy and successfully reproduce in powerline corridors, and to identify the principal factors affecting scrub–shrub abundance and nesting success. We found that corridors were occupied by scrub–shrub birds of high regional conservation priority, however, four of seven focal scrub–shrub bird species were scarce or absent in narrow corridors, and the abundance of these species was highest in corridors of intermediate width. Overall, nest survival was low (0.14) at these sites relative to other types of early successional habitats in the region, however, if we consider only our sites that were wider than the median width (≥49 m), nest survival in corridors was (0.33), similar to survival rates reported in other studies of scrub–shrub birds. We conclude that powerline corridors provide habitat for early successional birds of conservation concern, with wider corridors (≥50 m) contributing more to regional conservation of these species.

• Komonen, A., Lensu, T., & Kotiaho, J. S. (2012). Optimal timing of power line rights-of-ways management for the conservation of butterflies. *Insect Conservation and Diversity*, 1-8.

Abstract: 1. Habitat loss, fragmentation, and degradation are the main threats to biodiversity. Human activities also create new habitat types that might fulfil ecological requirements for a variety of species. 2. This study investigates whether the vegetation clearing (=shrub and tree cutting) on drained mire patches on power line rights-of-ways (ROWs) keep plant communities in an early successional stage and thus provide habitats for mire specialist and non-mire butterflies. It was further studied what would be the optimal clearing interval in terms of butterfly species richness and abundance. 3. The results show that tree height, especially the height of birch, increases linearly over the 7-year period following vegetation clearing. The average birch height had a significant negative relationship with the species richness of mire and non-mire butterflies. 4. The clearing interval had a significant curvilinear relationship with the abundance of both mire and non-mire butterflies, such that the highest abundances were documented two to four growing seasons after the clearing, which would hence be the ecologically optimal vegetation clearing cycle. 5. In general, vegetation management on power line ROWs enhance favourable conditions for butterflies and may maintain habitats for mire-dependent butterflies, even on drained mires.

• Lanham, J. D., & Whitehead, M. A. (2011). "Managing early successional habitats for wildlife in novel places." *Sustaining Young Forest Communities*, 209-224.

Abstract: Utility rights-of-way stretch for thousands of kilometers across the North American landscape. In deciduous forests of the Central Hardwood Region, rights-of-way provide opportunities for conserving early successional species, including a broad array of songbirds and butterflies. Although the millions of hectares managed by the utility industry to provide electricity, natural gas, and other services are not usually viewed by the public as beneficial for wildlife conservation, we suggest that rights-of-way can be valuable early succession habitats in addition to more "traditionally" created areas like clearcut harvests.

• Marshall, J. S., & Vandruff, L. W. (2002). "Impact of selective herbicide right-of-way vegetation treatment on birds." *Environmental Management*, *30(6)*, 801-806.

Abstract: Power line rights-of-way provide a major portion of the shrub habitat in New York. Since this habitat type is on the decline, many of the birds dependent on shrub habitat are also declining. The methods used to control right-of-way vegetation could therefore have serious impacts on several birds of conservation concern. Since New York is increasingly using selective herbicide treatments in vegetation management, we sought to investigate the potential impacts of these treatments on nesting birds. The study looked at plots in two adjacent rights-of-way before and after a selective herbicide treatment in one of the rights-of-way. We investigated three bird species: alder flycatcher (*Empidonax alnorum*), chestnut-sided warbler (*Dendroica pensylvanica*), and gray catbird (*Dumetella carolinensis*). All three species exhibited a preference for shrub vegetation around nest sites. The selective herbicide treatment did not significantly decrease that shrub vegetation, and neither the density nor the nesting success of the three species declined following the treatment. We conclude that selective herbicide vegetation management encourages the development of shrub habitat without negatively impacting the birds nesting in the habitat.

• Mercier, C., Brison, J., & Bouchard, A. (2001). "Demographic Analysis of Tree Colonization in a 20-Year-Old Right-of-Way." *Environmental Management, 28(6)*, 777-787.

Abstract: Past tree colonization dynamics of a powerline-right-of-way (ROW) corridor in the Haut-Saint-Laurent region of Quebec was studied based on the present age distribution of its tree populations. This colonization study spans 20 years, from 1977 (ROW clearance) to 1996. The

sampled quadrats were classified into six vegetation types. Tree colonization dynamics were interpreted in each type, and three distinct patterns were identified. (1) Communities adapted to acidic conditions were heavily colonized by *Acer rubrum*, at least for the last 12 years. (2) Communities adapted to mesic or to hydric conditions were more intensely colonized in the period 1985–1987 than in the following 9 years; this past success in tree colonization may have been caused by herbicide treatments, which could have facilitated tree establishment by damaging the herbaceous and shrub vegetation. (3) Cattail, vine-raspberry, and reed-dominated communities contained few tree individuals, with almost all trees establishing between 1979 and 1990; those three vegetation types appear as the most resistant to tree invasion in the ROW studied.
This study supports the need for an integrated approach in ROW vegetation management, in which the selection of vegetation treatment methods would depend on the tree colonization dynamics in each vegetation type. Minimizing disturbances inflicted on ROW herbaceous and shrub covers should be the central strategy because disturbances jeopardize natural resistance to future tree invasion, except in communities adapted to acidic conditions where the existing vegetation does not prevent invasion by *A. rubrum*. Many trees are surviving the successive cutting operations by producing new sprouts each time, particularly in communities adapted to mesic and hydric conditions. In these cases, mechanical cutting should be replaced by a one-time stump-killing operation, to avoid repeated and unsuccessful treatments of the same individuals over time.

• Nesmith, J. C. (2004). *Stable, low-growing plant communities in the western Cascade Mountains: species processes and their implications for rights-of-way management*. (Master's Thesis). Oregon State University, Corvallis.

Abstract: The processes that lead to stable, low-growing plant communities and the characteristics of the species that form them are of great interest to rights-of-way (ROW) managers and others wishing to better understand plant community resistance to tree invasion on managed landscapes. The use of stable, low-growing plant communities as a mechanism to control tree invasion on ROWs has been widely acknowledged, but little is known about what plant characteristics lead to stable communities or how different treatment methods affect low-growing communities in the Pacific Northwest. The goal of this study was to assess the resistance of stable, low-growing communities to tree invasion on ROW in the Pacific Northwest and to identify common characteristics among the species in these communities that contributed to the formation of stable communities. To address this goal, we investigated 1) the abilities of different species within the low-growing component of the ROW communities to resist invasion by trees and to fill newly created gaps caused by disturbance, 2) the growth patterns and potential for vegetative reproduction of trailing blackberry (Rubus ursinus Cham and Schlecht) and creeping snowberry (Symphoricarpos mollis Nutt.) to understand how different clonal propagation patterns affect spread into unoccupied space and infilling of currently colonized areas, and 3) the effectiveness of several common vegetation control methods for reducing the density of undesirable species and promoting the development of low growing plant communities on ROW. These factors are important processes that determine the stability of a low-growing plant community. This project was conducted at three sites in the western foothills of the Cascade Mountains of Oregon and Washington. Species composition and abundance was measured in roughly 330 2x2 m plots at each site prior to the application of three different treatments aimed at removing tall-growing target species. The plots were measured again two years later to assess changes in species cover. The growth pattern and architecture of trailing blackberry and creeping snowberry was also investigated through the careful excavation of both individual plants and lxi m plots centered in dense thickets of each species. The various treatments used in this study resulted in an average increase in non-target cover of 65% from 2000 to 2002 while reducing tall target cover by an average of 53%. No difference was found in the change in average non-target

cover or tall target cover among treatments. The effectiveness of the various treatments in reducing target cover varied significantly based on the type of target species being treated. There were no strong differences in resistance among the common low growing species to invasion by tall target species. The range in increase in tall target cover in plots dominated by low-growing species was highly skewed, as tall target cover increased very little in many plots and by as much as 28% in a very few. In the first two years following disturbance, shrubs capable of rapid horizontal expansion through vegetative reproduction, such as trailing blackberry and bracken fern (Pteridium aquilinum), were most successful filling gaps. Their ability to expand rapidly led to their high abundance following disturbance. The successful colonization of gaps by trailing blackberry was a result of its growth pattern, which focused on rapid spread as this species produced new canes annually that grew up to 1.9 m during their first year. This may allow it to be a successful colonizer of gaps. It was also capable of forming dense thickets and averaged 113 stems/m2. The growth pattern of creeping snowberry, which focused more on infilling, may allow it to maintain areas of dense, persistent cover, as it averaged 237 stems/m2 in dense thickets. It was also capable of horizontal spread through the initiation of new ramets along creeping stems. These stems averaged 0.6 m during their first year of growth. Both strategies of growth and spread allowed these shrubs to form thickets of dense vegetation. The use of stable low-growing plant communities as a management tool to reduce tree seedling establishment and growth can have many benefits including reduced costs due to lower tree density and longer periods of time between treatments, increased wildlife habitat, and aesthetic appeal. However, for this management approach to be most successful, one must have an understanding of the plant community where it is being applied, the plant characteristics that will lead to the formation of stable, low-growing communities, and how the different available treatment options will affect the resulting plant community. This study addressed many of these topics to produce a more comprehensive understanding of how stable, low-growing plant communities can be used as a management tool for reducing tree invasion in the Pacific Northwest. The two-year duration of this study, while allowing for many new insights, limited the scope of some of our conclusions. Continued monitoring of these research sites, as has been done in several locations in the northeast United States, would greatly increase the strength of our conclusions.

• Scurrah, F. E., & Schindler, D. W. (2010). "Towards a Manitoba Hydro boreal woodland caribou strategy: Outcomes." *Rangifer, 32(2),* 115-124.

Abstract*:* Manitoba Hydro is responsible for the continued supply of energy to meet the needs of the province and is committed to protecting the environment when planning the construction and operation of its facilities. Corporate policy dictates ongoing improvement of Environmental Management Systems (EMS) in order to meet or surpass regulatory requirements. Environmental objectives are reviewed annually and programs are modified when necessary to address improvements in environmental performance. Manitoba Hydro plans and constructs major transmission projects throughout northern Manitoba, which includes areas occupied by boreal woodland caribou. In recognition of the potential issues associated with hydro transmission construction in boreal caribou range, Manitoba Hydro hosted an expert workshop on May 8, 2007 to provide objective advice in the development of a draft corporate strategy that effectively directs targeted monitoring and research for environmental assessment and mitigation. The workshop focused on assessing the potential threats to boreal woodland caribou from a transmission line construction and operation perspective, and identifying appropriate approaches in site selection and environmental assessment (SSEA) and long-term monitoring and research. A total of nine threat categories were reviewed to determine the degree and magnitude of potential effects that may result from transmission construction and operation; and of the original nine, five final threat categories were delineated. The main elements of the workshop provided strategic approaches for proactive

pre-construction monitoring, research on recruitment and mortality for local populations impacted by ROWs and control areas, and various habitat monitoring, management, and mitigation techniques. Research and monitoring priorities have been identified and continued collaboration with Manitoba Conservation and other land users were also identified.

• Smith, M. B., Aborn, D. A., Gaudin, T. J., & Tucker, J. C. (2008). "Mammalian predator distribution around a transmission line." *Southeastern Naturalist*, *7(2)*, 289-300.

Abstract: The effects of a transmission line right-of-way (TROW) on the distributions of mammalian predators were investigated by placement of track plates at specific locations. A total of 50 tracks were detected. The large-bodied carnivores exhibited a strong preference for the TROW (χ^2 = 8.652, 2 df, p = 0.013). In contrast, the small-bodied predators were distributed more uniformly, exhibiting no significant differences in their distributions (χ^2 = 1.927, 2 df, p = 0.382). The TROW likely facilitates the travel of the large-bodied carnivores by offering an area that is relatively free from obstruction. The higher-than-expected occurrence of the small-bodied predators in the TROW may have been due to temporal variations caused by dietary enhancements available at particular times of the year.

• Sulak, J. A., & Kielbaso, J. J. (2000). "Vegetation management along transmission utility lines in the United States and Canada." *Journal of Arboriculture*, *26(4)*, 198-205.

Abstract: A survey investigating vegetation control methods along transmission rights-of-way (ROW) was sent to 220 Utility Arborist Association companies in Canada and the USA. The survey contained questions regarding ROW characteristics, control methods used, total amount of money spent on vegetation management, and priorities of vegetation management programmes. More than 75% of respondents used herbicides in ROW vegetation management. However, the area treated mechanically outnumbered that treated chemically by a margin of 2.7 : 1. Garlon 3A and Garlon 4 were the herbicides most often utilized. An estimated 549,869 gallons (2,081,474 litres) of herbicide were applied to transmission ROWs in 1995. The responses indicate that quite low levels of active ingredients are being applied per acre. Basal, high-volume foliar, and low-volume foliar with a backpack or handgun applications accounted for approximately 75% of the areas of transmission ROWs treated with herbicides.

• Yahner, R. H. (2004). "Wildlife Response to More Than 50 Years of Vegetation Maintenance on a Pennsylvannia, US, Right-of-Way." *Journal of Aboriculture, 30(2),* 123-12.

Abstract. The State Game Lands 33 Research and Demonstration Project (or the Bramble and Byrnes Study) was initiated in Pennsylvania, U.S., in 1952, which makes this project the longest continuous study documenting the effects of mechanical and herbicidal maintenance on wildlife and plants along an electric transmission right-of-way (ROW). The project has provided hands-on, scientific information on the effects of ROW maintenance for use by the scientific community, public, and utility companies. This paper briefly describes treatments, vegetation, and wildlife studies conducted on this ROW. In addition, the possible impact of highway development on the future of this study is discussed.

• Yahner, R. H. (2010). "Use of a right-of-way by breeding birds in Lake County, Illinois." *Transactions of the Illinois State Academy of Science*, *103(3/4)*, 141-144.

Abstract: Since 2007, there have been three objectives at the Lake County Research and Demonstration Area (LCRDA) in northeastern Illinois to: 1) compare commonly-used mechanical and herbicidal maintenance treatments on controlling target trees (trees capable of growing tall in wire zones and possibly causing a blackout, hereafter termed undesirable), 2) develop plant cover types that are resistant to tree invasion, and 3) determine the effectiveness of mechanical and herbicidal maintenance on vegetation and wildlife species of high public interest. The wire-border zone method of vegetation management was implemented on the right-of-way (ROW) on eight units of the Lake County Area, and four of the eight units (Gurnee Sites) were mowed in November 2009. The wire-border usually results in a tree-resistant forb-shrub-grass cover type in wire zones and a tall shrub cover type in border zones, thereby producing wildlife habitat diversity on the ROW.

• Yahner, R. H., & Hutnik, R. J. (2004). "Integrated vegetation management on an electric transmission right-of-way in Pennsylvania, US." *Journal of Arboriculture*, *30(5),* 295-300.

Abstract. Integrated vegetation management (IVM) has been used for the maintenance of vegetation along an electric utility transmission right-of-way (ROW) at the State Game Lands (SGL 33) Research and Demonstration Area, Centre County, Pennsylvania, U.S., since 1987. In addition, the wire–border zone method was implemented on the ROW in 1987. The wire–border zone method results in forb–grass–shrub cover types in wire zones and shrub cover types in border zones. The SGL 33 Research and Demonstration Area has been studied since 1953, which makes this 51-yearold project the longest continuous study documenting the effects of mechanical and herbicidal maintenance on flora and fauna along an electric transmission ROW. In this paper, our objective is to present target (undesirable) tree density and cover-type development in response to IVM prior to the most recent treatment (2000) and 2 to 3 years after treatment. Results were compared to those obtained from the late 1980s and 1990s. For all units combined (except handcut) in 1999, average target tree densities prior to treatment were 288 trees/ha (117 trees/ac) in wire zones and 759 trees/ha (307 trees/ac) in border zones. Excellent control of target tree density [62 to 124 trees/ha (25 to 50 trees/ac)] was noted in wire zones of mowing plus herbicide, stem–foliage spray, and foliage spray units; moderate control [371 to 680 trees/ha (150 to 275 trees/ac)] was observed in low-volume basal spray, high volume basal spray units, and mowing units; and poor control (4,818 trees/ha [1,951 trees/ac]) was found in the handcut unit. In 2003, the density of target trees in all treatment units combined was 1,544 trees/ha (625 tree/ac) in wire zones and 1,594 trees/ha (645 trees/ac) in border zones. If the handcut unit was omitted from the calculations, then only 340 target trees/ha (138 trees/ac) in wire zones and 501 trees/ha (203 trees/ac) in border zones were present. IVM of a ROW is not a "tree-proof" but rather a "tree resistant" means of reducing tree invasion. Competition with existing plants and wildlife predation on tree seeds on a ROW managed via the wire–border zone method minimized but did not eliminate tree invasion. Since 1987, IVM and the wire–border zone method of ROW maintenance has increased the time between treatment cycles, thereby reducing labor and chemical costs at the SGL 33 Research and Demonstration Area.

• Yahner, R. H., Hutnik, R.J., & Liscinsky, S. A. (2002). "Bird populations associated with an electric transmission right-of-way." *Journal of Arboriculture, 28(3),* 123-130.

Abstract: A 2-year study of bird populations was conducted along a 230-kV transmission line right-of-way (ROW) in spring (June) and summer (August) 2000 and 2001. Forty-four species were observed on the ROW during 2000 and 2001. In 1987 and 1988 combined, 39 species were noted on the ROW; thus, bird populations have changed relatively little over the past 13 to 14 years. In both 2000 and 2001, slightly more species occurred on the ROW in summer (n = 26–32) than in spring (n = 25–26), and considerably fewer species were noted in the adjacent forest in both spring (n = 8–13)

and summer (n = 7). Common bird species (≥50 individuals/100 ha/day) on the ROW were those adapted to brushy or early successional habitat. Most species were found in the low-volume basal spray and foliage spray units (n = 29 and 28 species, respectively), and fewest species were noted in the handcutting unit (n = 19 species). Considerably more bird species were observed in border zones than in wire zones of the ROW in 2000 and 2001 combined (n = 39 versus 17 species, respectively). Moreover, abundance of all bird species combined was nearly fourfold higher in border zones (1,530 individual birds/100 ha/day) than in wire zones (393 birds/100 ha/day). Thus, the border zone is a very important habitat for birds along a ROW, with its combination of shrub–forb–grass cover type.

• Yahner, R. H., Ross, B. D., Yahner, R. T., Hutnik, R. J., & Liscinsky, S. A. (2004). "Long-term effects of rights-of-way maintenance via the wire-border zone method on bird nesting ecology." *Journal of Arboriculture*, *30(5),* 288-294.

Abstract. The long-term nesting ecology of birds was studied during 2002 and 2003 on the State Game Lands (SGL) 33 Research and Demonstration Area, which is located along a 230-kV transmission right-of-way (ROW) of FirstEnergy (Penelec) in the Allegheny Mountain Region, Centre County, Pennsylvania, U.S. The objectives of this study were to compare nest abundance, success, and placement (1) in handcut versus herbicide-treated study sites (units) and (2) in wire versus border zones. In addition, results from this study were compared to those obtained in a previous study conducted in 1991–1992 on the ROW to better understand the long-term effects of vegetation maintenance management on wildlife. Thirty-three and 26 nests of 10 bird species were noted in 2002 and 2003, respectively. The most frequently encountered nests in 1991–1992 and 2002–2003 were those of bird species adapted to early successional habitats, for example, eastern towhee (*Pipilo erythrophthalmus*), created by the wire–border zone method of vegetation maintenance on the ROW. Thirteen (39%) of 33 nests of all species combined fledged young in 2002 compared to 17 (65%) of 26 nests in 2003. Nesting success in 2003 on the SGL 33 ROW was typical of most studies of bird nesting success in a variety of habitats and was comparable to that recorded in 1991–1992. The low-volume basal unit was more important as nesting habitat than either handcut or mowing plus herbicide units, with nine species nesting in the low-volume basal unit versus only four species in each of the other two units. Thirty-five (59%) of the 59 nests on the ROW were in wire zones, whereas 24 (41%) nests were in border zones. In conclusion, mowing plus herbicide treatment on a ROW may be the best application of the wire–border zone method in terms of resistance to seedling invasion of undesirable trees, cover-type development in the wire zone, and its value as wildlife habitat. Because early successional habitat is becoming less common in the eastern United States and because species dependent on these habitats are showing populations declines, the maintenance of a ROW via the wire–border zone method is extremely valuable to the long-term conservation of early successional bird species.