13th International Symposium

Environmental Concerns in Rights-of-Way Management

PART X

Vegetation Management

Vegetation management has been practiced by rights-of-way (ROW) managers (primarily on electric transmission ROW) since the early twentieth century. Early use of physical control methods, including mechanized and manual cutting of incompatible vegetation, gradually gave way to herbicide-based programs beginning in the early 1950s. Research on the impacts of herbicide use on ROW began in earnest in the 1950s and continues to the present. Impacts to flora, fauna, and human health grew out of general concerns related to pesticides (including herbicides) in the early days of the modern environmental movement. Rachel Carson's *Silent Spring* helped give rise to this movement. Rachel Carson and Frank Egler were among the first to introduce the concept that selective use of herbicides and establishment of a compatible natural plant community can resist invasion by trees. This biological control of incompatible vegetation has been demonstrated through decades of practice and research. Research has informed improved practices over seven plus decades and led to the establishment of integrated vegetation management (IVM) as an industry best management practice. The authors present an annotated bibliography of articles, books, and research that we believe provide the scientific and economic foundation for IVM and can be a resource for current practitioners of ROW vegetation management.

Annotated Bibliography of Articles, Books, and Research Papers Related to Rights-of-Way Vegetation Management—1950s to Present

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Keywords:
Compatible/Incompatible Species, Economic Sustainability, Environmental Impacts, Herbicide Use, Integrated Vegetation Management (IVM), Invasive Species, Rare/Threatened/Endangered Species, Stewardship, Stewardship Accreditation, Vegetation Management, Wetland Impacts, Wildlife Habitat.

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INTRODUCTION:

Vegetation management has been practiced by rights-of-way (ROW) managers (primarily on electric transmission ROW) since the early twentieth century. Early use of physical control methods, including mechanized and manual cutting of incompatible vegetation, gradually gave way to herbicide-based programs beginning in the early 1950s. Research on the impacts of herbicide use on ROW began in earnest in the 1950s and continues to the present. Impacts to flora, fauna, and human health grew out of general concerns related to pesticides (including herbicides) in the early days of the modern environmental movement. Rachel Carson's *Silent Spring* helped give rise to this movement. Rachel Carson and Frank Egler were among the first to introduce the concept that selective use of herbicides and establishment of a compatible natural plant community can resist invasion by trees. This biological control of incompatible vegetation has been demonstrated through decades of practice and research. Research has informed improved practices over seven plus decades and led to the establishment of integrated vegetation management (IVM) as an industry best management practice. The authors present an annotated bibliography of articles, books, and research that we believe provide the scientific and economic foundation for IVM and can be a resource for current practitioners of ROW vegetation management.

Our purpose was two-fold: (1) to provide a resource to practitioners and (2) to educate vegetation managers on what IVM is and what it isn't. Various publications, such as the UAA *Newsline*, show that vegetation managers are doing great work in the field and are passionate about their work and environmental stewardship. However, the years of involvement with the Right-of-Way Stewardship program and other consulting show that many vegetation managers talk IVM but cannot articulate a definition of IVM, nor do they understand that it is a system, and cherry-picking certain elements of IVM do not add up to IVM.

The bibliography focuses on the environmental and economic case for IVM. It does not include other bodies of work relevant to herbicide use, such as efficacy, methods of application, mode of action, environmental fate, or public health and safety. The paper also does not include papers on routing of ROW or construction impacts and restoration following construction. Each of these subject areas have extensive literature available.

STANDARDS

- American National Standards Institute, Inc. 2018. A300 (Part 7) Tree, Shrub, and Other Woody Plant Management – Standard Practices (Integrated Vegetation Management). Tree Care Industry Association, Inc., Londonderry, NH.

American National Standards Institute, Inc. (ANSI) standards have rigorous requirements for due process, consensus, and other criteria for approval that must be met by the standards developer. The standard drafting committee was comprised of a broad array of industry, professional society, and government representatives. Use of ANSI standards is voluntary but they are widely viewed and accepted as standards for good practice.

- Miller, R.H. 2021. Best Management Practices - Integrated Vegetation Management Third Edition. International Society of Arboriculture. Atlanta, GA.

The International Society of Arboriculture best management practices (BMP) is a companion document to the American National Standards Institute (ANSI) A300 Part 7 standards for IVM. The publication sets out BMPs for implementing each element of IVM: Communication with Internal and External Stakeholders; Planning and Implementation; Set Objectives, Evaluate the Site, Define Action Thresholds, Evaluate and Select Control Methods, Implement IVM, and Monitor Treatment Effectiveness and Environmental Protection.

- Right-of-Way Stewardship Council: Accreditation Requirements. 2016. Dovetail Partners, Minneapolis, MN.

These requirements and associated accreditation were developed by the Right-of-Way Stewardship Council (ROWSC). Members of the ROWSC include the electric and gas industries, IVM contractors, environmental NGOs, and the public. The accreditation requirements define IVM principles and practices that represent contemporary IVM programs.

BIBLIOGRAPHY

1. Abrahamson, L.P., C.A. Nowak, P.M. Charlton, and P.G. Snyder. 1993. "Cost effectiveness of Herbicide and Non-herbicide Vegetation Management Methods for Electric Utility Rights-of-Way in the Northeast: State-of-the-Art Review." In Proceedings of the 5th International Symposium on Environmental Concerns in Rights-of-Way Management, 1993, Montreal, Quebec, Canada, edited by Doucet, G.J., C. Seguin, and M. Giguere, pp. 27–43.

A multiphase study was conducted to assess available information on herbicide and non-herbicide management methods for electric utility ROW. Goals of the study included: (1) review of existing literature, (2) examination of results on areas where landowner agreements preclude use of herbicides, and (3) evaluation of vegetation management programs that do not use herbicides. The literature review included 188 papers mostly from the 1980s and early 1990s. Direct costs, indirect costs, and effectiveness of vegetation management methods were reviewed and evaluated. Site visits were

made to ROWs in New York, Rhode Island, New Jersey, Vermont, and Pennsylvania to evaluate incompatible stem densities on non-herbicide treated sites. Densities of up to 30,000 stems per acre were reported. Direct costs of treatments are reported from four studies. Mechanical treatment costs for the region ranged from $308–$648 per acre. Herbicide treatment costs ranged from $196–$260 per acre. Indirect costs/impacts of mechanical vs. herbicide based programs were also evaluated. Note: the term IVM is never mentioned in this "state-of-the-art" paper—dated in 1993.

2. Ballard, B.D., H.L. Whittier, and C.A. Nowak. 2004. "Northeastern Shrub and Short Tree Identification: A Guide for Right-of-Way Vegetation Management." Research Foundation of the State University of Albany, New York, for and in Conjunction with the SUNY College of Environmental Science and Forestry. Syracuse, New York, USA.

This guide to shrub identification contains a key for identification of the more than 100 shrubs commonly found on electric utility ROW in the northeast U.S. The guide also presents information of ROW vegetation management and border zone/wire zone management. It is included in this bibliography as an example of good practice for education and training of IVM program managers and field workers.

3. Ballard, B.D., C.A. Nowak, L.P. Abrahamson, E.F. Neuhauser, and K.F. Finch. 2002. "Integrated Vegetation Management on Electrical Transmission Rights-of-Way Using Herbicides: Treatment Effects Over Time." In Proceedings of the 7th International Symposium on Environmental Concerns in Rights-of-Way Management, 2000, Calgary, Alberta, Canada, edited by Goodrich-Mahoney, J.W., D.F. Mutrie, and C.A. Guild, pp. 47–55. NY: Elsevier Science, Ltd.

Authors describe an ecological approach to managing vegetation on ROWs, integrated vegetation management, to promote desirable/compatible, stable, low-growing communities that will resist invasion by undesirable, tall-growing tree species. Vegetation management studies consistent with IVM took place on a 25-kilometer section of Niagara Mohawk Power Corporation's Volney-Marcy transmission ROW in Upstate New York. Stem density of desirable and undesirable woody plants were followed over an 11-year period. Two maintenance cycles using herbicides were carried out in this time period. It was hypothesized that stem density of undesirable woody plants would continue to decrease over time and stem density of desirable species would increase or remain the same over time, thus, moving towards a more stable community of woody, desirable species. Undesirable species densities were maintained and desirable densities increased over 11 years using an IVM approach. A stable community of woody, desirable species has not been reached and may need another 10–20 years before it develops on the powerline. Shrub abundance needs to be increased to attain maintenance levels.

4. Bonneau, J., and S. Mucha. 2019. "Climate Change Adaptation Strategies in VM." In Proceedings of the 12th International Symposium on Environmental Concerns in Rights-of-Way Management, 2018, Denver, Colorado, USA, edited by Espinoza, A., and N.G. Pupa, pp. 371–380. Utility Arborist Association.

The authors recognize ROWs as containing the most connected landscapes in the U.S. and many other countries around the world. These connected lands are thought to have an important role in the future movement of habitats and species as the climate warms. The authors present research conducted to determine the availability of adaptation strategies for managing vegetation on ROWs in the face of climate change, and present the outcomes of an evaluation of general adaptation strategies for their compatibility with ROW management. The research and evaluation seek to inspire modifications in IVM practices on ROWs to include actions to preserve biodiversity and create resilient ecological communities.

5. Bramble, W.C., W.R. Byrnes, and R.J. Hutnik. 1985. "Effects of a Special Technique for Right-of-Way Maintenance on Deer Habitat." Journal of Arboriculture 11(9): 278–284.

White-tailed deer habitat and use were evaluated on an electric transmission ROW before and after five different herbicide treatments and hand cutting. Evaluations also were made in the adjoining forest. The technique used for all treatments provided for division of the ROW into a central wire zone and two border zones (WZ/BZ). Selective treatment of only tall-growing trees was carried out on the border zones, as contrasted with complete treatment of all trees and tall shrubs in the wire zone. In addition, herbicide in a pellet formulation was applied to the wire zone to produce a herb-grass plant cover. Deer presence increased on all ROW treatment areas from 1982 to 1984. Deer browsed both woody and herbaceous vegetation comparably on the ROW and in the forest.

6. Bramble, W.C., and W.R. Byrnes. 1992. "Small Mammals in Plant Cover Types on an Electric Transmission Right-of-Way." Journal of Arboriculture 18(6): 316–321.

This paper presents results of a study on the abundance and diversity of small mammals in common plant cover types on an electric transmission ROW in Central Pennsylvania. A diverse, small mammal population composed of seven species was captured on the ROW. This diversity was in sharp contrast to the total of two species captured in

adjoining undisturbed forest. The authors conclude that ROW act as a large forest opening which not only provided habitat conditions suitable for the forest species of small mammals, but also for numerous other non-forest species.

7. Bramble, W.C., R.H. Yahner, and W.R. Byrnes. 1994. "Nesting of breeding birds on an electric utility line right-of-way." Journal of Arboriculture 20(2): 124–129.

A nesting study was carried out on an electric utility ROW in Central Pennsylvania. Active nests of 13 species were found in the ROW in both hand-cut and herbicide treatment ROW areas. Average nesting success for all species was 68%. Shrubs were the most commonly used nesting cover. Grass and forb cover was also used for nesting. Nesting success in grass and forb cover was 100%.

8. Bramble, W.C., and W.R. Byrnes. 1983. "Thirty Years of Research on Developments of Plant Cover on an Electric Transmission Right-of-Way." Journal of Arboriculture 9(3): 67–74.

The authors present results of thirty years of research on an electric transmission ROW in Central Pennsylvania. Vegetation was maintained with herbicide applications and compared to mechanical treatments. The authors present a general discussion of vegetation regrowth following initial clearing. In this case, oak-hickory forest type was cleared. If untreated, a complex secondary succession will take place following clearing that will tend toward a return to climax forest. There is a small initial reduction in total plant cover following clearing, which will be rapidly made up by the spread of plants common in the forest. Species common in forest gaps and clearings will then increase in the ROW. This plant community is not resistant to reinvasion by trees, mostly from the continuous supply of tree seeds. To produce a low, dense cover that will resist invasion by trees, species that spread vegetatively should be encouraged by appropriate herbicide applications. Reductions in tree species and conversion to low-growing plants was documented over the 30 years of the project to date. Constant use of the ROW by wildlife has been observed over the 30 years of research. Wildlife include white-tailed deer, ruffed grouse, wild turkey, cottontail rabbits, woodchuck, gray squirrel, skunk, opossum, and white-footed mice. Amphibians and reptiles were also observed.

9. Bramble, W.C., R.H. Yahner, and W.R. Byrnes. 1999. "Effect of Herbicide Maintenance of an Electric Transmission Right-of-Way on Butterfly Populations." Journal of Arboriculture 25(6): 302–307.

The authors present results of a study carried out in 1997 of the butterfly populations on the ROW in the Allegheny region of Central Pennsylvania. The objective was to determine if herbicide applications produced an adverse impact on butterfly populations. Results indicate that herbicide applications for vegetation maintenance did not have adverse effects on butterfly species and number of individuals compared to hand-cutting without herbicides. The number of species counted in hand-cut areas was 21. Species counts in herbicide-treated areas ranged from 41 to 63, depending on the treatment type. The presence of flowering plant species was a highly important factor in evaluation of treatments on butterfly populations. Forty flowering species were found in the hand-cut areas. Flowering species in herbicide-treated areas ranged from 55 to 139, depending on the treatment type.

10. Carson, R.L. 1962. Silent Spring. New York, NY: Fawcett World Library, 73–75 pp.

Rachel Carson presents a discussion on selective spraying as a method to eliminate plants tall enough to interfere with electric wires on ROW. The object of selective spraying is to eliminate tall, woody plants by direct treatment and to preserve all other vegetation, such as shrubs, ferns, and wildflowers. There are references to Frank Egler's "Brush Control Recommendations for Rights-of-Way" and introduces the concept of using shrub plant community's natural ability to resist invasion by trees. The context of the discussion is to present sound methods of pesticide application versus the indiscriminate and destructive use of pesticides presented elsewhere in the book.

11. Chick, T.A. 2016. "Resistance Variability of Right-of-Way Ground Cover Species." In Proceedings of the 11th International Symposium on Environmental Concerns in Rights-of-Way Management, 2015, Halifax, Nova Scotia, Canada, edited by Doucet, G.J., pp. 115–125. Utility Arborist Association.

The author explores allelopathy as an element of biological control to resist tree invasion on IVM-managed ROWs. Research by Niering and Goodwin (1974) and Bramble et al. (1990) identified some shrub and herbaceous groundcover species and their ability to provide biological control. These studies suggested that competition for light was the primary driver in slowing plant succession. However, researchers in ecology, forestry, and agriculture also recognized allelopathy as an interference component and have noted additional species that may provide invasion resistance. The paper references lists of plant species with a range of resistance to tree invasion published in other papers.

12. Confer, J.L. 1999. The Diversity and Abundance of Birds Nesting Under Power Lines of New England Electric System Companies' and Eastern Utilities Associates. Study report.

This study conducted by New England Electric System and Eastern Utilities (now National Grid companies) assesses the effect of vegetation in ROWs on bird communities. Shrubland birds are in decline in the Northeast. Rights-of-way provide an increasing important source of shrub habitat for this avian guild. Birds were counted at 258 sites. A total of 77 species were detected. The Eastern Towhee, Prairie Warbler, and Field Sparrow were especially common on ROW in comparison to statewide data, Massachusetts North American Breeding Bird Survey data.

13. Confer, J.L. 2000. Density, Diversity, and Nesting Success of Birds on Managed Shrublands of Northeastern United States: The Importance of Utility Rights-of-Way. Study Report.

Building on the data from Confer (1999), this study looked at nesting success of open cup nesting birds on electric utility ROW in New York, Massachusetts, and Maine. Most of the surveyed ROW were shrublands managed using selective application of herbicides. The study concluded that ROW would support the greatest diversity of shrubland birds if management created some areas dominated by herbs and other areas dominated by shrubs. Nesting success was measured within the ROW, at the forest edge, and within the forest 20 meters from the ROW. Nesting success exceeded 50% (56% for the total sample) in all three areas. This level of nesting success compares favorably to 49% in 35 studies of open cup nests. Study also focused on habitat and nesting success of Golden-winged Warbler. The study noted low level parasitism by Brown-headed Cowbirds in Golden-winged nests, though these nests also successfully fledged Golden-winged Warblers.

14. Confer, J.L. 2002. "Vegetative Structure and Shrubland Birds in Rights-of-Way Management." In Proceedings of the 7th International Symposium on Environmental Concerns in Rights-of-Way Management, 2000, Calgary, Alberta, Canada, edited by Goodrich-Mahoney, J.W., D.F. Mutrie, and C.A. Guild, pp. 373–381. NY: Elsevier Science, Ltd.

The authors present findings from several studies (Confer 1999 and 2000) on point counts of birds in ROW in the Northeastern U.S. Bird density was high with a mean of 14.8 individuals and 12.2 species per point count for birds nesting or foraging in the ROW. Federal surveys show that shrubland birds are declining throughout the Northeastern U.S. Thus, ROW support an abundance of shrubland birds that are declining elsewhere, probably because of the succession of shrublands into forests throughout most of the Northeastern U.S. Vegetation management by selective herbicide sustained more individuals and individual species than cutting. Most shrubland species showed a habitat preference for about 50% shrub cover.

15. Confer, J.L., T. Hauck, M.-E. Silvia, and V. Frary. 2008. "Avian shrubland management and shrubland nesting success." In Proceedings of the 8th International Symposium on Environmental Concerns in Rights-of-Way Management, 2004, Saratoga Springs, New York, USA, edited by Goodrich-Mahoney, J.W., L.P. Abrahamson, J.L. Ballard, and S.M. Tikalsky, pp. 407–412. Washington, D.C.: Electric Power Research Institute.

The authors quantify that electric utilities maintain more acreage of managed shrublands on powerline ROW than is provided by all other sources combined in the Eastern U.S. The study quantified increases in the number of individual birds (21%) and bird species (27%) following thinning shrub density of electric utility ROW in Sterling Forest State Park in New York. Reduction in shrub density was accomplished by mechanical cutting and herbicide treatment of stumps.

16. Donohue, S., M. Tyrrell, and T. Doyle. 2012. "Important Considerations for Utility Right-of-Way Selection, Routing, and Vernal Pool Management." In Proceedings of the 9th International Symposium on Environmental Concerns in Rights-of-Way Management, 2009, Portland, Oregon, USA, edited by Evans, J.M., J.W. Goodrich-Mahoney, D. Mutrie, and J. Reineman, pp. 309–318. Champaign, IL: International Society of Arboriculture.

The authors look at vernal pools on existing and adjacent newly constructed ROW in the Northeast. Twenty-eight vernal pools were documented based on regulatory biological and geomorphologic criteria. Vernal pool wildlife and amphibian egg masses were abundant in pools within and adjacent to ROW. Vernal pool habitat characteristics were maintained in existing ROW corridors. The conclusion was that functioning vernal pools can exist in utility corridors in the Northeast.

17. Duncan, C.P., A. Finamore, A. Slayton, and K. Marcoux. 2012. "Vernal Pool Occurrence and Species Distribution within Transmission Right-of-Ways in Maine." Abstract accepted for the 10th Symposium on Environmental Concerns in Right-of-Way Management, Utility Arborist Association. 2012, Phoenix, Arizona, USA.

This paper examined vernal pool efficacy, including species occurrence and distribution in both ROW and non-ROW conditions, and identified the potential effects of ROWs on vernal pools. Breeding activity in vernal pools within and near over 600 linear miles of transmission lines was identified and evaluated. Data were collected and analyzed for 1,834 vernal pools, all of which contained either wood frog or spotted salamander egg masses, or both. Results indicate that ROW conditions do not prohibit the presence of breeding

vernal pool species. Rights-of-way creation and maintenance should not be considered incompatible with vernal pool habitat preservation.

18. Durand, J., B. Windmiller, and F.P. Richards. 2008. "Vernal Pool Identification – Current and Future Permitting Implications." In Proceedings of the 8th International Symposium on Environmental Concerns in Rights-of-Way Management, 2004, Saratoga Springs, New York, USA, edited by Goodrich, J.W., L.P. Abrahamson, J.L. Ballard, and S.M. Tikalsky, pp. 479–492. NY: Elsevier Science, Ltd.

The authors present a discussion on the evolving regulatory framework for vernal pool protection. They point out the habitat value and increasing concern of environmental regulators. The paper does not review ROW construction or maintenance impacts or mitigation. This paper provides an excellent example of how environmental regulations evolve and advises VM managers and project developers to be aware of new issues to address in permitting.

19. Egler, F.E. 1953. Vegetation Management for Roadside and Rights-of-Way, pp. 299–322. In Smithsonian Institution 1953 Annual Report. Smithsonian Institution, Washington, D.C.

This often-cited paper is one of the earliest using and defining the term "vegetation management." Dr. Egler was Chairman of the Committee for Chemical Brush Control Recommendations for Right-of-Ways at the American Museum of Natural History. The paper discusses all types of ROW we refer to today (roadside, railroad, gas pipeline, telephone, and electric utility) and familiar application techniques (basal and foliar). He also discusses impacts to wildlife and aesthetics. Most importantly the paper describes the concepts of "relay floristics" and "initial floristic composition." All referenced plant communities and impacts of use of herbicides are based in the Northeast U.S. Herbicides referenced are 2,4,5 T, 2,4 D and ammonium sulfate. Dr. Egler refers to "research and development areas" established by the New England Power Company in Massachusetts, the Niagara Mohawk Power Corporation in New York, Pennsylvania Power and Light in Pennsylvania, and others. In his summary he stated, "Basal herbicide application results in a shrubland composed of shrubs, forbs, and grass. Such vegetation resists tree seedling invasion."

20. Egler, F.E. 1975. The Plight of the Right-of-Way Domain. Mount Kisco, NY: Futura Media Services.

The subtitle for this book is "Victim of Vandalism." This is a two-volume book on ROW vegetation management. Dr. Egler was a Professor of Botany and Ecology at Connecticut College. The preface to the book was written by William Neiring (Neiring 1958 and 1974). The author details the history of ROW vegetation management (Egler 1953) and proposes a better way forward based on an ecological approach, as opposed to technology-based warfare with unwanted plants/trees. The concept of "floristic succession" is presented as an alternative to traditional plant succession. The author presents requisite elements for a sound vegetation management program: knowledge of the flora, knowledge of vegetation types, long-term planning, conversion of original species, maintenance of low stable vegetation, rights of landowners, conservation organization (NGO) policies, qualifications for a vegetation manager, training for a vegetation manager, position of the vegetation manager in the organization, the environmental impact, cost-benefit analyses, and the vegetation management plan. The book contains quotations from Jonathan Swift and William Shakespeare. The book is dedicated to Rachel Carson and the "Coming Generation," that it may rectify the mistakes of this generation.

21. Electric Power Research Institute. 2000. Technical Report: 1000525. Right-of-Way Treatment Cycles: Update 2000. Palo Alto, CA: EPRI, and ESEERCO.

Authors are C.A. Nowak, B.D. Ballard, and P.M. Charlton. This is a re-publication and update of an ESEERCO report that evaluated cost and effectiveness of mechanical and chemical treatment methods on 18 ROWs across New York State. Seven treatment methods—hand cutting, mowing, cut stump, dormant basal, summer basal, selective ground foliar, and aerial—were evaluated. The study determined long-term costs, cycle length, density and height of capable trees, changes in incompatible vegetation, and the average annual cost among the treatment methods. It discusses the treatment effects on tree density, tree height, shrub cover, and herbaceous cover. Authors show that over a treatment cycle, herbicides had a greater effect in reducing stem density than hand cutting or mowing; tree height response was inconsistent; only cut stump resulted in substantial reduced height; and shrub cover increased after all herbicide treatment types. Herbaceous cover increased in response to mechanical and herbicide treatments. The overall conclusion: research and monitoring showed that selective application of herbicides is the best means to control incompatible tree species, increase desirable (compatible) plant species, maintain site integrity by reducing plant community and soil disturbance, and reduce treatment costs.

22. Electric Power Research Institute. 2002. Technical Update: 1005366. Wildlife and Integrated Vegetation Management on Electric Transmission Line Rights-of-Way. Palo Alto, CA: EPRI.

This report describes the component steps of an IVM system: (Step 1) Understanding pest and ecosystem dynamics; (Step 2) Setting management objectives and tolerance levels; (Step 3) Compiling treatment

options; (Step 4) Accounting for economic and ecological effects of treatments; (Step 5) Site-specific implementation of treatments; and (Step 6) Adaptive management and monitoring. The report describes biological control via the persistent presence of desirable grass-forb-shrub communities as the core element of IVM.

23. Electric Power Research Institute 2003. Technical Report: 1005371. Landscape Fragmentation and Electric Transmission Corridor Siting and Management. Palo Alto, CA: EPRI.

Landscape fragmentation, especially forest fragmentation, is often an environmental issue during the siting of transmission ROW. However, little research has been undertaken to quantify possible effects. Landscapes are fragmented by many elements, including urbanization, forestry, agriculture, and the many elements of infrastructure that support the needs of society. It may be possible, through management, to mitigate the fragmenting effects of existing ROW or minimize fragmenting effects of planned ROW. Corridors have been traditionally thought of as connections from one habitat patch to another through a surrounding inhospitable landscape. The literature on corridors remains controversial. Generalizations about corridors and fragmentation are not useful, and specific habitats and species need to be considered when assessing impacts. This report provides a primer on landscape pattern analysis and a guide on using landscape metrics to assess changes in landscape patterns.

24. Electric Power Research Institute. 2004. Technical Report. Transforming Knowledge of Shrub Ecology and Management to Promote Integrated Vegetation Management on Powerline Corridors. Palo Alto, CA: EPRI.

The report draws upon long-term IVM research, primarily in the Northeast and New York State, to develop a framework and training materials for IVM. Training materials were used at a workshop at the SUNY College of Environmental Science and Forestry in September 2003. EPRI and SUNY have made the materials available for IVM training to anyone interested in IVM.

25. Electric Power Research Institute. 2012. Technical Report: 1025379. Cost-effectiveness of Different Herbicide and Non-Herbicide Alternatives for Treating Transmission Rights-of-Way Vegetation: An Illustrative Guide. Palo Alto. CA: EPRI.

The report is authored by C.A. Nowak. The report provides a cost-effectiveness definition, steps, and illustrations to guide application of cost-effectiveness, and provides a model application of cost-effectiveness analysis. It includes Appendix A, long-term cost-effectiveness of mechanical versus chemical treatment of powerline ROWs in New York State. The analysis used data from studies between 1975 and 1995. The Present Value of Cost calculated for mechanical and chemical treatments was $1,329 and $945, respectively. The author caveats about the study due to assumptions necessary to run the analysis, but concludes herbicides are the more cost-effective treatment compared to mowing.

26. Environmental Energy Alliance of New York (EEANY). 1990s. Applications of Integrated Pest Management to Electric Utility Rights-of-Way Vegetation Management in New York State.

The EEANY paper details the evolution of the term "IVM" as an applied form of integrated pest management (IPM) on electric utility ROWs in New York State. From available evidence and personal knowledge, this paper includes the first use of the term IVM. The paper identifies the essential elements of an IPM/IVM strategy: prevention, biological control, monitoring, assessment, and control measures (mechanical and herbicide treatments). Biological control is identified as a core element of IPM/IVM. Biological control on ROW is achieved by promoting establishment of low-growing, relatively stable plant communities. Full text of the EEANY Position Paper is included in: McLoughlin, K.T. (2002) *Integrated Vegetation Management – The Exploration of a Concept to Application.*

27. Environmental Consultants, Inc. (ECI). 1991. Determination of the Effectiveness of Herbicide Buffer Zones in Protecting Water Quality on New York State Powerline Rights-of-Way. Empire State Electric Energy Research Corporation (ESEERCO), Schenectady, New York. Report EP 89–44.

This report and research assessed the effectiveness of herbicide buffer zones to prevent deposition of herbicides into bodies of water and wetlands from herbicide applications in New York State. This research became the technical basis for establishing herbicide application buffer zones in utility vegetation management plans approved by utility and environmental regulators in New York State. More detailed results are presented in Norris and Charlton 1993.

28. Ferrandiz, L.S. 2008. "A Broad-Based, IVM Approach to Right-of-Way Management on Long Island, NY." In Proceedings of the 8th International Symposium on Environmental Concerns in Rights-of-Way Management, 2004, Saratoga Springs, New York, USA, edited by Goodrich, J.W., L.P. Abrahamson, J.L. Ballard, and S.M. Tikalsky, pp. 65–69. NY: Elsevier Science, Ltd.

The author examines social and environmental conditions influencing the application of integrated vegetation management on Long Island, New York. By evaluating soil conditions, property ownership, and population and land use, the Long Island Power Authority

selects and deploys various IVM methods. This broad-based IVM approach strives to balance cost, legal considerations, public acceptance, and environmental impacts.

29. Finch, K.E., and S.D. Shupe. 1997. "Nearly Two Decades of Integrated Vegetation Management on Electric Transmission Rights-of-Way." In Proceedings of the 6th International Symposium on Environmental Concerns in Rights-of-Way Management, 1997, New Orleans, Louisiana, USA, edited by Williams, J.R., J.W. Goodrich-Mahoney, J.R. Wisniewski, and J. Wisnewski, pp. 67–75. NY: Elsevier Science, Ltd.

This paper describes a gradual evolution of herbicide-based vegetation management from broadcast and helicopter-based application to selective use of herbicides within the context of IVM. Selective application within the context of IVM resulted in reduced herbicide usage rates from more than six gallons of concentrate per acre when helicopter spraying, to less than one gallon per acre over two decades. Integrated vegetation management methodology also provided reduced regulatory conflicts, greater public acceptance, enhanced wildlife habitat, improved aesthetics, reduced worker and public exposure to herbicides, and significant cost savings.

30. Frizzell, M. 2012. "Electric Transmission Right-of-Way Reclamation." In Proceedings of the 9th International Symposium on Environmental Concerns in Rights-of-Way Management, 2009, Portland, Oregon, USA, edited by Evans, J.M., J.W. Goodrich-Mahoney, D. Mutrie, and J. Reineman, pp. 465–468. Champaign, IL: International Society of Arboriculture.

This paper presents a study by the Sacramento Municipal Utility District (SMUD) and Pacific Gas and Electric (PG&E) that initiated a cooperative reclamation effort on transmission ROW that had become overgrown since construction in the early 1960s. In the last 10 years at the time of the study, the two utilities had worked together to manage this ROW. In its current state, the ROW required minimal vegetation management annually to maintain compliance and function. After an initial mastication and logging project, three different herbicide applications with various techniques and conditions were administered. The goal was to establish a low-growing, dynamic plant community that thrives well below the conductors and provides competition that suppresses tall and fast-growing species that once populated the ROW. The management techniques utilized have benefited the environment by creating plant species diversity, eliminating exotic invasive species, and providing a valuable fuel break between a fire-prone plant community and three local urban areas.

31. Garant, Y., J. Domingue, and F. Gauthier. 1997. "Effectiveness of Three Vegetation Control Methods in Establishing Compatible Plant Species in Powerline Rights-of-Way in Northeastern Quebec." In Proceedings of the 6th International Symposium on Environmental Concerns in Rights-of-Way Management, 1997, New Orleans, Louisiana, USA, edited by Williams, J.R., J.W. Goodrich-Mahoney, J.R. Wisniewski, and J. Wisnewski, pp. 77–81. NY: Elsevier Science, Ltd.

This study by Hydro-Quebec evaluated the efficiency of three control methods in establishing compatible vegetation, tested in Northeastern Quebec: (1) manual cut, (2) manual cut plus land application of Tordon 101 and TCA, and (3) aerial application of Tordon 101 and Silwet L-77. Sampling plots were randomly distributed in vegetation zones in which the density of incompatible stems were measured. The most efficient method in controlling incompatible woody stems was aerial spraying of Tordon 101. Only 2,900 stems/ha were measured in these spans. Stem density of incompatible species was intermediate (14,184 stems/ha) after a ground application of Tordon 101 and TCA. A high density of 73,000 stems/ha was observed in spans that were treated by mechanical cutting.

32. Goodfellow, J.W. 2012. "Creation of an Industry Best Management Practice for Adoption of a Closed Chain of Custody for Herbicide Use in the Utility Vegetation Management Industry." In Proceedings of the 9th International Symposium on Environmental Concerns in Rights-of-Way Management, 2009, Portland, Oregon, USA, edited by Evans, J.M., J.W. Goodrich-Mahoney, D. Mutrie, and J. Reineman, pp. 369–371. Champaign, IL: International Society of Arboriculture.

The author presents development of a best management practice (BMP) related to the supply chain and use of herbicides in the utility vegetation management industry. The project resulted in creation of an end-to-end strategy for managing herbicide chain of custody from manufacturer to custom blender, distributor, utility owner, and applicator. The BMP is intended to reduce the risk of potential mixing error, public and applicator exposure, and inappropriate disposal of wastes. Once established, the new BMP would be available for incorporation in vegetation management specifications throughout the utility industry. The author later developed and published the ISA Closed Chain of Custody for Herbicide in the UVM Industry.

33. Goodfellow, J.W. 2011. "ROW Steward Accreditation Program-Update." Utility Arborist Newsline 2(6): 28–30.

This article describes the background and opportunity to develop a voluntary, third party ROW vegetation management accreditation program.

The program standards are proposed to be based on ANSI A300, ISA Best Management Practices and EPRI Standards for Assessing Performance of IVM on ROWs. The program was modeled on other successful "green certification" programs developed by the Forest Stewardship Council and the Sustainable Forestry Initiative. The program, as of March 2012, was in the development stage under the sponsorship of the Utility Arborist Association and other industry organizations. The program was looking to identify an international nongovernmental environmental group to act as the accrediting institution.

34. Goodfellow, J.W., C.A. Nowak, and J.E Wagner. 2017 Vegetation Management Business Cost Benefit of Herbicide Use. Centre for Energy Advancement through Technological Innovation (CEATI), Montreal.

The authors present a business case for the practice of IVM on electric and gas ROW. The scope was limited to direct operational/maintenance cost. Two different vegetation management strategies were compared: IVM-based use of herbicides to control incompatible species and repeated mechanical treatment (cutting/mowing) without herbicides. An extensive literature review was conducted to develop models of changes in stocking of incompatible species over time and methods to conduct comparative economic analysis. Twenty-year vegetation maintenance prescriptions specific to three hypothetical case studies based on IVM and mechanical treatments were developed. In each case, the present value of the IVM treatment cost is approximately half of the cost of mechanical treatment. This project convincingly demonstrates that a vegetation management strategy based on the principles of IVM, including the use of herbicides, is less costly than a strategy that makes no use of herbicides but relies simply on repeated mechanical and manual cutting of incompatible trees within the ROW. These findings establish the foundation for a business case for the use of herbicides in the management of ROW vegetation.

35. Goodfellow, J.W. 2019. "Adapting the Principles of Integrated Pest Management to IVM on Electric Utility ROW." In Proceedings of the 12th International Symposium on Environmental Concerns in Rights-of-Way Management, 2017, Denver, Colorado, USA, edited by Espinoza, A., and N.G. Pupa, pp. 361–364. Utility Arborist Association.

The author examines the significant revisions made to the ANSI A300 Part 7 standard for IVM which was completed in 2018. The changes were in part an effort to better harmonize the IVM standard with the principles of IPM. This included adaptation of the principles of Economic Injury Level (EIL) and Economic Threshold (ET) that are core to IPM and which correlate to Tolerance Level I (TL) and Action Threshold (AT) in IVM. The revised standard guides best management practice for maintaining utility ROW and other sites where the establishment and maintenance of early successional plant communities is an objective.

36. Goodfellow, J.W. 2019. "Establishing an Empirical Basis for Wire Zone Width on an Electric Transmission ROW." In Proceedings of the 12th International Symposium on Environmental Concerns in Rights-of-Way Management, 2018, Denver, Colorado, USA, edited by Espinoza, A., and N.G. Pupa, pp. 395–399. Utility Arborist Association.

Although not suitable in every situation, the wire zone/border zone (WZ/BZ) model has been recognized as an industry best management practice for decades. In practice, the adoption and application of the model have been inconsistent. The author provides practitioners with an understanding of factors that should be considered when adopting the WZ/BZ model, and specifically when defining the appropriate WZ width.

37. Goodfellow, J.W., C. Mahan, and P.M. Charlton. 2018. The Cost Efficiency of IVM: A Comparison of Vegetation Management Strategies for Utility Rights-of-Way. Report funded by the TREE Fund Utility Arborist Research Fund Grant #18-UARF-01.

This report establishes a business case for the practice of IVM on electric and gas transmission ROW. Economic analysis of IVM and non-IVM vegetation management strategies were based on least cost analysis and cost-effectiveness. The report concludes the present value of cost over a 20-year evaluation period are approximately half as much as controlling incompatible plant species without the use of herbicides. The report references three other studies showing 20- to 30-year cost savings from the use of herbicides in the range of 45% to 48%. The cost advantage of the IVM-based strategy was shown to provide additional significant benefits—less site disturbance, water quality, reduced incompatible tree density and height, wildlife habitat, bird species diversity and abundance, amphibian and reptile diversity and abundance, and butterfly species diversity and abundance. These benefits come at no extra costs. Lastly, the IVM strategy demonstrated lower risk (lower maximum height) between treatments.

38. Guerrero-Murphy, G., T. Follensbee, and J. Disorda. 2016. "Best Management Practices (BMPs) for Protection of Threatened and Endangered Species during Integrated Vegetation Management and Operations and Maintenance of Electric Transmission Lines in Vermont." In Proceedings of the 11th International Symposium on Environmental Concerns in Rights-of-Way Management, 2015, Halifax, Nova Scotia, Canada, edited by Doucet, G.J., pp. 345–352. Utility Arborist Association.

Vermont Electric Power Company (VELCO) developed BMPs to protect threatened and endangered species and promote general wildlife habitat and plant biodiversity values along electric transmission line corridors during IVM and line maintenance activities. Vermont Electric Power Company has invested considerably in IVM for many decades, resulting in ROW plant communities that include approximately 50 threatened and endangered plant and animal species. As a result, VELCO needed to protect these species, minimize regulatory compliance risks, address stakeholder concerns, and promote sound ecological and natural capital stewardship. The development of BMPs to Protect Threatened and Endangered Species was completed in October 2013. This effort required stakeholder engagement regarding vegetation management, operations and maintenance activities, and ecological resources; management planning; GIS analysis and management of sensitive species occurrence data; biological surveying to establish baseline data for threatened and endangered species; and evaluation and analysis of existing management techniques and practices. This paper presents an overview of the BMPs for Protection of Threatened and Endangered Species, including the processes for development and implementation, outcomes, and lessons learned.

39. Gwozdz, J., L. Payne, K. Gorski, and J. Kooser. 2016. "Herbicide Use Rates Over Four Treatment Cycles: Proof the IVM Tool is Working." In Proceedings of the 11th International Symposium on Environmental Concerns in Rights-of-Way Management, 2015, Halifax, Nova Scotia, Canada, edited by Doucet, G.J., pp. 127–133. Utility Arborist Association.

The New York Power Authority (NYPA) has data from the past four treatment cycles that show a decreasing trend in the herbicide use rates, indicating the establishment of a stable desirable plant community. New York Power Authority began its overall IVM program in 1998 utilizing a four-year treatment cycle and has been collecting these treatment data since. Looking specifically at the treatment methods and amounts of herbicides application rates for each year of the four-year cycle will show a decrease in usage, which will begin to level out at a very minimal rate over several treatment cycles. These data clearly show that the IVM program has proven effective. New York Power Authority has positive data indicating that as the program matures, the herbicide application rates become minimal. A mature IVM program which has developed an established desirable plant community can be maintained with a minimal rate of herbicide use.

40. Haggie, M.R., R.A. Johnstone, and H.A. Allen, Jr. 2008. "Tree, Shrub and Herb Succession and Five Years of Management Following the Establishment of a New Electric Transmission Right-of-Way through a Wooded Wetland." In Proceedings of the 8th International Symposium on Environmental Concerns in Rights-of-Way Management, 2004, Saratoga Springs, New York, USA, edited by Goodrich, J.W., L.P. Abrahamson, J.L. Ballard, and S.M. Tikalsky, pp. 47–59. NY: Elsevier Science, Ltd.

The authors present results of a 5-year study of vegetation succession following construction of a new electric transmission ROW through a wooded wetland in Delaware. The herbaceous and shrub plant communities were examined following two clearing methods: (1) non-selective clear-cut of all woody plants, trees, and compatible shrubs, and (2) selective removal of targeted tall-growing trees. Integrated vegetation management techniques (selective application of herbicides) were carried out after the clearing. Results showed that IVM interventions stimulated vegetation succession from a mature wooded wetland to a low shrub/herbaceous plant community as successfully in the clear-cut as in the selective-cut areas. The total number of species reflects the loss of trees. Trees were replaced by a two-fold increase in the number of herbaceous species. Shrub species numbers remained relatively stable.

41. Haggie, M.R., H.A. Allen, and R.A. Johnstone. 2019. "Formulation of PSVI to Measure the Benefits of ROW Habitat Change for Pollinators (*Apis* and *Bombus* spp.) Following the Management Transition from Traditional Cutting-Mowing Practices to IVM." In Proceedings of the 12th International Symposium on Environmental Concerns in Rights-of-Way Management, 2018, Denver, Colorado, USA, edited by Espinosa, A., and N.G. Pupa, pp. 557–569. Utility Arborist Association.

The authors present a Pollinator Site Value Index (PSVI) applicable to ROWs historically managed using mechanical methods, then transitioned to IVM. The PSVI developed by the authors provides an estimate of a botanical community's value to pollinators. The vegetation variables assessed include: forbs, vines, and small shrubs; breeding and over-wintering habitat quality; nectar source value; pollen source value; and flowering month range. The PSVI was applied to six case studies in Maryland, Michigan, North Carolina, and Tennessee. The maintenance history, vegetation, and conclusions from each case study are very different. However, the authors concluded the PSVI provides a defensible index to assess plant community value to pollinators at each site and compared mechanical and IVM-based maintenance regimes. In all six case studies, the PSVI showed improved pollinator habitat from IVM-based maintenance.

42. Halle, C., C. Mahan, D. Krause, and E. Brown. 2019. "Future Vegetation Management Observatories: The Value of Industry and Academic Partnerships in Understanding Ecological Impacts of ROW VM

and Engaging Students of all Disciplines in Practical Environmental Issues." In Proceedings of the 12th International Symposium on Environmental Concerns in Rights-of-Way Management, 2018, Denver, Colorado, USA, edited by Espinosa, A., and N.G. Pupa, pp. 401–405. Utility Arborist Association.

This paper summarizes a panel presentation at the ROW 12 Symposium. The panelists reflect on the longest continuous study of the effects of ROW vegetation management on local ecosystems—Pennsylvania State Game Lands (SGL33)—and the value of research and demonstration projects. Until recently, most projects and research had been in the Eastern U.S. Since 2015, an industry-university collaboration has begun to establish similar long-term VM "observatories" in substantially different environments in the Western U.S. In general, the findings from the eastern and western sites seem to support the idea that modifying the habitat can be beneficial (or at least not harmful) for certain wildlife and pollinator species. The panelists commented on the role of the UAA and the Tree Research Education and Endowment (TREE) Fund in sponsoring and promoting future research. The panel also focused discussion on improving student outreach, expanding research opportunities, increasing community awareness, and leveraging industry associations to help recruit trained students into industry careers.

43. Howe, J.L. 2016. "Initial Lessons from ROW Stewardship Accreditation." In Proceedings of the 11th International Symposium on Environmental Concerns in Rights-of-Way Management, 2015, Halifax, Nova Scotia, Canada, edited by Doucet, G.J., pp. 147–154. Utility Arborist Association.

The paper describes the Right-of-Way Stewardship accreditation program administered by the ROW Stewardship Council (ROWSC). The accreditation process presents the opportunity for companies to demonstrate their commitment to ROWSC standards, and third-party recognition ensures an independent, proven process to convey credibility and bring recognition to IVM programs. The purpose of this research presented in this paper was to explore the experience of participants to date in the ROWSC accreditation process in order to better understand their organizational goals and objectives, how those objectives have been realized thus far, and to identify areas of process improvement. The results suggest that early adopters found ROWSC accreditation helps demonstrate the utility's commitment to the environment, helps them gain credibility in the marketplace, supports innovation in utility vegetation management, and results in improvement in their IVM process. Increased participation by utilities and greater recognition of ROWSC over time will likely greatly benefit new and existing accredited utilities.

44. Johnstone, R.A. 1990. "Vegetation Management: Mowing to Spraying." Journal of Arboriculture 16(7): 186–189.

This paper presents a case history of how to change a utility (Delmarva Power) vegetation management program from mowing to selective application of herbicides. Change resulted in reduced maintenance costs and improved wildlife habitat, less negative visual impact from treatments, and better accessibility to the ROW.

45. Johnstone, R.A. 1993. "Vegetation Management with Environmental Stewardship." In Proceedings of the 5th International Symposium on Environmental Concerns in Rights-of-Way Management. 1993, Montreal, Quebec, Canada, edited by Doucet, G.J., C. Seguin, and M. Giguere, pp. 456–459.

The author presents a case history of the application of IVM on electric utility ROWs on the Delmarva Peninsula in the U.S. Historically, vegetation management had been done with brush hog mowing and hand cutting. In the 1980s, Delmarva Power initiated the use of herbicides under the watchful eye of state and federal regulators. The paper endorses a proactive public relations policy and engagement of regulators and stakeholders. Technical aspects of IVM and herbicide application are addressed. Environment stewardship was a core element of Delmarva Power's approach and resulted in partnerships with regulators and environmental NGOs.

46. Johnstone, R.A., M.R. Haggie, and H.A. Allen, Jr. 2002. "Tree, Shrub, and Herb Succession and Five Years of Management Following the Establishment of a New Electric Transmission Right-of-Way through a Mixed Woodland." In Proceedings of the 7th International Symposium on Environmental Concerns in Rights-of-Way Management, 2000, Calgary, Alberta, Canada, edited by Goodrich-Mahoney, J.W., D.F. Mutrie, and C.A. Guild, pp. 73–81. NY: Elsevier Science, Ltd.

The authors present results of a 5-year study of vegetation succession following construction of a new electric transmission ROW through upland mixed forest in Delaware. The herbaceous and shrub plant communities were examined following two clearing methods: (1) non-selective clear-cut of all woody plants, trees, and compatible shrubs, and (2) selective removal of targeted tall-growing trees. Integrated vegetation management techniques (selective application of herbicides) were carried out after the clearing. Results show that IVM interventions stimulated vegetation succession from a mature wooded wetland to a low shrub/herbaceous plant community as successfully in the clear-cut as in the selective-cut areas. Total number of species remained relatively stable but reflect a substitution of trees by herbaceous species, while shrub species numbers remained relatively constant.

47. Johnstone, R.A., and M.R. Haggie. 2008. "Vegetation Management Best Practices for Reliability and Ecosystem Management." In Proceedings of the 8th International Symposium on Environmental Concerns in Rights-of-Way Management, 2004, Saratoga Springs, New York, USA, edited by Goodrich, J.W., L.P. Abrahamson, J.L. Ballard, and S.M. Tikalsky, pp. 27–32. NY: Elsevier Science, Ltd.

The authors report monitored plant community changes and cost of treatment from three cycles of IVM work on Delmarva Power ROWs. Selective herbicide treatment of incompatible trees was observed (no data are presented) to allow more growing space for low-growing plant species, resulting in less disturbance of the plant community from later cyclic maintenance. Cost of second and third cycle treatments was reduced by approximately 50% in comparison to costs of repeated mowing.

48. Johnstone, R.A., and M.R. Haggie. 2012. "Regional Vegetation Management Best Practices Case Studies: An Applied Approach for Utility and Wildlife Managers." In Proceedings of the 9th International Symposium on Environmental Concerns in Rights-of-Way Management, 2009, Portland, Oregon, USA, edited by Evans, J.M., J.W. Goodrich-Mahoney, D. Mutrie, and J. Reineman, pp. 77–86. Champaign, IL: International Society of Arboriculture.

This paper presents four case studies on IVM implementation. The paper references the newly developed and published A300 (Part 7) Tree, Shrub, and Other Woody Plant Management – Standard Practices (Integrated Vegetation Management) (2006). The IVM approach recommended by the standard follows a continuous process: to set objectives, evaluate site, define action thresholds, evaluate and select control methods, implement IVM, monitor treatment and quality assurance, and reset objectives. This paper documents the changes in plant species and wildlife habitat on electric and gas utility ROW in varying types of ecosystems, including the coastal plain pine barrens of New Jersey, a glacial remnant habitat of Michigan, a lake plain habitat of Michigan, and a limestone-dominated lake habitat of Tennessee. Plant species are evaluated as desirable or undesirable for utility safety and reliability, mutual benefits for nature trails, diversity, dominance percentage, number of stems, non-native invasive species, threatened or endangered species, comparison to wildfire, prairie, and benefits to native pollinators and other wildlife.

49. Johnstone, R.A., and M.R. Haggie. 2016. "Integrated Vegetation Management (IVM) Partnerships with Agencies and Utilities to Improve Habitat for Pollinators, Birds, and other Wildlife." In Proceedings of the 11th International Symposium on Environmental Concerns in Rights-of-Way Management, 2015, Halifax, Nova Scotia, Canada, edited by Doucet, G.J., pp. 167–182. Utility Arborist Association.

In 2009, Integrated Vegetation Management Partners, Inc. developed successful partnerships between Baltimore Gas & Electric Company (BGE) and federal/state/local government agencies and conservationists on electric transmission ROW in the suburban community of Columbia, Maryland, and a rural area of the South River Greenway near Davidsonville, Maryland. These partnerships involved the establishment of case studies where plant community changes were followed with photographic and botanical documentation to compare various vegetation management practices, from mowing and hand cutting to broadcast and selective application of herbicides. University, government agency, and volunteer researchers also documented the population changes of birds, butterflies, and bees that were utilizing the ROW habitat for breeding, nesting, and feeding. Results indicate that when ROW vegetation is managed utilizing an IVM approach, selective herbicide treatments will allow early successional plant communities to dominate the ROW and provide habitat for some wildlife species.

50. Jury, K. 2016. "Case Study: Class C Prairie and the Transmission Right-of-Way." In Proceedings of the 11th International Symposium on Environmental Concerns in Rights-of-Way Management, 2015, Halifax, Nova Scotia, Canada, edited by Doucet, G.J., pp. 183–190. Utility Arborist Association.

In collaboration with the scientists at the Chicago Botanic Garden, Commonwealth Edison (ComEd) monitored vegetation at three sites in Northeastern Illinois to determine if it is cost-effective to convert overgrown ROW to Class C prairie. Tall-growing trees and brush were removed at each site consistent with ComEd's Transmission Vegetation Management Plan and IVM BMPs utilizing a brush mower and individual tree removals. Cut stumps were treated with herbicide. While this research is ongoing, floristic quality data indicate a Class C prairie can readily be established on sites adjacent to existing high-to-moderate quality plant communities with moderate added program cost. Initial public reaction had been positive through media commentary and Chicago Botanic Garden publications.

51. Kooser, J., K. Gorski, L. Khitrik, D. Coogan, L. Payne, J. Gwodz, and P. Brier. 2016. "ROW Vegetation Changes Over Four Treatment Cycles, IVM Controls the Growth of Non-Compatible Trees." In Proceeding of the 11th International Symposium on Environmental Concerns in Rights-of-Way Management, 2015, Halifax, Nova Scotia, Canada, edited by Doucet, G.J., pp. 191–200. Utility Arborist Association.

Since the late 1990s, the New York Power Authority (NYPA) used IVM principles to guide the vegetation management program on 1,400 miles of transmission lines ROW. The authors present the changes observed in plant communities following four cycles of IVM treatments. Data from the initial field surveys (1999–2002) showed medium to high density (1,000 – >3,000 stems per acre). Non-compatible stands occupied 18%, while stands with low densities of non-compatible species (0–1,000 stems per acre) occupied 50% of the total acreage. Data taken after four treatment cycles (2011–2014) indicate that medium-to-high density had been reduced to 6% while the percentage of low density non-compatibles had been increased to 70%. Reductions in the heights of non-compatible species have also been noted. A core principle of IVM is biological control through competition from compatible species. New York Power Authority's data over four treatment cycles clearly demonstrates this benefit of IVM.

52. Krause, D., C.G. Mahan, and R.H. Yahner. 2014. "Game Lands 33 Project: 60 Years of Electrical Right-of-Way (ROW) Research." In Proceedings of the 10th International Symposium on Environmental Concerns in Rights-of-Way Management, 2012, Phoenix, Arizona, USA, edited by Doucet, G.J., pp. 159–162. Utility Arborist Association.

The paper presents the sixty years of research from an initial "five-year" project at Game Lands 33 in Pennsylvania. This is the site of the "Bramble and Byrnes" studies. The original conservationists and sportsmen concerns about the harmful impact that herbicides might have on the flora and fauna on or near the ROW proved unfounded. In fact, the data showed a positive impact. The study found that deer, small mammals, birds, reptiles, and even butterflies—considered a true test of environmental impact—were taking advantage of the cleared ground and were thriving. Furthermore, the plant and animal communities themselves were shown to be unknowing helpers in resisting the invasion of unwanted woody plants, through plant competition and by animal feeding behaviors. The resulting shrubs, grasses, and wildflowers supply food and shelter on the ROW that are not found in the adjacent dense forests.

53. Labarr, M., M. Fowle, J. Disorda, and C. Peterson. 2016. "Collaborating to Enhance Habitat for Priority Bird Species in Vermont's Champlain Valley." In Proceedings of the 11th International Symposium on Environmental Concerns in Rights-of-Way Management, 2015, Halifax, Nova Scotia, Canada, edited by Doucet, G.J., pp. 363–369. Utility Arborist Association.

In 2012 and 2013, Audubon Vermont worked collaboratively with the Vermont Electric Power Company (VELCO) to conduct surveys for seven priority bird species along a transmission line ROW in the southern Champlain Valley. The objective of the study was to determine if priority species were present and if trained volunteers could collect data to assist Audubon in determining if VELCO's IVM treatments created the vegetative structure that supported priority bird species. Data support the conclusion that vegetative structure created by VELCO's current management efforts supported priority bird species. This collaborative effort by VELCO, Audubon Vermont, and Audubon Chapter volunteers demonstrated a successful approach by industry, nongovernmental organizations, and citizen scientists to better understand the presence of priority birds along this ROW. Management recommendations based on the surveys were provided to and incorporated by VELCO.

54. Mahan, C.G., D. Krause, and C. Duncan. 2016. "Plant and Animal Community Response to Long Term Vegetation Management Practices on Rights-of-Way." In Proceedings of the 11th International Symposium on Environmental Concerns in Rights-of-Way Management, 2015, Halifax, Nova Scotia, Canada, edited by Doucet, G.J., pp. 201–204. Utility Arborist Association.

The Pennsylvania State Game Lands 33 and the Green Lane Research and Development Area research projects in Central Pennsylvania began in 1953, in response to public concern about the impact of vegetation management practices on wildlife habitat within electric transmission ROW. Both projects provide invaluable information for understanding the response of plants and animals to vegetation management on ROW. Many of the findings are of particular interest to wildlife managers because species in decline are still found on our ROW study areas. In particular, bird assemblages requiring early successional plant communities are declining throughout the Eastern U.S. and were thriving in the ROW. The objective of this study was to continue this long-term research project and document trends in wildlife and plant species. Results support earlier work that finds many bird species that reproduce in the ROW (e.g., eastern towhee, field sparrow) are on the Audubon society's conservation watchlist. Species of amphibians, often negatively affected by fragmenting landscape features, were found using the unique border zone habitat. The high diversity of native plants potentially support over 200 species of Lepidoptera.

55. Mahan, C.G., B.D. Ross, H. Stout, and D. Roberts. 2019. "The Effect of VM Approaches on Electric Transmission ROWs on Bees Pre- and Post-Treatment." In Proceedings of the 12th International Symposium on Environmental Concerns in Rights-of-Way Management, 2018, Denver, Colorado, USA, edited by Espinosa, A., and N.G. Pupa, pp. 649–652. Utility Arborist Association.

This paper presents research on

ROW habitat and conservation benefits for wild pollinators. The authors surveyed flower-visiting insects in different vegetation management treatments in a long-term research ROW to determine which provide the best promoted pollinator abundance and species richness. Game Lands 33 sites with long-stabilized, early successional habitat were utilized for the study. Data showed a high diversity (96 bee species and 179 non-bee morphospecies) in six ROW sites. Results suggest selective, low-volume herbicide applications may promote high pollinator abundance and species richness. This survey also shows that long-term maintenance of ROW habitat has the potential to support many wild pollinator species.

56. Mahan, C.G., B. Ross, H. Stout, and I. Fisher. 2018–2021. Floral and Faunal Research on Utility Rights-of-Way at State Game Lands 33, State Game Lands 103, and Green Lane Research and Demonstration Areas: Report to Cooperators 2018–2021. Available at https://sites.psu.edu/transmissionlineecology/files/2016/02/2021_FLORAL-AND-FAUNAL_Report.pdf.

This report to cooperators updates research on these well-known "Bramble and Byrnes" research sites, dating back to 1953. This update presents data and research on all aspects of floral and faunal communities on these long-term sites. This paper can also be accessed through the Utility Arborist Association website at *www.gotouaa.org/project/research* (accessed August 2022).

57. Marshall, J.S., L.W. VanDruff, S.D. Shupe, and E. Neuhauser. 2002. "Effects of Powerline Right-of-Way Vegetation Management on Avian Communities." In Proceedings of the 7th International Symposium on Environmental Concerns in Rights-of-Way Management, 2000, Calgary, Alberta, Canada, edited by Goodrich-Mahoney, J.W., D.F. Mutrie, and C.A. Guild, pp. 355–362. NY: Elsevier Science, Ltd.

Shrubland habitats and the birds nesting in them are declining in the Northeast U.S. Rights-of-way can provide productive avian habitat with appropriate vegetation management. The study evaluated the avian productivity of two ROW vegetation management options: mowing and selective application of herbicides. Birds were found to have more territories and nests in areas with more shrub cover, and in this study, the mowed areas. Mowing may create better short-term habitat for birds, and selective herbicide treatments may create a more stable long-term shrub layer. Neither treatment provided more productive habitat. The authors conclude that whichever treatment produces more abundant stable habitat would be more beneficial for birds.

58. McLoughlin, K.T. 1997. "Application of Integrated Pest Management to Electric Utility Rights-of-Way Vegetation Management in New York State." In Proceedings of the 6th International Symposium on Environmental Concerns in Rights-of-Way Management, 1997, New Orleans, Louisiana, USA, edited by Williams, J.R., J.W. Goodrich-Mahoney, J.R. Wisniewski, and J. Wisnewski, pp. 118–126. NY: Elsevier Science, Ltd.

The author presents background on IPM as a process/framework for ROW vegetation management. Integrated pest management is a process that balances the use of cultural, biological, and chemical procedures for reducing pest populations to tolerable levels. Rather than relying solely on chemicals (or eliminating chemicals completely), IPM seeks to produce a combination of pest control options that are compatible with the environment, economically feasible, and socially acceptable. The practice of IPM on electric utility ROWs can better be defined as IVM. This paper is one of the first to use and define the term "IVM," that is now widely accepted in the industry. The paper describes the practice of IVM by New York State utilities.

59. McLoughlin, K.T. 2002. "Integrated Vegetation Management – The Exploration of a Concept to Application." In Proceedings of the 7th International Symposium on Environmental Concerns in Rights-of-Way Management, 2000, Calgary, Alberta, Canada, edited by Goodrich-Mahoney, J.W., D.F. Mutrie, and C.A. Guild, pp. 29–45. NY: Elsevier Science, Ltd.

As a follow-up to the author's 1997 paper on IVM, this paper further explores concepts of IVM and the electric utility industry use of the term. The author laments "the acronym IVM has become synonymous with ROW vegetation management and is now used throughout the industry as an ambiguous descriptive term for virtually all ROW vegetation management activities." The author asserts that an authentic IVM program needs to be based on the principles and practices of the established IPM body of knowledge.

60. McLoughlin, K.T. 2002. "Endangered and Threatened Species and ROW Vegetation Management." In Proceedings of the 7th International Symposium on Environmental Concerns in Rights-of-Way Management, 2000, Calgary, Alberta, Canada, edited by Goodrich-Mahoney, J.W., D.F. Mutrie, and C.A. Guild, pp. 319–326. NY: Elsevier Science, Ltd.

Electric utility vegetation programs have resulted in ROWs becoming refugia for many rare, threatened, and endangered species. While ROW owners and managers welcome their presence as components of the stable, low-growing plant community desired for biological control, the industry is now, in some instances, being "penalized" for having achieved these milestones in biodiversity, in that costly studies, inventories, and surveys are often requested/required when these species are discovered.

61. McLoughlin, K.T. 2014. "Integrated Vegetation Management: From its Roots in IPM to the Present." In Proceedings of the 10th International Symposium on Environmental Concerns in Rights-of-Way Management, 2012, Phoenix, Arizona, USA, edited by Doucet, G.J., pp. 227–270. Utility Arborist Association.

This paper traces the origins of IVM from legislation requiring IPM for all uses of pesticides in New York State (NYS) and an initiative by the NYS Public Service Commission requiring IPM on electric utility ROW. New York State electric utilities had a long history of selective use of herbicides to establish stable low-growing plant communities. The motivation for selective herbicide use and the establishment of low-growing plant communities is traced back to Rachel Carson's *Silent Spring*, and Frank Egler. The author presents how these legal requirements led to development of IVM in the 1980s and 1990s in NYS and the Northeast U.S. The Northeast Blackout of 2003 led to the first nationwide ROW vegetation management standard in 2006: NERC Standard FAC-003-1. In the same time period, ANSI A300 Standards, Part 7 – Integrated Vegetation Management was published in 2006. A set of best management practices based on the ANSI IVM Standard was published by the ISA in 2007. The author compares and contrasts the current popular use of the term "IVM" with the well-defined concepts of IPM, from which IVM first emerged in the 1980s.

62. Money, N.R. 2008. "Development of an Integrated Resource Management Strategy for Transmission Right-of-Way Corridors for Successful Implementation of Integrated Vegetation Management in California." In Proceedings of the 8th International Symposium on Environmental Concerns in Rights-of-Way Management, 2004, Saratoga Springs, New York, USA, edited by Goodrich, J.W., L.P. Abrahamson, J.L. Ballard, and S.M. Tikalsky, pp. 33–36. NY: Elsevier Science, Ltd.

The author describes the historic background for establishment of ROW corridors in California and the evolving interests of landowners and the public in the vegetation management practices employed by the electric utility, Pacific Gas and Electric (PG&E). Pacific Gas and Electric's vegetation management methods evolved from nearly exclusive use of mechanical control to IVM methods, and were to meet the reliability, environmental, social, and economic goals of the utility, landowners, regulators, and the public. The author discusses the integrated resource management decision-making process that was used to develop the IVM program. Integrated resource management is a process framework that identifies all compatible resource uses and objectives long-term vegetation management benefits for the utility, landowners, and the public. Clear identification of resource uses leads to development of vegetation management methods that are then implemented within an IVM program.

63. Murcia, C. 1995. "Edge Effects in Fragmented Forests: Implications for Conservation." Tree 10: 58–62.

The author presents a discussion on the effects of edges in fragmented forests. There is a general notion that edge effects are deleterious for forest fragments, though there is little consensus on what an edge is, how to measure edge effects, or how deleterious they are. The discussion is focused on edge effects in forest fragments and does not review edge effects in unbroken forest.

64. Neiring, W.A. 1958. "Principles of Sound Right-of-Way Management." Economic Botany 12(2): 140–144.

The author notes the vast acreage of landscape traversed by ROW and the opportunity for the application of sound management that would benefit the utility with reduced costs on a long-range basis but also results in high conservation values to the nation.

65. Neiring, W.A., and R. Goodwin. 1974. "Creation of Relatively Stable Shrublands with Herbicides: Arresting Succession on Rights-of-Way and Pastureland." Ecology 55: 784–795.

The authors measured the stability of shrublands to invasion by trees on an electric utility ROW on the Connecticut Arboretum. The study site is on land contiguous to Connecticut College. This ROW had been managed using selective applications of herbicide for at least 15 years. Connecticut College researchers promoted selective use of herbicides to manage ROWs in the late 1950s. The concept of stability can be explained in terms of "initial floristic composition" hypothesis of Egler in the 1950s. The authors conclude that creating relatively stable shrub communities by the selective use of herbicides has practical applications in ROW and wildlife management, naturalistic landscaping, and the maintenance of habitat diversity.

66. Nickerson, N.H., and F.R. Thibodeau. 1984. The Effect of Power Utility Rights-of-Way on Wetlands in Eastern Massachusetts. Study Report submitted to the New England Power Company. MA: Westboro.

This study report summarizes the results of tracking five years of natural revegetation of a newly cleared 345-kilovolt ROW in Massachusetts. The specific goals of the study were to determine how the natural ecological conditions change as a result of ROW construction and maintenance; how long these differences persist; and whether any changes, temporary or permanent, occur in the wetlands which can be considered an important negative or positive impact, in terms of the interests identified in the Massachusetts Wetland Protection Act. The authors concluded that opening forested areas of wetland to construct electric powerlines has a net beneficial effect on many ecological parameters, especially in New England where open

space is at a premium because of forest development on abandoned farms. The value of the cleared ROWs as open corridors for connecting otherwise non-contiguous natural areas, for developing shrub rather than tree vegetation, and for developing edge effect feeding/nesting/cover opportunities for many animals, is clearly indicated. In most cases there was no evidence on long-term degradation of wetland values as they compare to the Massachusetts Wetland Protection Act.

67. Nickerson, N.H. 1992. "Impacts of Vegetation Management Techniques on Wetlands in Utility Rights-of-Way in Massachusetts." Journal of Arboriculture 18(2): 102–106.

The paper presents results of studies on vegetation management techniques in wetlands in Massachusetts. The studies compared five ROW treatments (hand cutting, mowing, cut stump treatment with herbicides, basal herbicide application, and foliar herbicide application) to determine their impacts on wetlands on electric utility ROW. The conclusion reached was that there was no significant impact to wetland value or function from any of the vegetation management techniques. Mechanical treatments resulted in higher impacts to cover value for wildlife than those involving herbicides. Residue from petroleum products (bar oil and hydraulic fluid) were recovered on the leaf litter from mechanically treated sites. No herbicides residues were recovered from herbicide-treated sites.

68. Nickerson, N.H., G.H. Moore, and A.D. Cutter. 1994. Study of Environmental Fates of Herbicides in Wetlands on Electric Utility Rights-of-Way in Massachusetts Over the Short Term. Final Report.

This study examined the environmental fate of two herbicide active ingredients, triclopyr and glyphosate, applied to Red Maple trees in wetlands in Massachusetts. The purpose of the study was to quantify the soil residues of the herbicides immediately following application and their environmental fate in the soil up to 12 months after application. Foliar application was found to result in the least residue in the soil. These residues biodegraded to below detectable limits in less than 12 months. Cut stump treatments resulted in the highest soil residues and were present in the soil for up to 18 months. Tests were conducted for movement in the soil. Glyphosate did not move laterally or vertically in the soil. Triclopyr did not move laterally but was found to move vertically in small amounts. Assessment as to the least environmentally damaging and most effective vegetation control measure of the four methods studied points to low-volume foliar application of glyphosate as the method of choice.

69. Norris, L.A., N.H. Nickerson, K. Bentsen, W.C. Bramble, W.R. Byrnes, and K.L. Carvell. 1989. Study of the Impacts of Vegetation Management Techniques on Wetlands for Utility Rights-of-Way in the Commonwealth of Massachusetts. Environmental Consultants, Inc.

The study report describes research performed to evaluate the impacts of vegetation management techniques on electric utility ROWs crossing wooded wetlands in Massachusetts. The project included a review of published literature, interviews with subject matter experts, and field studies on selected ROW wooded wetlands. Models were also used to evaluate the potential risk of groundwater pollution from herbicide use in vegetated wetlands. Five principal vegetation management techniques were evaluated: hand cutting, mowing, foliar herbicide application, basal herbicide application, and cut stump herbicide applications. Results of the study indicated that there are no significant impacts to wetlands from the current vegetation management techniques used on ROW in Massachusetts. Mechanical treatments result in relatively higher impacts than selective herbicide use. Residue from petroleum products (bar oil and hydraulic fluid) were found in the leaf litter on mechanically treated sites. No herbicide residues were found on herbicide-treated sites.

70. Norris, L.A. 1997. "Address Environmental Concerns with Real Data." In Proceedings of the 6th International Symposium on Environmental Concerns in Rights-of-Way Management, 1997, New Orleans, Louisiana, USA, edited by Williams, J.R., J.W. Goodrich-Mahoney, J.R. Wisniewski, and J. Wisnewski, pp. 213–218. NY: Elsevier Science, Ltd.

Dr. Norris asserts that "many environmental concerns about ROW siting, construction, and management can be addressed most effectively with scientific data from field- and laboratory-based research and monitoring programs. Examples of research are used to illustrate this point. Both the public and entities managing ROW will best be served by increased research and monitoring.

71. Norris, L.A., and P. Charlton. 1993. "Determination of the Effectiveness of Herbicide Buffer Zones in Protecting Water Quality." In Proceedings of the 5th International Symposium on Environmental Concerns in Rights-of-Way Management, 1993, Montreal, Quebec, Canada, edited by Doucet, G.J., C. Seguin, and M. Giguere, pp. 147–152.

This study and results published by the Empire State Electric Energy Research Corporation was initially published 1991 (ESSERCO paper is available from ECI). The authors conducted three studies to determine: (A) water quality criteria that will protect aquatic organisms and human health, (B) the effect of buffer zone width and vegetation density on herbicide deposition outside the treated area, and (C) the effectiveness of specific buffer strategies in protecting water quality during operational use of herbicides. The second study determined spray deposition at

distances from 0 to 100 feet from the downwind edge of areas treated by either stem-foliar or basal methods. The results showed that in all cases where there was vegetation in the buffer zone, stream water quality criteria would be achieved if buffers of 25 feet or more are used. The third study was a field test of buffer zone effectiveness and was conducted involving high-volume stem foliage and low-volume basal applications of picloram, triclopyr, 2,4-D, or imazapyr. Buffers of 10 to 100 feet were employed. Application of these water quality protection criteria to the results from this project show the buffer zones tested in this study protected surface water quality with a significant margin of safety. While wider buffer zones could be used, results indicate no substantive gain in safety would be achieved. This study has been referenced in many regulatory filings and environmental impact reviews as the basis for buffers to protect surface waters.

72. Nowak, C.A., L.P. Abrahamson, E.F. Neuhauser, C.G. Foreback, H.D. Freed, S.B. Shaheen, and C.H. Stevens. 1992. "Cost-Effective Vegetation Management on a Recently Cleared Electric Transmission Line Right-of-Way." Weed Technology 6: 828–837.

Cost-effectiveness (degree of vegetation control and cost) of several methods of herbicide application are evaluated in this study. Treatments that increase compatible plants and decrease incompatible plants and have relatively low cost are considered to be cost-effective. Three herbicides, 2,4 D, picloram, and triclopyr, were applied in the field using cut stump, basal, and stem-foliar methods. Both selective and non-selective treatments were carried out. Non-selective and stem-foliar application were most effective during first and second conversion cycles, respectively. This paper is the initial published data from a long-term study (Nowak 2012).

73. Nowak, C.A., L.P. Abrahamson, D.J. Raynal, and D.J. Leopold. 1993. "Selective Vegetation Management on Powerline Corridors in New York State: Tree Species Composition Changes from 1975 to 1991." In Proceedings of the 5th International Symposium on Environmental Concerns in Rights-of-Way Management, 1993, Montreal, Quebec, Canada, edited by Doucet, G.J., C. Seguin, and M. Giguere, pp. 153–158.

In this study, tree densities and species composition were compared on powerline corridors in New York State over a 16-year period across a wide range of management schemes, environmental conditions, and plant communities. In 1975, 58 permanent vegetation measurement plots, 0.03 to 0.08 ha in size, were established on 21 corridors across New York. Tree densities and species composition were measured in 1975 and 1991. On ROWs where trees were selectively removed using herbicides, tree populations were observed at constant low density. There was a spatial redistribution of trees in 1991 compared to 1975, with fewer trees in the corridor centerline and more in the border areas along corridor edges in 1991. An increase in tree density was observed on corridors that did not receive herbicide treatments to control trees, hand cutting only. Species composition generally did not change over the study period. Authors concluded that operational, selective removal of trees on powerline ROW with herbicides can lead to the creation of relatively stable, compositionally constant, low-density tree populations.

74. Nowak, C.A., and B.D. Ballard. 2005. "A Framework for Applying Integrated Vegetation Management on Rights-of-Way." Journal of Arboriculture 31(1): 28–37.

The authors suggest that IVM is purportedly being used by many ROW organizations across the U.S. They go on to state, in many instances, IVM has become a name applied to old management approaches. The authors state that IVM is more than repackaged old techniques. Integrated vegetation management is an in-depth system of information gathering, planning, implementing, reviewing, and improving vegetation management treatments. The paper then describes a six-step management system for implementation of IVM.

75. Nowak, C.A. 2014. "What is this Integrated Vegetation Management, this IVM – Now, Today, and into the Future?" In Proceedings of the 10th International Symposium on Environmental Concerns in Rights-of-Way Management, 2012, Phoenix, Arizona, USA, edited by Doucet, G.J., pp. 281–287. Utility Arborist Association.

Integrated vegetation management has been touted over the past few decades as an approach for ROW vegetation management. It is an approach based on IPM systems at its core, but also includes the necessary administrative and institutional support to create a management system. Integrated vegetation management was central to the development of the existing American National Standards Institute (ANSI) A300 Part 7– 2006 Vegetation Management standards and the International Society of Arboriculture best management practices. Integrated vegetation management has continued to evolve over the last decade, with examples of expanded emphasis of work on: (1) broad assessment of environmental impact, (2) building social awareness and responsibility, and (3) elevated focus on safety and reliability of service. This paper presents a history of IVM, its current state and use by ROW industries, and possible future changes. A bibliography of key references is provided.

76. Payne, L., J. Gwodz, J. Kooser, and K. Gorski. 2016. "Integrated

Vegetation Management Works: The Proof is in the Program." In Proceedings of the 11th International Symposium on Environmental Concerns in Rights-of-Way Management, 2015, Halifax, Nova Scotia, Canada, edited by Doucet, G.J., pp. 205–213. Utility Arborist Association.

Implementation of IVM for controlling undesirable, tall-growing woody vegetation, while at the same time promoting the desirable low-growing plant communities on electric transmission ROW, has been proven to be a successful treatment strategy. An overview of the New York Power Authority's (NYPA) program over the past four treatment cycles (1 treatment cycle is 4 years) clearly shows trends that managing for a desirable, low-growing stable plant community is definitely working. New York Power Authority collected extensive vegetation management data over the past four treatment cycles, which clearly show that managing for a desirable stable plant community has proven effective in balancing the utilities operational, environmental, economic, social, reliability, and safety goals on its ROW.

77. Putz, F.E., and C.D. Canham. 1992. "Mechanisms of Arrested Succession in Shrublands: Root and Shoot Competition Between Shrubs and Tree Seedlings." Forest Ecology and Management 49: 267–275.

The authors investigated the relative effects of aboveground and belowground competition from shrubs on the growth of tree seedlings as a mechanism for arresting succession to tree species in old fields in New York State. Tree encroachment (invasion) into shrub-dominated stands can be reduced by both root and shoot competition. The severity of competition varies with site conditions; belowground competition is intense where soil resources are limited, whereas effects of shade are relatively more severe on sites with good soil. As background, the authors reference papers by Egler, Niering, and others at Connecticut College on the management of shrubs as an environmentally sound method for reducing tree encroachment in powerline ROWs.

78. Quant, J.M., C.A. Nowak, and M. Dovcial. 2016. "Human-Based Spread of Invasive Plants from Powerline Corridors in New York State." In Proceedings of the 11th International Symposium on Environmental Concerns in Rights-of-Way Management, 2015, Halifax, Nova Scotia, Canada, edited by Doucet, G.J., pp. 87–96. Utility Arborist Association.

The authors' research goals were to (1) quantify the spread of invasive propagules during typical vegetation management operations, and (2) make recommendations for cleaning protocols for vehicles and workers. Authors met with vegetation management crews over two seasons (2013 and 2014) and sampled material accumulating on workers, ATVs, and mowers to quantify propagule movement. In 2013, an estimated 66,400 propagules were moved from 31 research sites across New York State, and at least 6% of these were clearly identified as IE species. In 2014, an estimated 93,000 propagules were moved from 30 sites, and at least 10% of these were IE species. Data suggest that vehicles have a greater capacity to move propagules than workers. The most frequently transported invasive exotic species were Morrow's honeysuckle (*Lonicera morrowii*) and purple loosestrife (*Lythrum salicaria*). Authors recommend that cleaning protocols should take into account vector type (worker, ATV, or mower), soil drainage, and ecoregion, and should include washing.

79. Richards, N.A. 1973. "Old Field Vegetation as an Inhibitor of Tree Vegetation." In Proceedings of the Colloquim 'Biotic Management Along Transmission Right-of-Way,' 1973, American Institute of Biological Sciences, Amherst, Massachusetts, pp. 78–88. The Cary Arboretum of the New York Botanical Gardens.

The author, a professor of silviculture at SUNY ESF, presents case studies and ecological elements that contribute to sustaining "perennial meadows." These meadows resist and inhibit natural regeneration and tree planting efforts. Ecological factors include: soil moisture and nutrient competition, shading, burying, microclimate extremes, faunal damage, and phytochemical effects. Case studies suggest that old fields dominated by grasses, forbs, and herbaceous species are more resistant to tree invasion than fields dominated by woody shrubs.

80. Rigby, M., M. Gach, and T.E. Sullivan. 2012. "Urban Wildlife Sanctuary Along an Electric Transmission Right-of-Way: A Successful Partnership." Abstract in the 10th Symposium on Environmental Concerns in Right-of-Way Management, 2012, Phoenix, Arizona, USA.

The paper presents a case history of IVM practiced on a ROW within an urban wildlife sanctuary managed by New England Power Company and the Massachusetts Audubon Society. The sanctuary is largely on land belonging to New England Power Company. This historic partnership is a showcase for stakeholder engagement with an environmental organization. Wildlife habitat is the primary ecological value managed for through application of IVM. Published in the *T&D World* Vegetation Management Supplement (2014).

81. Rogers, T.W. 2016. "Impacts of Vegetation Management Practices on Animal, Plant, and Pollinator Habitats." In Proceedings of the 11th International Symposium on Environmental Concerns in Rights-of-Way Management, 2015, Halifax, Nova Scotia, Canada, edited by Doucet, G.J., pp. 227–230. Utility Arborist Association.

The author's objective for this paper was to examine what is known from research and operational experience about the impacts of various vegetation management techniques on animal, plant, and pollinator habitats. Based on years of field research and operational experience, vegetation management techniques employed in ROW management play a significant role in maintaining and improving habitat needed for sustaining threatened and endangered (T&E) animal, plant, and pollinator species. Plant, animal, and pollinator species respond differently to the use of various vegetation management methods. Knowledge from years of practical experience and 60+ years of research will demonstrate that managing ROWs using IVM techniques is the best approach for establishing and maintaining these critical habitats. The paper includes an extensive bibliography of Bramble and Byrnes and Yahner papers from Game Lands 33 and Green Lane studies in Pennsylvania.

82. Russo, L., H. Stout, D. Roberts, B.D. Ross, and C.G. Mahan. 2021. "Powerline Right-of-Way Management and Flower-Visiting Insects: How Vegetation Management Can Promote Pollinator Diversity." Plos One 16(1): e 0245146. http://doi.org/10.1371/journal.pone.0245146 (accessed July 2022).

The authors surveyed flower-visiting insects over two years in different vegetation treatment in long-term stable "Bramble and Byrnes" research sites in Pennsylvania to determine which best promoted pollinator abundance and species richness. Data showed a high diversity of flower-visiting insects (126 bee species and 170 non-bee species) in six ROW plots. Sites requiring and higher level of maintenance work (higher amounts of herbicide applied) had a negative effect on bee species richness, but low levels of herbicide application were compatible with a high abundance and species richness of flower-visiting insects. The authors demonstrate that there is substantial potential for pollinator conservation in ROW, maintained using selective herbicide application within the context of an IVM program.

83. Sheridan, P.M., S.L. Orzell, and E.L. Bridges. 1997. "Powerline Easements as Refugia for State Rare Seepage and Pineland Plant Taxa." In Proceedings of the 6th International Symposium on Environmental Concerns in Rights-of-Way Management, 1997, New Orleans, Louisiana, USA, edited by Williams, J.R., J.W. Goodrich-Mahoney, J.R. Wisniewski, and J. Wisnewski, pp. 451–460. NY: Elsevier Science, Ltd.

The authors present data from field survey on the inner coastal plain and pinelands of Georgia, Maryland, and Virginia. Sixty-five state-listed rare plant species were documented. Endangered and threatened plant species were also found. Powerlines clearly serve as refugia for plants and might serve as a local measure of biodiversity in regions where the surrounding natural vegetation has been highly altered.

84. VanBossuyt, R. 1987. "New England Electric System Companies' Selective Right-of-Way Management Program." In Proceedings of the 4th Symposium on Environmental Concerns in Rights-of-Way Management, 1987, Purdue University, Indiana, USA, edited by Byrnes, W.R., and H.A. Holt, pp. 123–127.

The author presents program development and 20+ years of ROW vegetation management practice on New England Electric System ROW using selective application of herbicides. New England Electric System was the predecessor to National Grid, the holding company of New England Power Company and The Narragansett Electric Company. The author and primary contractor, Vegetation Control Service, Inc., were among the earliest developers of low-volume selective herbicide application methods dating back to 1963.

85. VanSplinter, J.L., C.A. Nowak, and M. Fierke. 2019. "Implications and Guidance from the Literature for ROW Managers Looking to Promote Pollinator Habitat." In Proceedings of the 12th International Symposium on Environmental Concerns in Rights-of-Way Management, 2018, Denver, Colorado, USA, edited by Espinoza, A., and N.G. Pupa, pp. 437–448. Utility Arborist Association.

The objective for this study was to determine the current state of knowledge, technology, and practice for managing ROW corridor vegetation with a focus on pollinator habitat. A literature review was conducted to determine the current state of knowledge, technology, and practice. The review includes 36 studies from North America and Europe investigating powerline, roadway, and railway ROW. The authors note that most of the studies were observational with little experimental/conclusive evidence to support one management technique over others. The authors use the available study to develop an eight-step guidance for managing ROW for pollinators. The importance of proceeding with caution, on the ground learning, and adaptive management are emphasized due to the limited evidence available.

86. VanSplinter, J.L., B.D. Ballard, C.A. Nowak, and M.K. Fierke. 2019. "Setting Up a Long-Term Research Study of Pollinators on ROWs: Experience from Literature and the Field." In Proceedings of the 12th International Symposium on Environmental Concerns in Rights-of-Way Management, 2018, Denver, Colorado, USA, edited by Espinoza, A., and N.G. Pupa, pp. 631–639. Utility Arborist Association.

The authors discuss the 2014 Presidential Memorandum, "Creating a Federal Strategy to Promote the Health

of Honey Bees and Other Pollinators," to addresses enhancement and creation of pollinator habitat as a top priority. Electrical ROW and the 9.6 million acres of early successional habitat they provide in the U.S. offer an opportunity to address this need. Determining baseline data, trends, and BMPs require long-term monitoring and research. This paper addresses three key elements of initiating long-term pollinator projects on ROWs: (1) experimental design and site selection, (2) vegetation and insect pollinator monitoring techniques, and (3) obtaining appropriate baseline information. The importance of partnerships between utilities and scientists are emphasized as the "glue" holding research and development of adaptive management for pollinator habitat together.

87. Walden, D.L., S. Morawski, and I.E. Hegemann. 2008. "Mitigation Measures for Rare Species During Necessary Maintenance Activities Within Existing Rights-of-Way." In Proceedings of the 8th International Symposium on Environmental Concerns in Rights-of-Way Management, 2004, Saratoga Springs, New York, USA, edited by Goodrich, J.W., L.P. Abrahamson, J.L. Ballard, and S.M. Tikalsky, pp. 529–539. NY: Elsevier Science, Ltd.

The authors discuss the increasing importance of electric and gas ROW for maintained field and shrubland habitat. Discussion is presented on the diversity and abundance floral and fauna species on ROW and the presence of rare, threatened, and endangered species on ROW. Case studies are presented on practices utilized during maintenance and construction activities on ROW to protect the habitat and species. The case studies all provide evidence that the disturbance associated with the maintenance of utility infrastructure had no impact on the habitat for each of the monitored species.

88. Watkins, C.N., and L.L Young. 2018. "IVM and Environmental Compliance on State, Federal, and Tribal Lands." In Proceedings of the 12th International Symposium on Environmental Concerns in Rights-of-Way Management, 2018, Denver Colorado, USA, edited by Espinoza, A., and N.G. Pupa, pp. 449–458. Utility Arborist Association.

Rights-of-way in the Western U.S. often cross public lands, and many IVM control methods require special authorization by land management agencies. Arizona Public Service (APS) recently navigated this regulatory landscape and obtained approval to conduct an IVM program, including chemical, manual, and mechanical control methods on Arizona state, tribal, Bureau of Land Management (BLM), and U.S. Forest Service (USFS) lands. The authors present this case study as a model for other Western U.S. ROW managers who implement IVM programs on public lands. Successfully obtaining these authorizations took varying investments of time and resources, but the benefits of IVM more than justified the cost of compliance.

89. Wells, T.C., K.D. Dalgarno, and R. Read. 2002. "Reducing Costs Using Integrated Vegetation Management on Electric Utility Transmission Lines in British Columbia." In Proceedings of the 7th International Symposium on Environmental Concerns in Rights-of-Way Management, 2000, Calgary, Alberta, Canada, edited by Goodrich-Mahoney, J.W., D.F. Mutrie, and C.A. Guild, pp. 63–72. NY: Elsevier Science, Ltd.

The authors carried out IVM protocols and treatments on three sites on BC Hydro corridors in British Columbia. Pre-treatment inventories were conducted to define growth rates and stand densities of incompatible species, as well as identifying compatible/competitive ground cover and to determine action thresholds for treatment. A site-based prescriptive approach was taken to select the appropriate combination of manual, mechanical, chemical, and natural control methods to establish short- and long-term site objectives. Results from the study indicate that selective approaches to ROW maintenance allow long-term site objectives to be met at reduced costs. This is achieved by optimizing treatment cycle lengths or reducing maintenance by clearing only what is necessary to establish compatible plant communities. Selective treatments also resulted in protection of riparian zones and wildlife habitats and promoted opportunities for compatible use.

90. Westerhold, M., A. Geggestad, and S. Peters. 2019. "Herbicide Impacts on Pollinators: Current State of Knowledge and Best Management Practices." In Proceedings of the 12th International Symposium on Environmental Concerns in Rights-of-Way Management, 2018, Denver, Colorado, USA, edited by Espinoza, A., and N.G. Pupa, pp. 421–432. Utility Arborist Association.

The authors attempt to better understand the potential effects of herbicides and adjuvants on pollination and pollinator habitat through industry outreach and a review of the literature. The review summarizes findings from previous studies and focuses on peer-reviewed research. Direct and indirect effects are summarized for active and inert ingredients common to utility VM. The authors offer numerous BMPs focused on preservation of pollinators and pollinator habitat.

91. Wetteroff, J., and D. Koniecka. 2006. Environmental Consultants, Inc. Transmission Right-of-Way Invasive Non-Woody Plant Species Control. Palo Alto. CA: EPRI.

The authors point out that concerns over invasive plants have been

increasing for decades. Executive Order 13112, signed by President Clinton in 1999, was an initial step to "prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause." The paper provides an annotated bibliography of 40 papers. Most of the papers focus on individual problem species and control methods. None of the papers specifically point to ROW as contributing to the spread of invasive plants. The authors surveyed and interviewed a number of electric utilities to provide case studies of how utilities are incorporating control of invasive plants into their VM programs. The paper also presents a list of state and federal laws related to invasive plants.

92. Willyard, C.J., and S.M. Tikalsky. 2008. "Research Gaps Regarding the Ecological Effects of Fragmentation Related to Transmission-Line Rights-of-Way." In Proceedings of the 8th International Symposium on Environmental Concerns in Rights-of-Way Management, 2004, Saratoga Springs, New York, USA, edited by Goodrich-Mahony, J.W., L.P. Abrahamson, J.L. Ballard, and S.M. Tikalsky, pp. 521–527. NY: Elsevier Science, Ltd.

The authors conducted an extensive literature survey on the effect of transmission line ROW on the ecology of the local environment. Research gaps related to fragmentation are grouped into three categories: increased edge, invasive species, and early successional habitat. The authors comment that the ecological effects produced by linear ROW can be grouped into two broad categories: fragmentation of habitat and creation of ROW corridors, both of which can have positive and negative consequences depending on the species in question.

93. Windmiller, B., and A.J.K. Calhoun. 2002. "Conserving Vernal Pool Wildlife in Urbanizing Landscapes." Science and Conservation of Vernal Pools in Northeastern North America, pp. 233–251.

The paper presents background on the ecological value of vernal pools the impacts of urbanization on vernal pools, surrounding wetlands and terrestrial habitat. Impacts to vernal pool wildlife and conservation recommendations are presented.

94. Wininger, K., V. Wojcik, and C. Halle. 2019. "A Comparison of Pollinator Communities in ROWs and Unmanaged Lands: Understanding Habitat Opportunities in California Electric Transmission ROWs." In Proceedings of the 12th International Symposium on Environmental Concerns in Rights-of-Way Management, 2018, Denver, Colorado, USA, edited by Espinoza, A., and N.G. Pupa, pp. 503–512. Utility Arborist Association.

Researchers from Sonoma State University and the Pollinator Partnership conducted a three-year investigation with the objective of assessing and comparing pollinator communities associated with PG&E-managed ROW crossing conservation lands at Fairfield Osborn Preserve in Sonoma County, California, and the adjacent conservation lands, to gauge the value of each landscape to pollinators. Results lend support to the potential of IVM on ROW to increase the value of oak woodlands to pollinators. Pollinator richness was highest in treated ROW, and honeybees in particular showed preference for ROW as opposed to the other habitats studied. Pollinator occurrences increased over the 3-year study period.

95. Wojcik, V., P. Beesley, B. Brenton, E. Brown, and S. Hallmark. 2016. "Innovations in Right-of-Way Management that Support Pollinators, Ecosystem Services, and Safe Energy Transmission." In Proceedings of the 11th International Symposium on Environmental Concerns in Rights-of-Way Management, 2015, Halifax, Nova Scotia, Canada, edited by Doucet, G.J., pp. 249–258. Utility Arborist Association.

Pacific Gas and Electric Company and the Sacramento Municipal Utility District partnered with the Pollinator Partnership and others to research management techniques that support ecosystem services and the specific objective to create pollinator habitat on ROW. The flagship project in this collaboration is the American River Parkway Pollinator Project—the first long-term comparative monitoring field study in the Western Region that examined pollinator communities on actively managed ROW. Results show that ROW managed using IVM techniques designed to control non-native invasive plants and instead favor creation of low-growing, native plant communities resulted in an almost three-fold increase in bee abundance and a two-fold increase in bee species richness. The study provides support for developing BMPs for pollinator habitat management along ROW in Northern California. Additional studies are underway to better understand how these managed landscapes play a role in pollinator and ecosystem services support.

96. Yahner, R.H, W.C. Bramble, and W.R. Byrnes. 2001. "Response of Amphibian and Reptile Populations to Vegetation Maintenance of an Electric Transmission Line Right-of-Way." Journal of Arboriculture 27(4): 215–220.

This two-year study of amphibian and reptile populations was conducted

in Pennsylvania. The objectives were to compare diversity and abundance of amphibians and reptiles between the ROW and adjacent forest, among five treatment units on the ROW, and between wire and border zones on treatments on the ROW. Eight species were noted on the ROW. Detailed data is presented for the treatment types and wire vs. border zones. The ROW contained a greater diversity of amphibian and reptile species than the adjacent forest.

97. Yahner, R.H. 2002. "50 Years of Wildlife Research Along a Pennsylvania Right-of-Way." Dow AgroSciences.

The author presents a summary of the 50 years of research on the Game Lands 33 Research and Development Project in Pennsylvania. The R&D project began in 1952 and is the longest continuous study documenting the effects of mechanical and herbicidal maintenance on wildlife and plants along an electric transmission ROW. Researchers on the project have included Dr. Bill Bramble, Dr. Dick Byrnes, Dr. Rich Yahner, Dr. Russ Hutnick, and Mr. Steve Liscinsky. Research has evolved from initially studying the effects of ROW vegetation treatments on game species to development of tree-resistant cover types and impacts on bird populations, amphibians and reptiles, and small mammals. Twenty published research papers are available on the DVD, compiled and published by Dow AgroSciences.

98. Yahner, R.H., B.D. Ross, R.T. Yahner, R.J. Hutnik, and S.A. Liscinsky. 2004. "Long-Term Effects of Rights-of-Way Maintenance via the Wire-Border Zone Method on Bird Nesting Ecology." Journal of Arboriculture 30(5): 288–293.

The long-term nesting ecology of birds was studied during 2002 and 2003 on the State Game Lands 33 R&D area in the Allegheny Mountain region in Pennsylvania. The objectives of the study were to compare nest abundance, success, and placement in hand-cut versus herbicide-treated study sites and in wire zones vs. border zones. Thirty-nine percent of nests of all species combined fledged young in 2002 and 65% in 2003. Nesting success in 2003 was typical of most studies of bird nesting success in a variety of habitats. Fifty-nine percent of the 59 nests were in the wire zones, whereas 41% of nests were in border zones. In conclusion, mowing plus herbicide treatment on a ROW may be the best application of the wire zone-border zone method in terms of resistance to seedling invasion of undesirable trees, cover-type developments in the wire zone, and its value as wildlife habitat. Wire-border zone method is extremely valuable to the long-term conservation of early successional bird species.

99. Yahner, R.H., and R.J. Hutnik. 2004. "Integrated Vegetation Management on an Electric Transmission Rights-of-Way in Pennsylvania." Journal of Arboriculture 30(5): 295–300.

The authors review the history of maintenance of ROW on State Game Lands 33 in Pennsylvania since 1953. Authors note the border zone/wire zone method was implemented on these ROW in 1987. The objective of this study was to present incompatible tree-density data in response to IVM treatments two and three years after treatment in the year 2000. Treatments in historically herbicide-maintained sites included mowing, mowing plus herbicide, stem-foliage, foliage, basal low volume. Stem densities measured in 2002 and 2003 for these sites averaged 104 and 138 stems per acre in wire zones and 329 and 203 stems per acre in border zones. Historically, hand-cut-only sites were also measured. These sites averaged 2,501 and 3,551 stems per acre in border zones and 3,201 and 3,301 stems per acre in border zones. Authors concluded that IVM-based herbicide treatments result in a stable plant community that resists invasion by incompatible tree species. The authors report IVM and the wire-zone/ border-zone method has increased cycle length, thereby reducing labor and chemical costs.

100. Yahner, R.H., and R.J. Hutnik. 2005. "Plant Species Richness on an Electric Transmission Right-of-Way Using Integrated Vegetation Management." Journal of Arboriculture 31(3): 124–130.

In this paper, the authors' objective was to document plant species richness among treatment units and in relation to wire and border zones on the SGL 33 Research and Demonstration Area. Data was collected on the presence of plant species from late May through mid-August in both 2003 and 2004, and observed 125 vascular plant species in the 15 treatment units. The total number of species per unit ranged from a low of 35 species in a mowing unit to a high of 63 species in a basal low-volume spray unit. Of the total number of plant species found on the ROW, 95 (76%) and 110 (88%) occurred in wire and border zones, respectively. In wire zones, the average number of plant species ranged from 31 in mowing units to 41 in foliar spray units. In border zones, the average number of plant species varied from a low of 34 in mowing units to a high of 41 in hand-cut units. The proportion of exotic species did not vary appreciably between wire and border zones (19% and 22% of total, respectively) on the ROW.

101. Yahner, R.H., R.T. Yahner, and R.J. Hutnik. 2007. "Long-Term Trends in Small Mammals on a Right-of-Way in Pennsylvania." U.S. Journal of Arboriculture and Urban Forestry 33(2): 147–152.

The authors update a study of small mammals conducted 15 years earlier (1989 to 1990) on the State Game Lands 33 ROW. Field work involved a two-year live-trapping study in 2004 on small

mammal populations on this ROW. The objectives of the study were to determine relative abundance and species richness (number of species) in six major cover types and in the adjacent forest. One hundred twenty-one individuals of 8 species were observed in 2004 and 2005 combined; the most common species was the white-footed mouse (*Peromyscus leucopus*). One of the most important cover types to small mammals on the ROW was forb grass, whereas the forest cover type tended to be less diverse in terms of number of mammal species than in cover types on the ROW. Small mammals are important wildlife species on a ROW by consuming tree seeds, thereby reducing invasion of incompatible tree species.

CONCLUSION

Seventy plus years of research do, in fact, provide a powerful environmental and economic case for managing vegetation on ROW with herbicides within the context of an integrated system. The key word here is "system." Integrated vegetation management provides a system, a process, and a framework for managing to achieve an outcome—not just solving the problem of dense, tall-growing vegetation interfering with ROW objectives. The outcome, of course, is establishing low-growing, compatible vegetation that will prevent incompatible vegetation from dominating the plant community on the ROW. This outcome leads to lower cost inputs—crews, equipment, and volume of herbicide, and less impact on the environment. Rights-of-way managed using IVM provide greater conservation services—cleaner water, a more diverse and stable plant community, and wildlife habitat. All these outcomes demonstrate environmental stewardship by the ROW owner and practitioners. Integrated vegetation management also delivers on ROW objectives—access to assets and reliable delivery of utility services.

One item we were curious about as we reviewed these papers was when the term "IVM" first appeared, and who might have coined the term. The early practitioners cited using selective herbicide applications to develop low-growing plant communities were electric utility companies in New England, New York, and Pennsylvania. The concept of integration of selective application into a system based on IPM principles came out of efforts in New York State. While many attributed Kevin McLoughlin as the primary force (anyone who knows McLoughlin will understand our choice of the word "force"), the earliest use of the term IVM the authors could find was in the IPM position paper for New York State, Appendix A (McLoughlin 2002).

The economic case for IVM has been made by many authors. The most definitive and analytic case using industry-wide data is presented by John Goodfellow and others (Goodfellow and Nowak 2017; Goodfellow et al. 2018).

The authors reviewed more than 150 sources in the process of developing this annotated bibliography. The papers truly do tell an incredible story. Our purpose in writing the annotated bibliography was to provide a resource for practitioners of ROW vegetation management. We hope practitioners find it useful as they develop IVM programs and in educating internal and external stakeholders to demonstrate that IVM is the best approach. Current researchers and practitioners will lead the way in developing the next chapter of this evolving story through research, demonstration of new work practices, publication, and resulting changes to standards. We look forward to their work.

AUTHOR PROFILES

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Tom Sullivan has 40+ years of electric utility experience as an employee and consultant to National Grid, and its predecessor companies, and as a Project Management Consultant to other Northeast U.S. utilities. For most of his career, he managed the Transmission Forestry Department at National Grid. As a forester, Sullivan holds a Master of Science degree in biology from Boston University and a Bachelor of Science degree from the College of Environmental Science and Forestry at Syracuse. He is a Certified Arborist and Massachusetts Licensed Forester. Sullivan is active in professional organizations and has served as a Director of the Utility Arborist Association, from which he received the Utility Arborist Award in 2004. He is currently President of the Princeton Land Trust and Tree Warden for his hometown.

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Dr. Phil Charlton is Principal and Owner of Charlton & Associates, LLC. He has over 30 years of experience in the electric and pipeline utility vegetation management industry and was the 2001 recipient of the UAA Utility Arborist Award. Dr. Charlton holds Master of Science and Doctorate degrees in forest science from West Virginia University. He worked for Environmental Consultants, Inc. (ECI), a utility vegetation management consulting company, for 26 plus years. While at ECI, he participated in the assessment of the distribution line clearance and transmission rights-of-way vegetation management programs of over 150 utilities. Dr. Charlton was also involved in extensive research on tree-caused power outages, a wide range of herbicide use and related environmental issues, and developed cost and effectiveness models for ROW management in New York State. Dr. Charlton retired as President and Chief Operating Officer of ECI in 2006. He served as the Executive Director of the Utility Arborist Association from 2011 to 2021.

John W. Goodfellow
John Goodfellow has 40 years of experience in the utility industry, having held positions of responsibility for

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