CEATI Vegetation Management Project 4101

The Business Case for Herbicide Use in Integrated Vegetation Management Programs

BioCompliance Consulting Project team:

John Goodfellow

Chris Nowak, PhD

John Wagner, PhD

Concerns driving initiation of the project: *Consequences of tree-conductor faults*

- Electrical faults from energized conductors to trees can result in significant interruptions and major outages to customers

Simulated 230kV fault to test tree.

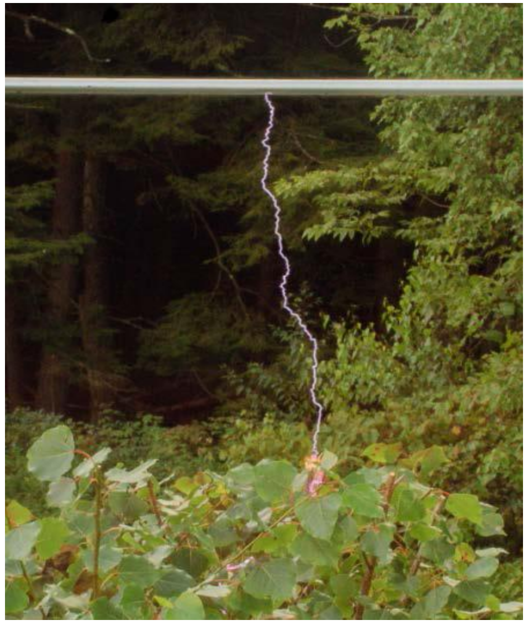
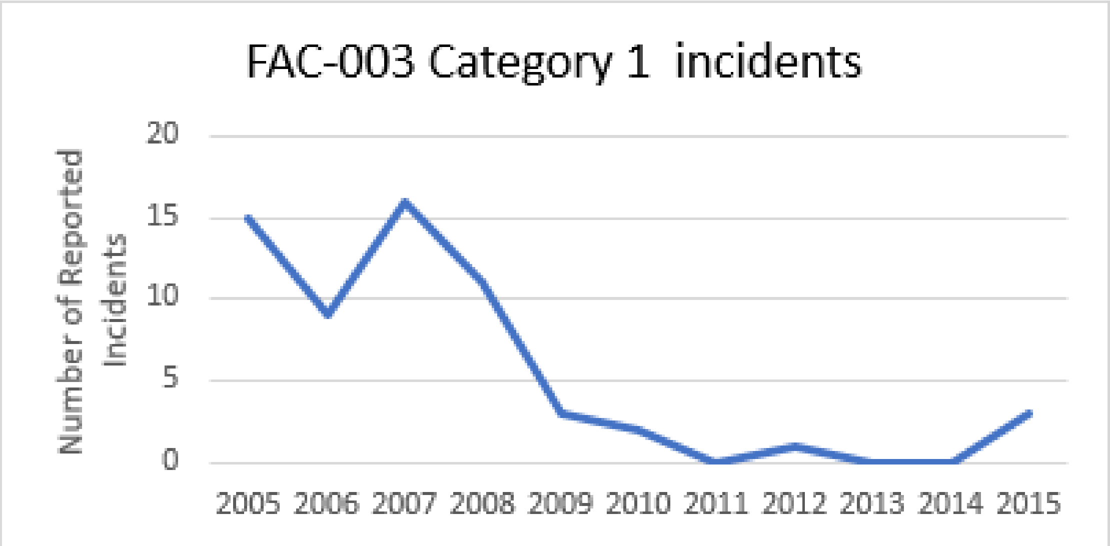


Photo Credit: EPRI HV Lab, Lenox, MA

Tree-initiated "grow in" faults on the North American high voltage grid (>200kV).



Concerns driving initiation of the project: *The cost of controlling incompatible trees*

- Electric transmission ROW are maintained to ensure:
  - safe operations
  - adequate clearances to energized conductors (>MVCD's)
  - provide access to energy delivery infrastructure for inspection, maintenance, repair and restoration
- Managing the risk of incompatible vegetation is a maintenance expense for utilities.
- Herbicide use is an effective means of maintaining ROW.

Photo credit: L, Payne, NYPA

Concerns driving initiation of the project: *Potential constraints to VM programs*

- Controversy with herbicide use due to concern from perceived risk to human health and the environment.
- Special interest groups that oppose herbicide use by utilities.
- The potential for additional regulatory restrictions that could increase the cost of ROW vegetation management practices.

Photo credit: L, Payne

Two fundamentally different vegetation management strategies were considered:

IVM-based program

- An IVM-based vegetation management program and strategy typically includes the use of a variety of methods and treatment types to control incompatible tall growing trees, including the use of herbicides.
- The concept is to *actively manage* the ROW corridor to create a relatively stable community of compatible plants to the disadvantage of tall growing trees.

Non-IVM program

- The non-IVM strategy considered simply relied on *controlling trees* by repeated mechanized non-selective cutting of all vegetation without the use other treatments and makes no use of herbicides.

Findings from Literature Review: Changes in Density & Height

- The rapid decrease in tree density after initial clearing is due to the efficacy of the herbicide in killing incompatible trees, but:
  - Density is not reduced to the lowest stable level because many trees are too small to locate in the first treatment post-clearing.
  - There is also often a bank of viable incompatible tree seeds that need to germinate and development into treatable trees.
- Even mechanical treatments, particularly mowing, can be expected to produce a significant decrease in incompatible tree density after initial clearing before resulting in a relatively constant high density of trees over time.
  - Decrease in density with mowing treatments is related to killing some species of incompatible trees; e.g. conifers and some species of deciduous trees that do not aggressively sprout or sucker.
- Only a few published papers highlighted or even mentioned height re-growth response data in passing.

Defining “*Stocking*” in terms of stem density and height

STOCKING		HEIGHT:	short	medium	tall	very tall	extra tall
			<3 feet	<6 feet	<10 feet	<13 feet	≥13 feet
DENSITY:			<1 meter	<2 meter	<3 meter	<4 meter	<4 meter
ultra light	<50/acre	<125/hectare	5%	5%	10%	15%	20%
very light	<500/acre	<1250/hectare	10%	20%	30%	40%	50%
light	<1000/acre	<2500/hectare	30%	50%	80%	100%	100%
medium	<3000/acre	<7500/hectare	80%	100%	100%	100%	100%
heavy	≥3000/acre	≥7500/hectare	100%	100%	100%	100%	100%

- Stocking is a term used in forestry to describe how fully occupied a site is with trees.
- Stocking expressed in this manner can be thought of as a volumetric parameter.
- The density scale is based on the literature and actual practice.
- The height scale is roughly based on re-growth responses, and an effort to harmonize imperial and metric units. The upper limit is based on practical experience.

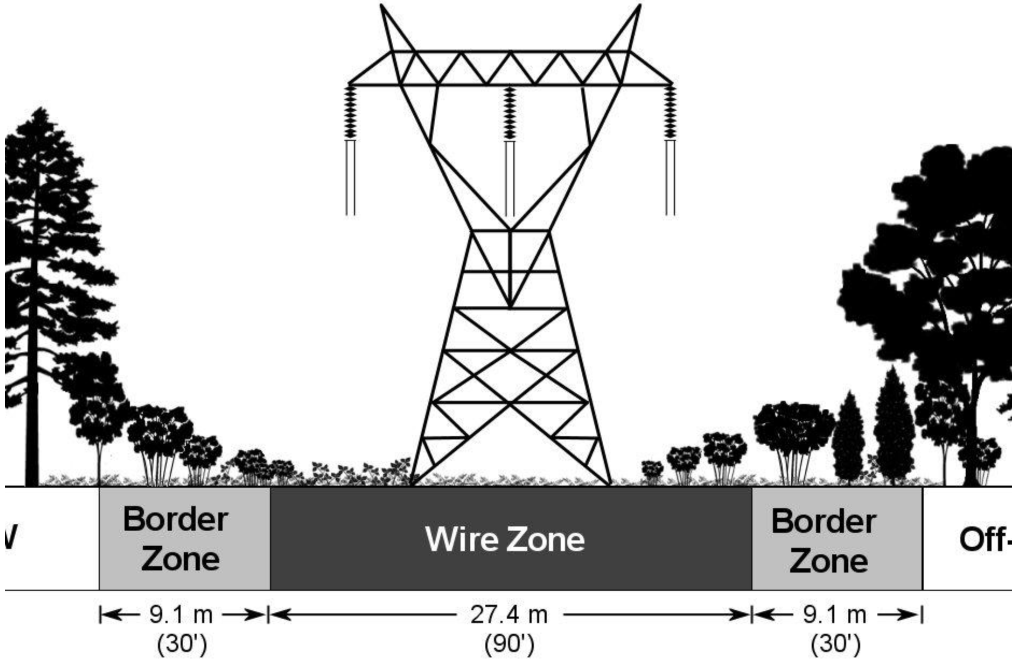
Findings from literature review: *Compatible cover as biological control*

- All plant life forms – grasses, ferns, herbs, shrubs – can suppress incompatible trees through interference (competition) and by providing habitat for seed and seedling predators. The intensity of competition is similar amongst a wide variety of plant cover types.
- Both herbaceous and wood-compatible plant cover types offer similar resistance to invasion by trees. The difference is a matter of duration.
- Compatible plant communities' competitive abilities apparently differ in their influence on trees, mainly by the duration of interference effects, rather than intensity, which means that shrubs can be considered better competitors for trees because they are taller than other compatible plant life forms.
- All compatible plant communities have openings (5-10%), so incompatible species are able to become established even in dense compatible covers.
- A ROW surrounded by maturing trees, especially in forest or woodland condition, will periodically receive thousands to millions of tree seeds across a hectare, which episodically produce thousands of successfully established, incompatible tree seedlings banked in the cover of compatible plants.

Findings from literature review: *Plant response to VM treatments.*

- Selective chemistry (e.g., growth regulator class of herbicide, phenoxy's) tends to produce more grass (monocots)
- Non-selective chemistry tends to a wider variety of grasses, ferns, shrubs, and trees
- Non-selective broadcast application of growth-regulator herbicides can result in more forbs and grasses (graminoids).
- Selective applications can result in communities with significantly more woody shrubs than non-selective treatments.
- Mowing tends to produce woody shrubs and trees.
- All herbicide treatments, if properly prescribed and applied, can achieve high rates of control of incompatible trees.
- While the amount of disturbance to compatible ROW plant communities does vary significantly among different herbicide treatments, tree invasion patterns are not different amongst many common ROW vegetation management herbicide treatments.
- While we believe IVM/herbicide use creates richer compatible plant communities, there is very little literature that supports this notion.

IVM in the context of wildlife habitat



- The quality of wildlife habitat is a function of juxtaposition and interspersion of important cover types (e.g. nesting, resting, feeding cover types)
- IVM relies on a variety of VM treatment methods that can result in greater diversity in compatible cover types.
- Importance of the “Edge Effect” – by definition long linear corridors create extensive edge.
- ROW can provide important routes of transit linking habitats, but can also cause fragmentation.
- The impact (positive or negative) of IVM on wildlife populations varies by species of interest.

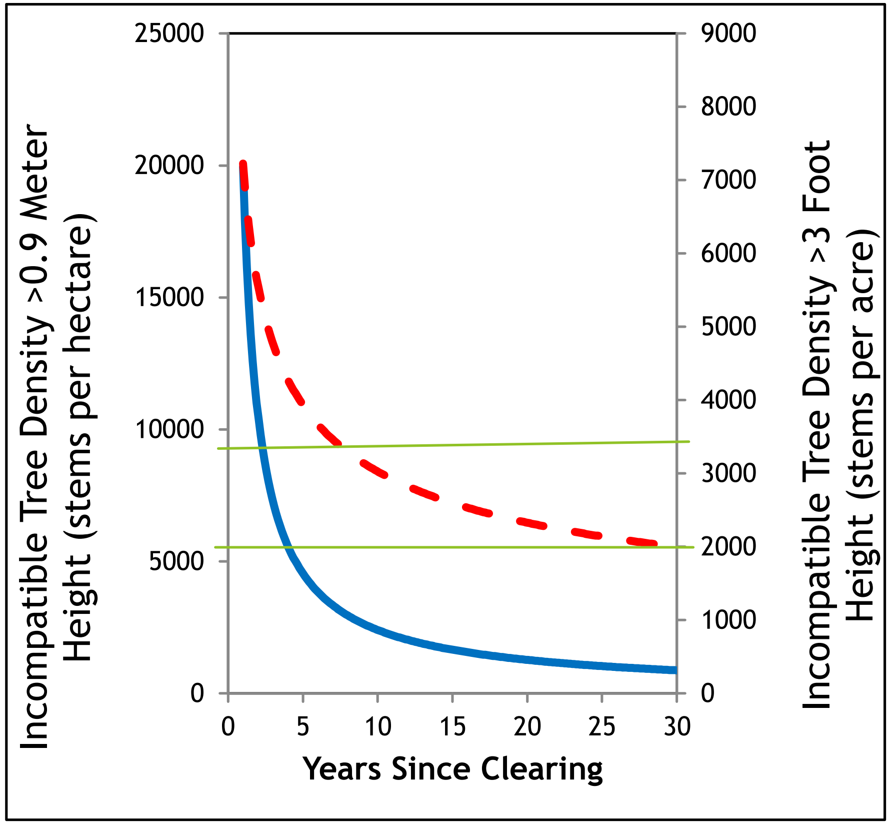
Vegetation Maintenance Treatments Considered

Treatment	Description	Application	Comments
Hack & Squirt, Frill	Application to recent cut on stem.	Cutting tool (e.g., machete, ax) and squirt bottle.	Very selective. Typically used on sensitive site with low density, larger (diameter & height) target stems.
Cut Stump	Application to cut surface and/or remaining bark.	Chain saw and squirt bottle or backpack sprayer	Very selective. Typically used on sensitive site with low density, larger (diameter & height) target stems.
Low Volume Basal	Application to lower bark, encircling the stem.	Backpack sprayers with low volume wands.	Selective. Typically used on sites with low density of incompatible stems. Dormant or growing season.
Low Volume Foliar	Application wetting foliage of target species.	Backpack sprayers or spray rig with “guns” and LV nozzles.	Selective. Typically used on sites with low to medium density incompatible stems
Hydraulic Foliar	Application wetting foliage of target species.	Powered spray rigs, high volume low concentration mixes.	Less selective, but can generally target incompatible stems. Typically used on medium to high density sites.
Broadcast, ground based	Application to foliage or freshly cut stubble.	Powered spray rigs, high volume low concentration mixes.	Non-selective. Typically applied to freshly cut stubble or follow-up treatment to regrowth after mowing.
Broadcast, aerial	Non-selective application to foliage	Aerial application by helicopter and specialized nozzles.	Non-selective. Used where access is limited, otherwise less common.
Mechanical Mowing	Cutting vegetation by mechanical means	Mechanized equipment, various sizes and types.	Typically non-selective, but in some cases can selectively target groups of incompatible stems.
Manual Cutting	Hand cutting of incompatible vegetation	Chain saw or other manual cutting tools.	Very selective. Typically used on sensitive site with low density, larger (diameter & height) target stems.

Approach to Economic Analyses

- Three basic approaches to economic analysis are typically applied to projects like this:
  - ***Least Cost Analysis*** focuses on direct quantifiable cost. Any benefits are limited to/stated as avoided costs.
  - ***Cost Effectiveness Analysis*** builds on the least cost approach, and includes consideration of benefits that may be qualitative or quantitative, but can not easily be monetized ($).
  - ***Cost Benefit Analysis*** considers both costs and benefits that are quantified in economic terms ($).
- The scope of work of the project was deliberately limited to consideration of direct cost attributable to each IVM treatment regimen.
- Indirect costs (e.g., permitting) were not considered.
- Benefits of IVM including such as ecosystem services were not considered in this study.

Density *'Production Functions'*



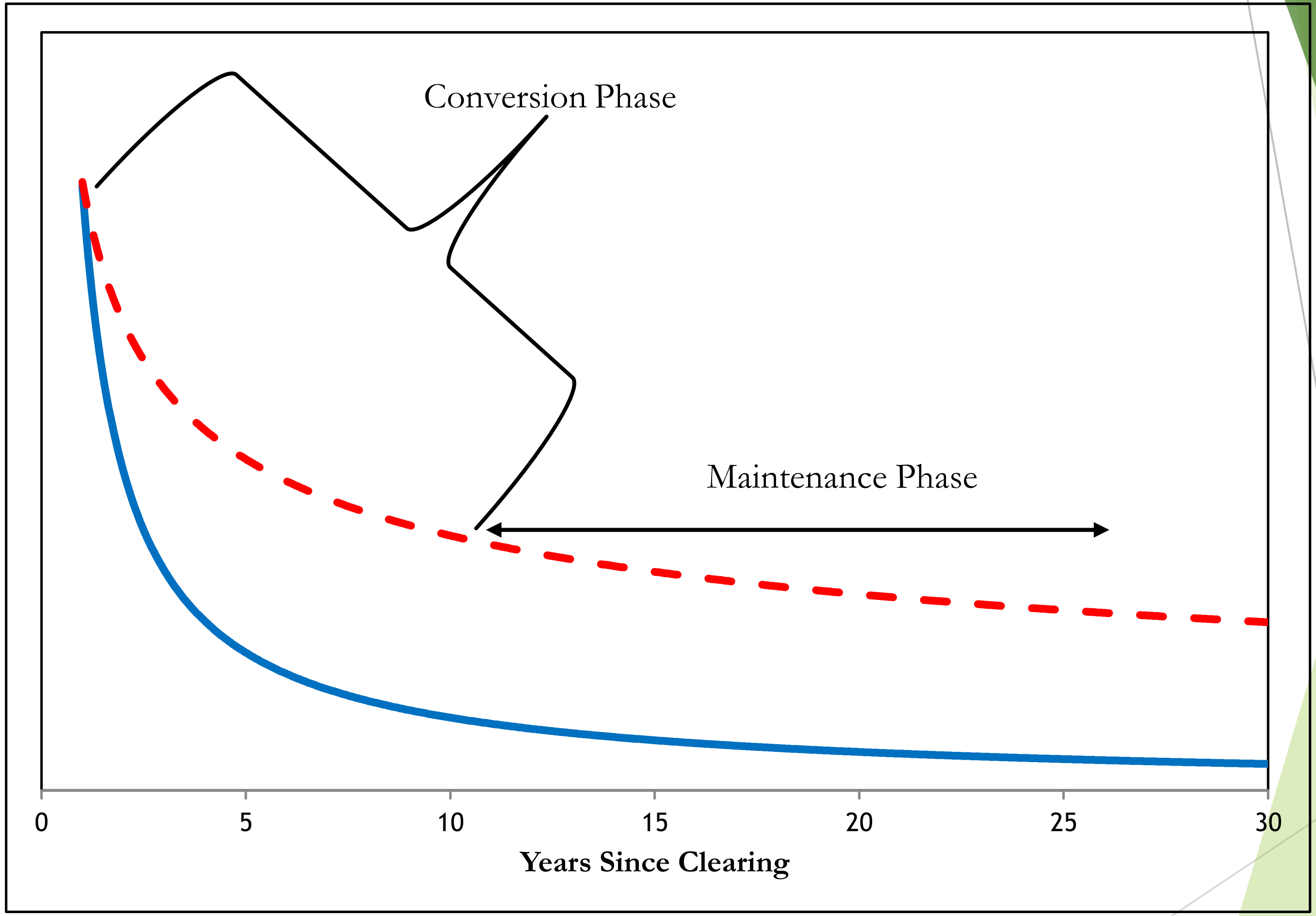
Projections for mechanical (dashed) and chemical (solid) control methods

- In economics, a production function is an equation, following a chosen model, that relates measurable output of a production process to measurable inputs.
- Simply put, a production function for this study is the number of incompatible trees in a right-of-way as a function of time.
- Two different production functions or equations were developed:
  - IVM-based program
  - Non-IVM based program

Basic Model for Density of Incompatible Trees

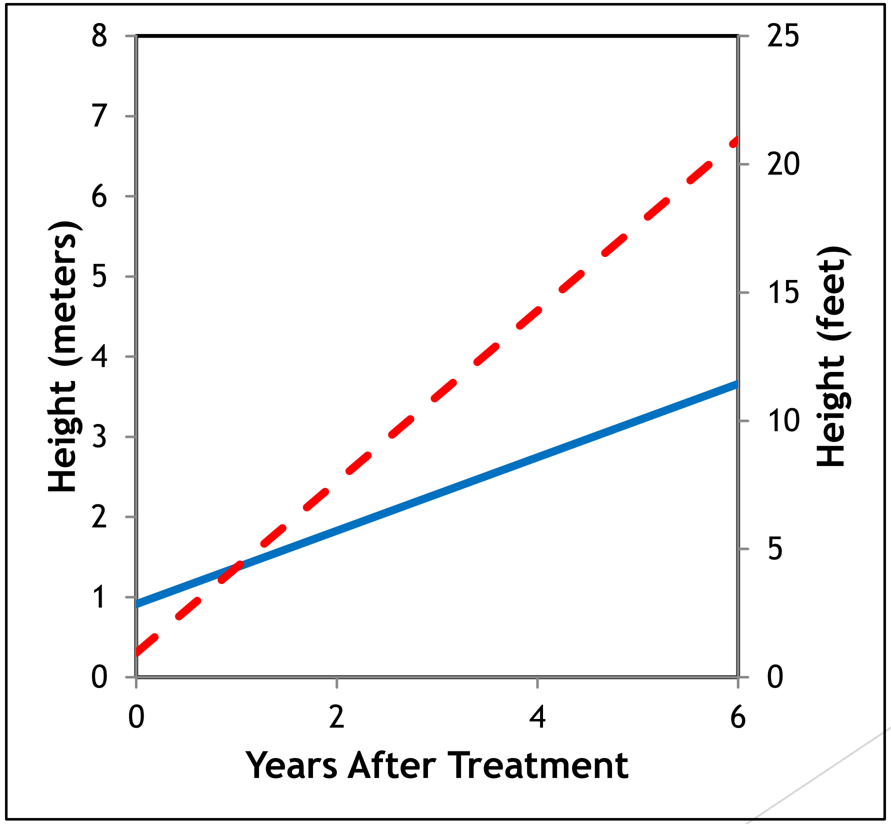
Two phases of ROW vegetation development were identified.

Projections for mechanical (dashed) and chemical (solid) control methods were developed



Height regrowth response *Production Functions* for incompatible stems is used to determine stocking

- For this study the height yield curves compare expected regrowth response rates of incompatible trees in a right-of-way as a function of time.
- Two different height yield curves were developed:
  - IVM-based program
  - Non-IVM based program
- Most of the incompatible trees that occur in areas maintained with herbicide treatments are assumed to originate as seedlings.
- Incompatible trees controlled by manual and mechanical cutting typically demonstrate vegetative sprouting and exhibit an exaggerated growth response.
- These differences are reflected in the slope of the regrowth response rate curves shown



Projections for mechanical (dashed) and chemical (solid) control methods

The stocking model was used to define the cost of each treatment over a range of densities and heights.

Selective High Volume Foliar		Height Class				
		short	medium	tall	very tall	extra tall
		<3 feet	<6 feet	<10 feet	<13 feet	≥13 feet
Density Class		<1 meter	<2 meter	<3 meter	<4 meter	≥4 meter
<50/acre	<125/hectare	N/A	$50	$100	$150	N/A
<500/acre	<1250/hectare	N/A	$100	$125	$225	N/A
<1000/acre	<2500/hectare	N/A	$175	$225	$300	N/A
<3000/acre	<7500/hectare	N/A	$400	$450	$600	N/A
≥3000/acre	≥7500/hectare	N/A	$500	$600	$800	N/A

While treatment costs can vary widely across a range of densities and heights, in actual practice the range in average costs is relatively narrow, reflecting the practitioner's natural bias to prescribing the most cost-efficient treatment for each site.

Assumptions Used in Economic Analyses

- Present Value of Cost (PV-C) was calculated for all treatments considered
  - ***3-, 4- or 5-year treatment intervals were considered***
  - ***Time between individual treatment prescriptions being compared could vary***
  - ***A time horizon of +/-20 years was considered***
  - ***Sensitivity Analyses, multiple iterations***
    - Discount rates of 5%, 10%, and 15%, and subsequently 3%, 5%, and 7%, were used in an initial assessment to determine sensitivity.
    - Over 100 combinations of incompatible tree density (low, average and high), treatment cycle lengths and discount rate were analyzed.
    - A ***5% discount was select as most representative***.
    - ***1, 2 and 3% cost (real) appreciation of treatment costs, and found to not be a significant factor.***

Three case studies were used in the economic analyses:

Case Studies

1. **Base case**

   Comparison of the PV-C of an IVM-based strategy involving different treatments that use herbicides to a non-herbicide strategy based on repeated mechanical mowing.

2. **Site reclamation**

   Cost comparison of the PV-C of re-establishing a preventive maintenance program for a ROW in which the incompatible vegetation has been maintained only with mechanical methods.

3. **Loss of herbicides**

   Evaluation of the PV-C implications of the loss of use of herbicides from an existing program (or ROW) that has historically been maintained using an IVM-based strategy including the use of herbicides.

Approach to Least Cost Economic Analysis

- Present Value Cost (PV-C), 20-year horizon, 5% discount factor.
- Each vegetation maintenance prescription included several treatments.
- IVM prescriptions involved a range of treatment types and treatment intervals.
- Non-herbicide prescriptions involved repeated mowing using a constant cycle period.

Base Case Study

Comparison of the PV-C of an IVM-based strategy involving different treatments that use herbicides to a non-herbicide strategy based on repeated mechanical mowing.

Time horizon of 20 years, beginning following initial clearing.

Capital cost of initial clearing was not included in the analyses.

Season	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
IVM herb.	Initial clearing		B-HVF			S-HVF					LVF					LVF					LVF
Non-herb.	Initial clearing					Mow					Mow					Mow					Mow

B-HVF = broadcast high volume foliar, S-HVF = selective high volume foliar, LVF=low volume foliar

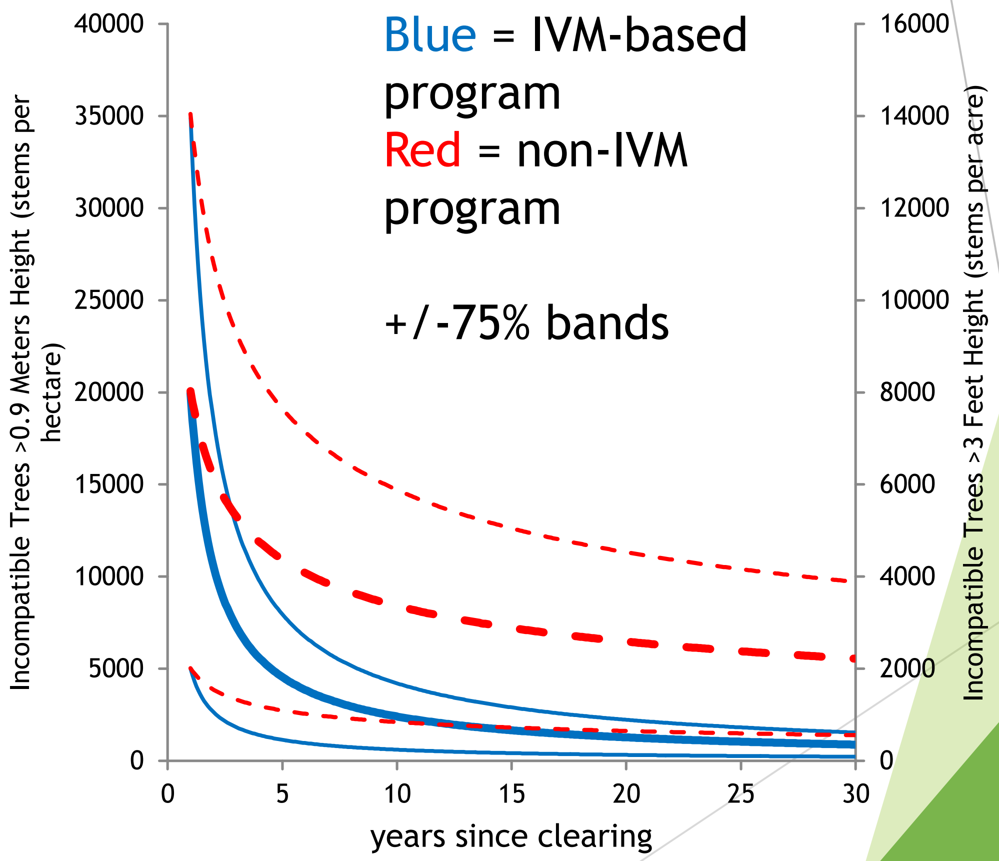
Base Case Study

Case Study	VM Strategy	PV(C) 20 yr. ($US/A)	PV(C) 20 yr. ($Cdn/H)	IVM Savings	Breakeven Discount Rate
Total Owned Cost, average stem density projection	IVM	$1,392	$4,642	48%	
	Mechanical	$2,697	$8,993		23.3%
Total Owned Cost, high (+75%) stem density projection	IVM	$1,642	$5,475	51%	
	Mechanical	$3,383	$11,281		33.0%
Total Owned Cost, low (-75%) stem density projection	IVM	$769	$2,564	40%	
	Mechanical	$1,284	$4,281		24.0%

The breakeven discount rate is the discount factor that would be required for the present value of the treatment costs for the non-IVM strategy to equal the present value of the IVM strategy that uses herbicides

Worst-Case Study, Based on Base Case

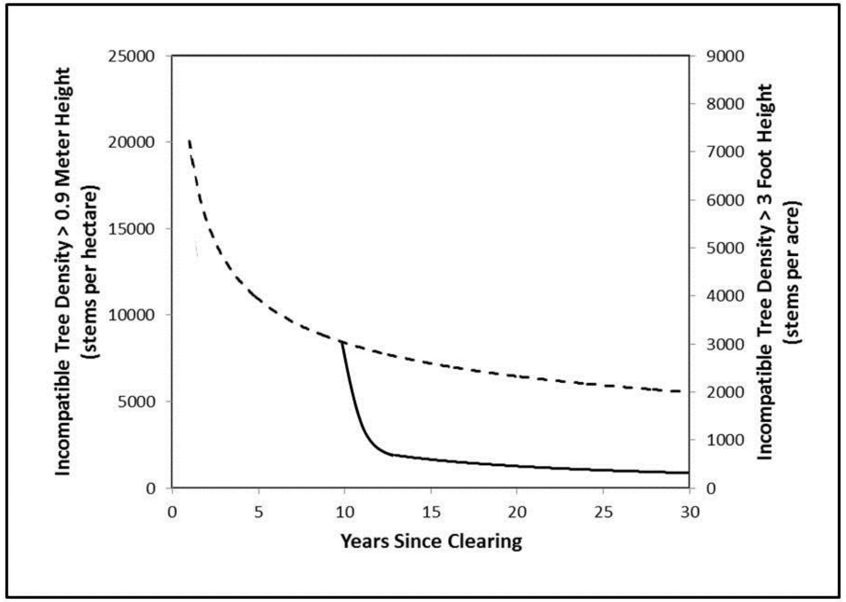
Worst Case Study	VM Strategy	PV(C) 20 yr. ($US/A)	PV(C) 20 yr. ($Cdn/H)	IVM Savings
Assume higher efficacy for mechanical treatments	IVM, average stem density	$1,392	$4,642	-8%
	Mechanical, low (-75%) stem density	$1,284	$4,281	
Assume lower efficacy for IVM treatments	IVM, high (+75%) stem density	$1,642	$5,475	39%
	Mechanical, average stem density	$2,697	$8,993	



ROW Reclamation Case Study

Comparison of the PV-C of converting to an IVM-based strategy on a ROW where VM has been deferred.

Time horizon of 20 years, beginning at densities expected at transition to the maintenance phase.



Season	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
IVM herb.	Mow & CS					S-HVF					LVF					LVF					LVF
Non-herb.	Mow					Mow					Mow					Mow					Mow

CS= cut stubble, S-HVF = selective high volume foliar, LVF=low volume foliar

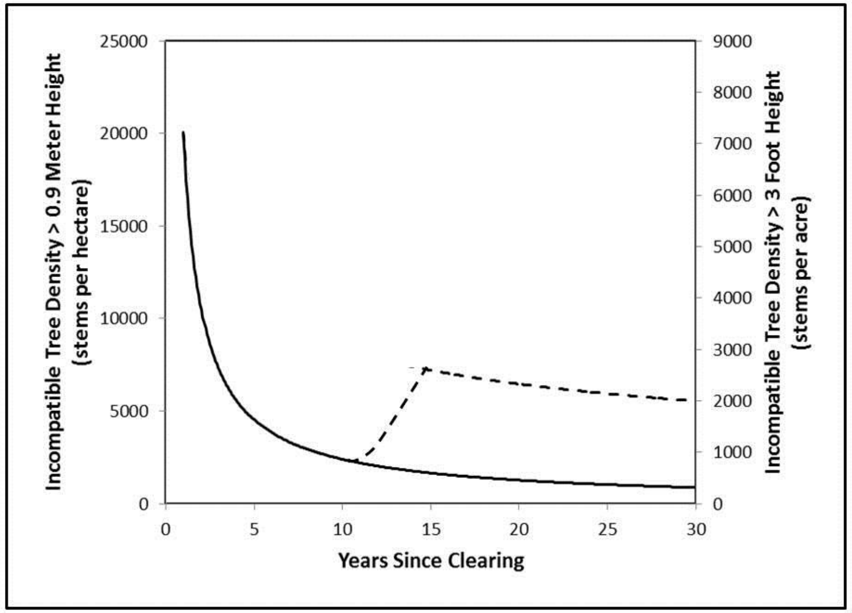
ROW Reclamation Case Study

Case Study	VM Strategy	PV(C) 20 yr. ($US/A)	PV(C) 20 yr. ($Cdn/H)	IVM Savings	Breakeven Discount Rate
ROW Reclamation, mowing and broadcast follow-up	IVM	$2,391	$7,973	32%	
	mechanical	$3,524	$11,751		48.0%
ROW Reclamation, mowing and cut Stubble	IVM	$2,335	$7,786	34%	
	mechanical	$3,524	$11,751		43.0%
ROW Reclamation, aerial	IVM	$885	$2,951	75%	
	mechanical	$3,524	$11,751		---

Loss of Herbicides Case Study

Comparison of the PV-C of loss of the use of herbicides from an established IVM-based program.

Time horizon of 20 years, beginning at densities expected at transition to the maintenance phase.



Season	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
IVM herb.	LVF					LVF					LVF					LVF					LVF
Non-herb.	Mow					Mow					Mow					Mow					Mow

LVF=low volume foliar

Loss of Herbicides Case Study

Case Study	VM Strategy	PV(C) 20 yr. ($US/A)	PV(C) 20 yr. ($Cdn/H)	Increase in Cost	Breakeven Discount Rate
Loss of herbicides from a well-established IVM program	IVM	$1,195	$3,985		---
	mechanical	$2,424	$8,083	203%	

Summary of Findings:

In every case, a vegetation management strategy based on the principles of IVM including the use of herbicides was shown to be significantly less costly than a strategy that makes no use of herbicides.

1. The present value of costs for the *base case study* was shown to be approximate half as much as simply controlling incompatible trees by repeated cutting without the use of herbicides over the same time period.
2. The present value of costs for the *reclamation case study* were shown to be approximately one third less costly than reclaiming a ROW by simply repeated mechanical cutting
3. The present value of costs for the *loss of herbicides case study were* shown to result in a very significant (2X) increase in the cost of vegetation maintenance work.

Conclusions:

Findings from this investigation establish the foundation for a business case for the use of herbicides in the management of ROW vegetation.

- This study convincingly demonstrates that adopting the principles of IVM with inclusion of herbicide-based treatments does not come at a cost premium over simply repeatedly cutting incompatible tall growing trees that may threaten the reliability and safe operation of the electric transmission lines.
- The differences in estimates of present value costs between an IVM strategy using herbicides and a non-IVM strategy which does not are substantial enough to account for any error or uncertainly in the data used in the study.
- An IVM strategy may initially require additional cost related to a follow-up herbicide application, which are recovered at the time of second following treatment.

Recommendations:

- Industry Standards and Best Management Practices for IVM should be adopted and incorporated in vegetation management programs used by utilities intended to preserve the function of electric transmission ROW.
- Industry Standards and Best Management Practices for IVM should guide the development of technical specification that establish requirements and practices used to maintain ROW vegetation in a manner consistent with intended use of the ROW.

Relevant Standards, BMP's, and accreditation references:

- ANSI A300 Part 7 *"Standard Practices, Integrated Vegetation Management, a. Utility Rights-of-way"* (2012)
- ISA BMP *"Integrated Vegetation Management"*, Second Edition (2014)
- ROW Steward Accreditation Requirements, ROWSC (2016)

A future opportunity:
Supplement this work with a study that considers the benefits of IVM

The results reported here involved "least cost analysis". The only benefits considered were the avoided costs directly attributable to each IVM treatment regime. Indirect costs and benefits, as well as environmental externalities, are not included in the scope of work.

BioCompliance is actively seeking support for a follow-on project that would including consideration of the benefits of IVM/herbicides in ROW vegetation management.

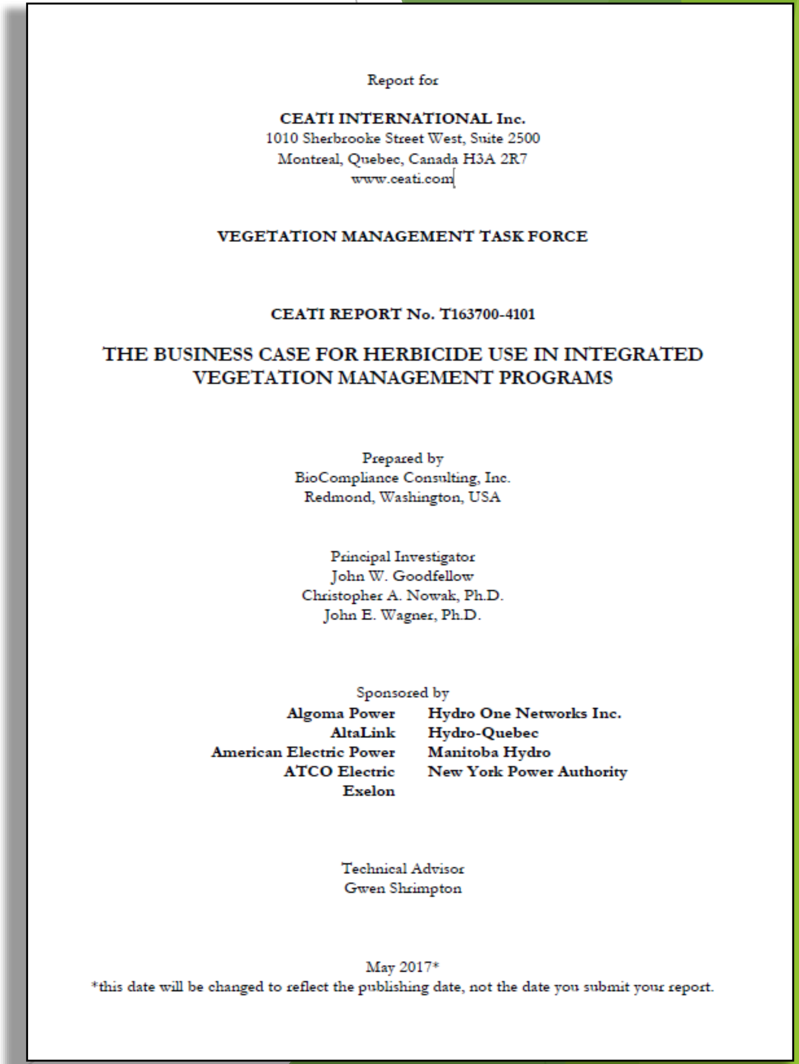
Project Undertaken under the Direction of the CEATI INTERNATIONAL Vegetation Management Task Force (VMTF)

For more information on the VMTF Program and Project Report, please visit www.ceati.com

or contact

Alex.Mogilevsky@ceati.com or

Paul.Ryan@ceati.com



Report for

CEATI INTERNATIONAL Inc.
1010 Sherbrooke Street West, Suite 2500
Montreal, Quebec, Canada H3A 2R7
www.ceati.com

VEGETATION MANAGEMENT TASK FORCE

CEATI REPORT No. T163700-4101

THE BUSINESS CASE FOR HERBICIDE USE IN INTEGRATED VEGETATION MANAGEMENT PROGRAMS

Prepared by
BioCompliance Consulting, Inc.
Redmond, Washington, USA

Principal Investigator
John W. Goodfellow
Christopher A. Nowak, Ph.D.
John E. Wagner, Ph.D.

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Exelon	

Technical Advisor
Gwen Shrimpton

May 2017*
*this date will be changed to reflect the publishing date, not the date you submit your report.