February 21, 2014

Ohio Department of Transportation
Office of Statewide Planning & Research
Research Section
Attention: Jill Martindale
1980 W. Broad Street, MS3280
Columbus, Ohio 43223

330-673-5685
Toll Free 1-800-828-8312
FAX 330-673-0860


Dear Ms. Martindale:

Davey Resource Group, a division of The Davey Tree Expert Company, is pleased to provide the final Interim Report and Phase 1 deliverables for the above referenced project. Enclosed are five copies of the Interim Report and a CD-ROM containing the following:

- Evaluating Vegetation Management Practices for Woody and Herbaceous Vegetation Interim Report
- Matrices

If you have any questions about these work products please contact me at 800-828-8312, extension 8079. It has been our pleasure to work with you on this important project. We look forward to working with you and the technical panel over the next two years field testing many of our recommendations during Phase 2.

Sincerely,

Cheryl Daniels
Project Manager

Enclosures
Evaluating Vegetation Management Practices for Woody and Herbaceous Vegetation

Interim Report

Prepared by:
Davey Resource Group
A Division of the Davey Tree Expert Company

Prepared for:
The Ohio Department of Transportation,
Office of Statewide Planning & Research

State Job Number 134834

February 21, 2014

Interim Report
Evaluating Vegetation Management Practices for Woody and Herbaceous Vegetation

Prepared by:
Jenny Gulick, Cheryl Daniels, Brad McBride, Colby Sattler
Davey Resource Group a division of The Davey Tree Expert Company

February 21, 2014

Prepared in cooperation with the Ohio Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration

The contents of this report reflect the views of the author(s) who is (are) responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Ohio Department of Transportation or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation.
Acknowledgments

The authors would like to thank the Technical Advisory Panel at Ohio Department of Transportation, Tim Guth, Duane Byers, Randy Sanders, Josh Wallace, Bob Zwick, Tom Corey, Ty Justice, Scott Lucas, and Jill Martindale, for their valuable input during this project. We would also like to thank the maintenance staff at Ohio Department of Transportation who participated in our online vegetation management practices survey and took part in meetings about this project.
Project Background

The Ohio Department of Transportation (ODOT) is challenged to manage vegetation along nearly 50,000 lane miles throughout Ohio’s diverse landscapes. Among the primary challenges are: rising demands for all road and roadside maintenance services, increased operational costs, reduced staff, regulatory restrictions, and public perception. Current vegetation management operations employ mostly mechanical methods using limited equipment resources, and only utilize herbicides and plant growth regulators to control growth on a very limited basis. The lack of industry specific cutting-edge tools and techniques cause operational inefficiencies that may increase the time it takes to perform roadside vegetation maintenance tasks and the number of cycles needed each growing season to maintain sight distances and aesthetics. These operational inefficiencies may increase the overall cost to ODOT to manage vegetation along Ohio’s state rights-of-way.

The overall purpose of the project is to determine what vegetation management practices can be implemented by ODOT Districts that contribute to safe highway use, but do so in a manner that increases efficiency and cost effectiveness, ODOT needs an Integrated Vegetation Management (IVM) program that is more innovative and employs a variety of processes and practices while continuing to place safety and environmental stewardship first.

Study Objectives

- Evaluate current statewide ODOT roadside vegetation management operations to understand existing challenges and needs.
- Research industry standards, academic studies, and model DOT IVM programs, and reach out to industry experts and vendors to identify innovative, safe, and cost-effective IVM processes and practices.
- Assess chemical, mechanical, biological and cultural methods, and analyze application timing and other technologies available to distinguish the best processes and practices for roadside vegetation management.
- Compare and contrast ODOT’s current roadside vegetation management operations to the research and assessment findings recommending alternative vegetation processes and practices for implementation statewide that will help managers increase efficiency and reduce program costs.

Description of Work

- Conducted a literature search of other DOT’s processes, academic research, vendor information, and industry standards.
- Analyzed current equipment, materials, and technologies available for roadside vegetation management.
- Reviewed ODOT data, manuals, and other vegetation management information.
- Participated in field meetings and operational demonstrations in four ODOT Districts.
- Created matrices of alternative solutions for vegetation management processes and practices.
Research Findings & Conclusions

ODOT Districts clearly know their mission and responsibilities related to vegetation management on state and interstate rights-of-ways. Across the state, managers and staff perform a variety of vegetation management tasks to allow for safe passage on roadways. However, Districts face many challenges including equipment and staff challenges that prevent them from responding proactively to vegetation management needs. The major challenges are: decentralized and disproportionate distribution of vegetation management equipment; lack of trained/experienced staff; lack of readily available technical resources in the Districts; outdated work specifications; and limited staff and budget resources which must be prioritized and allocated to roadway (not roadside) maintenance and safety projects. Because of this last challenge, vegetation management has become a lower priority and much of it has been deferred for many years in order to work other roadway maintenance tasks.

Our research revealed, that for nearly every vegetation management task ODOT Districts are responsible for, there are other DOTs and private companies who have developed vegetation management programs or protocols that result in greater efficiencies, increased safety, and improved aesthetics. It was concluded that if ODOT made significant changes in its herbicide use program, trained staff to identify problems and issues more quickly, and utilized equipment more effectively and properly, that great gains in efficiency and effectiveness would be realized and costs may be reduced in the short and long terms.

Recommendations for Implementation of Research Findings

It is recommended that the research findings (found in the attached matrices) are field tested so that they can be more thoroughly analyzed to determine which techniques will gain ODOT the greatest efficiencies and overall return on investment. Generally, this will be accomplished by selecting the best vegetation management processes and practices as determined by our research and field testing them using sufficient replication and randomization against ODOT’s standard operating procedures. Measurement and monitoring of the test sites over a two-year period will be performed to gather data about efficiency, costs, and effectiveness.

Based on our findings, the following areas are priorities that should be tested to improve existing ODOT vegetation management operations:

- **Chemical Methods:** increase targeted herbicide and plant growth regulator use, and utilize an application and follow-up treatment schedule to control noxious and invasive weeds, decrease the frequency of turf mowing, brush and tree trimming, and removal and maintain bare ground where needed.
- **Mechanical Methods:** purchase new equipment and/or more efficiently use existing equipment to perform vegetation maintenance tasks more quickly and safely.
- **Training and Communication:** provide training to vegetation management personnel on equipment use, plant identification, and herbicide selection, and encourage inter-District communication to streamline operations and create consistent vegetation management practices across the state.

It is anticipated that at the end of the testing period enough information will have been gathered to make immediate decisions regarding improvements to ODOT’s vegetation program that will result in greater efficiencies and cost savings.
The decision was made by ODOT’s Technical Advisory Committee for this research project to move forward with testing the top matrix recommendations that will have the biggest impact on ODOT’s operations and that testing should proceed in designated locations throughout the state over a two-year period. In an effort to reduce mow cycles, selective herbicides will be tested to minimize tall growing weeds that make mow cycles occur more frequently. Plant Growth Regulators will also be tested in areas that are difficult and more time consuming to manage the vegetation. Non-selective herbicides will be tested to prevent regrowth in areas where the brush is being cut back to provide better control and provide a better opportunity to plant desirable species. Chemical side trimming on trees will be tested in select locations. In addition to the chemicals, a few spray systems, specialized mowers, and equipment suited for large tree work such as a forestry bucket truck, large chipper, tree mulcher head, feller buncher head, and grapple will be tested over a two-year period between 2014 and 2016. Also, an herbicide manual and outreach materials for the Districts will be produced for staff as a resource and reference to help them achieve better results in their vegetation management work.

Deliverables Attached:

1. Matrices
   - Road Edge
   - Turf Maintenance
   - Brush/Shrub/Small Tree Maintenance & Removal
   - Large Tree Maintenance
   - Large Tree Removal
   - Planning and Operations

2. Glossary

3. Literature Search/References
**Road Edge**

### Current ODOT Process

- Selective herbicides are applied using a tractor and spray truck.
- Herbicides are applied along the road edge to control vegetation.
- Equipment setup and travel contributes to efficiency gains.
- Use drift control products to maintain a stable plant community.

### Base Ground

- Groundbreaking for the use of selective herbicides.
- Herbicides are applied to control vegetation along the road edge.
- Equipment setup and travel contribute to efficiency gains.

### Under Rail

- Herbicides are applied to control vegetation under the rail.
- Equipment setup and travel contribute to efficiency gains.

### Maintenance Vegetation

- Herbicides are applied to control vegetation in areas with maintained vegetation.
- Equipment setup and travel contribute to efficiency gains.

---

### Potential Benefits

- Reduces labor and travel time.
- Improves quality and safety of desired vegetation.
- Eliminates the need for manual labor.
- Improves site distance requirements.

### Herbicides/Materials

<table>
<thead>
<tr>
<th>Herbicide/Material</th>
<th>Cost (not included in Purchase Price)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imazapic</td>
<td>$195/Gallon (3.8 Liters)</td>
</tr>
<tr>
<td>Perspектив</td>
<td>$395/Ml. per L (1.0 L)</td>
</tr>
<tr>
<td>Kilograms</td>
<td></td>
</tr>
<tr>
<td>Perspектив</td>
<td>$245/Ml. per L (1.0 L)</td>
</tr>
</tbody>
</table>

### Purchase Price

<table>
<thead>
<tr>
<th>Purchase Price</th>
<th>Operational Cost Per Hour</th>
<th>Personnel Scale</th>
<th>Return on Investment</th>
<th>IVM Follow-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1000</td>
<td>$1000</td>
<td>5 People</td>
<td>$10,000</td>
<td></td>
</tr>
<tr>
<td>$2000</td>
<td>$2000</td>
<td>10 People</td>
<td>$20,000</td>
<td></td>
</tr>
<tr>
<td>$3000</td>
<td>$3000</td>
<td>15 People</td>
<td>$30,000</td>
<td></td>
</tr>
<tr>
<td>$4000</td>
<td>$4000</td>
<td>20 People</td>
<td>$40,000</td>
<td></td>
</tr>
<tr>
<td>$5000</td>
<td>$5000</td>
<td>25 People</td>
<td>$50,000</td>
<td></td>
</tr>
</tbody>
</table>

### Legend

- $39,000/mile: 1.61

---

### Considerations

- Herbicides and materials cost is not included in the purchase price.
- Labor and equipment cost is provided for ODOT and non-ODOT personnel.
- Equipment investment is based on a daily and seasonal basis.

---

### Equipment Investment

- Equipment investment is based on a daily and seasonal basis.
- Equipment investment is based on a daily and seasonal basis.

---

### Notes

- Technology: Selective herbicides are applied using a tractor and spray truck.
- Herbicides are applied along the road edge to control vegetation.
- Equipment setup and travel contributes to efficiency gains.
- Use drift control products to maintain a stable plant community.

---

### Equipment

- Equipment investment is based on a daily and seasonal basis.
- Equipment investment is based on a daily and seasonal basis.

---

### Operating Costs

- Operating costs are provided for ODOT and non-ODOT personnel.
- Operating costs are provided for ODOT and non-ODOT personnel.

---

### Personnel Scale

- Personnel scale is provided for ODOT and non-ODOT personnel.
- Personnel scale is provided for ODT and non-ODT personnel.

---

### Return on Investment

- Return on investment is provided for ODT and non-ODT personnel.
- Return on investment is provided for ODT and non-ODT personnel.

---

### IVM Follow-Up

- IVM follow-up is provided for ODT and non-ODT personnel.
- IVM follow-up is provided for ODT and non-ODT personnel.
The document contains information related to turf maintenance and weed control. It includes a table with recommended improvements, timing, frequency, potential benefits, herbicide costs, equipment purchases, and operating costs. The table also notes returns on investment (ROI) and various considerations.

### Recommended Improvement

<table>
<thead>
<tr>
<th>Description</th>
<th>Timing</th>
<th>Frequency</th>
<th>Potential Benefits</th>
<th>Herbicide Cost (per Application)</th>
<th>Equipment Purchased</th>
<th>Operating Cost / Hour</th>
<th>Personal Scale</th>
<th>ROI Follow-Up</th>
</tr>
</thead>
</table>

### Notes / Considerations

- Control or equipment and staff availability. Control encroaching invasive weeds that are difficult to mow with an herbicide program utilizing non-selective and selective herbicides depending on target species and timing.
- Weeds grow faster and taller than grass and can contribute to site distance issues, obscure fixed objects, and impact pedestrian and vehicle safety.
- Currently minimal to no herbicide use results in excessive vegetation that is labor-intensive to mow and maintain.
- Mowing accomplishes immediate vegetation control and is the most consistent vegetation management method.
- Without herbicide use, it may be more difficult to only mow as planned on scheduled events.

### Maintenance Turf

- Currently mowing operations are done 4x-6x per year. Mowing events are scheduled around holiday events. Currently no selective herbicides are being used to promote grass species with less maintenance requirements.

### Maintenance Best Practices

- Herbicides*: Imazapyr or Triclopyr
- Chemical: Liters)

* = Factored into purchase price

- Mowing production rate is very low.
- Rotary mowers are easier and less expensive to maintain.
- Flail mower decks require more maintenance in keeping knives sharp.
- Mowing production rate is very low.
## Brush/Shrub/Small Tree (<6" Diameter) Maintenance & Removal

### Current ODOT Process

**Objective:** The objective of this process is to maintain a healthy and aesthetically pleasing landscape by removing invasive vegetation and promoting the growth of desirable species. This includes the use of herbicides, mechanical methods, and biological controls to achieve this goal.

### Recommendations

**Possible Equipment:**
- Equipment Types:
  - Backpack Sprayers
  - String Trimmers
  - Tractors
  - Rotary Mowers
  - Forestry Mulchers
  - Herbicides

**Herbicide Usage:**
- Herbicides are used to control invasive vegetation. The type and application method will depend on the specific vegetation and site conditions.

**Cultural Practices:**
- These are non-chemical methods that promote desirable vegetation and natural control of weeds and invasive species. Cultural practices may include:
  - Mulching
  - Fertilization
  - Irrigation

**Pre- and Post-Treatment:**
- Pre-treatment activities include:
  - Site Preparation
  - Removal of non-desirable vegetation
- Post-treatment activities include:
  - Monitoring vegetation growth
  - Maintenance and follow-up

### Potential Benefits

**Immediate and/or Substantial Gain:**
- Reduction of maintenance costs
- Improved aesthetic appeal

**Substantial Immediate and Long-term Gain:**
- Enhanced ecosystem health
- Long-term cost savings

### IVM Follow-Up

**Schedule:**
- Year 1: 1
- Year 2: 1
- Year 3: 1

### Notes/Considerations

- Selective removal of stumps is recommended to prevent damage to desirable vegetation.
- Invasive vegetation should be removed before planting to prevent competition with desirable species.
- Small trees should be removed while still small to avoid vegetation encroachment.

### Selective Removal

#### Herbicide Treatment

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Cost Per Gallon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glyphosate</td>
<td>$64</td>
</tr>
<tr>
<td>Triclopyr</td>
<td>$17</td>
</tr>
</tbody>
</table>

**Application:**
- Herbicides should be applied to the surface of vegetation before treatment.
- Standard hand tools for these operations include chainsaws, lopping shears, and pruning saws.

**Legend**

- Immediate and/or Substantial Gain
- Substantial Immediate and Long-term Gain
- No Significant Benefit

### Table: Recommended Improvement

<table>
<thead>
<tr>
<th>Recommended Improvement</th>
<th>Timing/Frequency</th>
<th>Notes/Considerations</th>
<th>Potential Benefit</th>
<th>Herbicide Cost (Cost Included in the Purchase Price)</th>
<th>Purchase Price</th>
<th>Operational Cost Per Hour</th>
<th>Personnel Scale</th>
<th>Return on Investment</th>
<th>IVM Follow-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicide Treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Emergent Application with Selective Herbicide*</td>
<td>Low 1 Person/High 4 People</td>
<td>Immediate and/or Substantial Gain</td>
<td>Reduction of maintenance costs</td>
<td>Glyphosate ($64/gallon)</td>
<td>$168</td>
<td>$55</td>
<td>4 People</td>
<td>4 People</td>
<td>4 People</td>
</tr>
</tbody>
</table>

### Standard Equipment

- Standard equipment in ODOT garages includes:
  - Chainsaws
  - Lopping shears
  - Pruning saws

### Grazing

- Grazing can be extremely effective.
- Areas where options are limited, goats can be a slow process but in some conditions, they are effective.

### Rotary Mowers

- Rotary mowers allow for mowing on slopes/terrain, poor access, or when non-desirable vegetation is well distributed on the surface.

### Tractors

- Tractors with trailers can be used for mowing and application of herbicides in mixed areas.

### Forestry Mulchers

- Forestry mulchers cannot control invasive vegetation on sites where desirable vegetation is present.

### Additional Considerations

- Cultural practices and mechanical methods are necessary to enhance desirable vegetation and control invasive species.

---

### Purchase Price

- Vegetation Encroachment has out-paced vegetation management activities. Crews would like to catch up but are faced with manpower time and equipment constraints.

### Future Considerations

- Future considerations include:
  - Implementing an invasive vegetation management plan
  - Increasing the use of cultural practices
  - Evaluation of new herbicides and application methods

---

**Notes:**

- $ = Immediate and/or Substantial Gain
- $ = Substantial Immediate and Long-term Gain
- ** = No Significant Benefit

---

**Disclaimer:**

- The information provided is for planning purposes only and should be used in conjunction with specific site conditions and professional advice.
IVM Follow-Up

Decline and failure. Telescoping saw trucks are more suited for off-road work but are being used on road. A similar situation has occurred with herbicide use. Herbicide cost for Fosamine in the $500 range (4% liquid) can prove beneficial in inconspicuous areas.

Potential Benefits

- **Large Tree Maintenance to Improve Sight Distance** ( > 6" Diameter)

  **Current ODOT Process**

  **Description:** Tree maintenance is performed irregularly using a variety of equipment (29' lighting bucket trucks, forestry bucket trucks, telescoping saw trucks, Fall feeders, rotary mowers) using in-house and contracted labor. There is no consistency in a tree maintenance method.

  **ODOT’s Presented Challenges:**

  - There are three telescoping saw trucks with only one chipper of high enough capacity to keep up with the production.
  - Not enough forestry bucket trucks of proper size to adequately perform the work.
  - Use of non-forestry “lighting” buckets are not adequate replacements of forestry buckets.
  - Rotary and flail mowers as well as telescoping saw trucks do not leave proper cuts that allow the trees to be economically removed.
  - All of these operations do not have oversight by an ISA Certified Tree Worker which would be helpful for maintaining safety, production, and longer cycles.

  **Recommendation:**

  - Use of tools outside their purpose decreases zero efficiency and effectiveness of the tool. 
  - More equipment of sufficient reach, less outside contracting would be necessary. However, it must be realized without proper training, this maintenance can be very dangerous work.

  - There are trees being maintained that should be cut down to achieve greater and sharper lines of direction.

  Where trees are removed repositioned, it will be more economical in the long term to remove them rather than to continue maintenance.

<table>
<thead>
<tr>
<th>Goal Area</th>
<th>Recommended Improvement</th>
<th>Timing/ Frequency</th>
<th>Notes/Considerations</th>
<th>Potential Benefits</th>
<th>Purchase Price * of Equipment</th>
<th>Operational Cost Per Hour</th>
<th>Personnel Scale</th>
<th>Return on Investment</th>
<th>IVM Follow-Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large Tree Maintenance to Improve Sight Distance ( &gt; 6&quot; Diameter)</td>
<td>60' 4x4 Forestry Bucket Truck* + Chipper (12&quot; Diameter) + Loader on Skid Steer + 2 Trucks with Trailers</td>
<td>All Year</td>
<td>Requires more skill than Telescoping Saw Truck.</td>
<td>Compared to a Lighting Bucket Truck, a Forestry Bucket Truck offers better access, proper cutting techniques and is compliant with OSHA regulations for tree work.</td>
<td>$555</td>
<td>$5</td>
<td>3 People</td>
<td>$5555</td>
<td>Substantial Immediate and Long-term Gain</td>
</tr>
<tr>
<td>Off Road</td>
<td>60' 4x4 Forestry Bucket Truck* + Chipper (12&quot; Diameter) + Loader on Skid Steer + 2 Trucks with Trailers</td>
<td>All Year</td>
<td>Requires more skill than Telescoping Saw Truck.</td>
<td>Compared to a Lighting Bucket Truck, a Forestry Bucket Truck offers better access, proper cutting techniques and is compliant with OSHA regulations for tree work.</td>
<td>$555</td>
<td>$5</td>
<td>3 People</td>
<td>$5555</td>
<td>Substantial Immediate and Long-term Gain</td>
</tr>
<tr>
<td>On Road</td>
<td>Telescoping Saw Truck leaves stub cuts which will produce weakly attached water sprouts (branches) and can cause decline in the tree due to disease and decay.</td>
<td>All Year</td>
<td>Telescoping Saw Truck leaves stub cuts which will produce weakly attached water sprouts (branches) and can cause decline in the tree due to disease and decay.</td>
<td>不允许</td>
<td>$555</td>
<td>$5</td>
<td>3 People</td>
<td>$5555</td>
<td>Substantial Immediate and Long-term Gain</td>
</tr>
<tr>
<td>Off Road</td>
<td>60' 4x4 Forestry Bucket Truck* + Chipper (12&quot; Diameter)</td>
<td>All Year</td>
<td>Requires more skill than Telescoping Saw Truck.</td>
<td>Compared to a Lighting Bucket Truck, a Forestry Bucket Truck offers better access, proper cutting techniques and is compliant with OSHA regulations for tree work.</td>
<td>$555</td>
<td>$5</td>
<td>3 People</td>
<td>$5555</td>
<td>Substantial Immediate and Long-term Gain</td>
</tr>
<tr>
<td>On Road</td>
<td>Telescoping Saw Truck leaves stub cuts which will produce weakly attached water sprouts (branches) and can cause decline in the tree due to disease and decay.</td>
<td>All Year</td>
<td>Telescoping Saw Truck leaves stub cuts which will produce weakly attached water sprouts (branches) and can cause decline in the tree due to disease and decay.</td>
<td>不允许</td>
<td>$555</td>
<td>$5</td>
<td>3 People</td>
<td>$5555</td>
<td>Substantial Immediate and Long-term Gain</td>
</tr>
</tbody>
</table>

### Operational Costs

- **Herbicide Cost for Fosamine** is between $500 (4% liquid) and $1,500 a year.

### Equipment

- **Chipper (21" Diameter)** can be up to 5 times more efficient than a bucket crew.

### Performance

- **Grapple and Loader reduce manual labor in moving limbs and logs from drop zone to chipper.**

### Timings

- **Weather conditions limit flight days.** Can result in higher interception and avoid the most difficult sections.

### Return on Investment

- **5 People**

### Legend

- $5 = 100 - 150,000
- $55 = 100,001 - 150,000
- $555 = 150,001 - 200,000
- $5,555 = 200,001 - 500,000
- $55,555 = 500,001 - 1,000,000

- **0 Person**
- **1 Person**
- **2 People**
- **3 People**
- **4 People**

- **No Efficiency Gained**
- **3 People Efficiency Gained**
- **5 People Efficiency Gained**
- **7 People Efficiency Gained**
- **9 People Efficiency Gained**

- **Immediate and Substantial Gained**
Large Tree Removal (> 6" Diameter)

Current ODOT Process

Costs are compiled on a reimbursable basis only using a variety of equipment (6' Bucket trucks, forestry bucket trucks, pipe trucks, and other equipment) in order to improve job performance and safety. It is to be used as a guideline to assist in understanding current operations and the potential need for further equipment, jobs, or guidelines.

Large Tree Removal to Improve Sight Distance and Remove Hazard Trees

Tree removal is performed on a reactive basis only using a variety of equipment (29' bucket trucks, forestry bucket trucks, chipper, Cut-Stump Application, Telescoping Saw Truck, Grapple, Loader on Skid Steer, Telescoping Saw Truck, Grapple and Loader). There is no consistency in a tree removal method. There are two treatment methods that will be performed depending on availability of equipment.

- **Cut-Stump Application**
  - Chemical: All Indiana Bat Breeding Season
  - Mechanical: All Indiana Bat Breeding Season
  - Chemical: As needed during peak Indiana Bat Breeding Season
  - Mechanical: As needed during peak Indiana Bat Breeding Season

- **Telescoping Saw Truck**

**Operational Cost Per Hour**

<table>
<thead>
<tr>
<th>Size</th>
<th>Operational Cost Per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Size</td>
<td>$5.55</td>
</tr>
<tr>
<td>Trees &gt; 24&quot;</td>
<td>$5.55</td>
</tr>
<tr>
<td>Trees 6&quot;-24&quot;</td>
<td>$5.55</td>
</tr>
</tbody>
</table>

**Herbicide Cost**

<table>
<thead>
<tr>
<th>Herbicide</th>
<th>Cost per Gallon</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glyphosate</td>
<td>$17.92</td>
</tr>
</tbody>
</table>

**Personnel Scale**

<table>
<thead>
<tr>
<th>Size</th>
<th>Personnel Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any Size</td>
<td>1 Person</td>
</tr>
</tbody>
</table>

**Notes/Considerations**

- **Return on Work**
  - All year work.

- **Operational Cost Per Hour**
  - High-quality, fast work is not always accessible, which can lead to increased labor and overtime.
  - Non-ODOT operations.

- **Operational Cost Per Person**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Hour**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Person**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Hour**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Person**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Hour**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Person**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Hour**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Person**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Hour**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Person**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Hour**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Person**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Hour**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Person**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Hour**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.

- **Operational Cost Per Person**
  - Fast work can be achieved with minimal labor costs.
  - Fast work can be achieved with minimal labor costs.
### Planning and Operations

#### Current ODOT Process

**Description:** Beyond obtaining new equipment and implementing improved field operations, ODOT can gain efficiencies for vegetation management activities by improving a variety of administrative, operational, and personnel processes.

**2011 Challenge:** Decentralized and disproportionate distributions of equipment and trained/experienced staff; lack of readily available technical resources in the Districts; outdated work specifications.

**Recommended Solutions:** ODOT management should make technical resources available to the Districts that are customised for the local conditions; work specifications should be updated; staff should be trained on new techniques and basic vegetation management subjects so they can make quick, independent decisions appropriate for their County.

#### 2012 Proposed Solutions

<table>
<thead>
<tr>
<th>Area</th>
<th>Recommended Improvement</th>
<th>Notes/Considerations</th>
<th>Potential Benefits</th>
<th>Purchase Price</th>
<th>Return on Investment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Central Equipment</strong></td>
<td>Update and maintain central equipment database and provide easy access to District managers. Use more descriptive and standardised categories to track equipment.</td>
<td>Facilitates easier sharing of equipment within and between districts to maximize use of equipment.</td>
<td>$</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td><strong>Potential Benefits</strong></td>
<td></td>
<td>Solves decision-making process; increases efficiency by quickly producing a &quot;pre-tested&quot; and preferred solution(s) for a given situation; i.e. more effective equipment combinations, crew compliment, materials, etc.</td>
<td>$5-$5000</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td><strong>Equipment Utilization</strong></td>
<td>Review and update all VM labor and materials contract specifications. Add into contract-specifications (herbicide use, distance to move to side, accessibility).</td>
<td>Achieve more consistent results from contractors; incorporate current industry standards.</td>
<td>$</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td><strong>IVM Computer Aided Decision Tool</strong></td>
<td>Create a software application that automates decision-making for VM Best Practices and solutions. A user-friendly computer application that provides a VM solution based on variable inputs; compatible with a variety of computer hardware and operating systems.</td>
<td>Simplifies decision-making process; increases efficiency by quickly producing a &quot;pre-tested&quot; and preferred solution(s) for a given situation; i.e. more effective equipment combinations, crew compliment, materials, etc.</td>
<td>$5-$5000</td>
<td>****</td>
<td></td>
</tr>
<tr>
<td><strong>Review VM Contracts</strong></td>
<td>Perform greater public awareness/education about ODOT VM practices. Create public education pieces that can be distributed by field staff and posted on websites; encourage the public/business/organizations to support no-mow and restored native landscape areas.</td>
<td>Less complaints; more cooperation during projects; financial support for VM activities and programs.</td>
<td>$</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td><strong>Herbicide Manual</strong></td>
<td>Create a vegetation management plan for each District. Customize VM best practice management for each unique District; provides yearly goals for all VM activities to ultimately establish a proactive program that uses routine and preventive maintenance practices.</td>
<td>Begins a structured effort to be more proactive and set goals; addresses local VM challenges more precisely yet creates consistency statewide; identifies particular VM tasks that could be subcontracted.</td>
<td>$5-$5000</td>
<td>****</td>
<td>(per district)</td>
</tr>
<tr>
<td><strong>Invasive Insect/Disease Threat</strong> &amp; <strong>Risk Tree Management</strong></td>
<td>Update ODOT Invasive Pest Management Manual to include new, revised, improved, and complete Best Management Practices. Based on findings of VM Research Project, ODOT's VM Manual would be revised to include proven, efficient VM practices, and a procedure framework that includes all aspects of the operation (including staff and public safety, environmental concerns, regulatory restrictions, etc.) which combined define a true Best Management Practice.</td>
<td>Statewide consistency of VM; official documentation of practices that are tested and proven to be cost-effective, efficient, safe, and regulatory compliant. Elevation of ODOT VM programs to a premium program among peers and citizens.</td>
<td>$5-$5000</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td><strong>Integrated Vegetation Management Plan</strong></td>
<td>Maintain qualified and certified personnel for herbicide applications and tree maintenance in each District. Assess current staff qualifications, train and certify staff for ODA Pesticide Application License and ISA Tree Worker or Certified Arborist designations; maintain professional qualifications, training, and recertification dates in a database.</td>
<td>Staff will know how to perform related tasks safer, better, and more efficiently; increased professionalism of ODOT VM staff as viewed internally by other State departments and externally by the general public.</td>
<td>$5</td>
<td>***</td>
<td></td>
</tr>
<tr>
<td><strong>Personnel</strong></td>
<td>Provide annual/potential general VM training for all staff. Includes: plant ID, insect/pest identification, personnel use, equipment use and calibration, safe work procedures, storm avoidance and mitigation, Migratory Bird Act, State and Federal Endangered Species Act, OH safety topics list.</td>
<td>Increased staff professionalism, quicker and appropriate decision-making on the local level; less burden on equipment and manpower in the short and long terms.</td>
<td>$5-$5000</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td><strong>Training</strong></td>
<td>Review and update all VM labor and materials contract specifications. Add into contract-specifications (herbicide use, distance to move to side, accessibility).</td>
<td>Achieve more consistent results from contractors; incorporate current industry standards.</td>
<td>$</td>
<td>**</td>
<td></td>
</tr>
<tr>
<td><strong>Internal Collaboration</strong></td>
<td>Exchange inter-county and inter-district site VM visits and communication. Employees at various levels could go on rotation getting hands-on practice in each area, assuming and learning how other Districts or Counties perform VM operations while sharing their area ideas.</td>
<td>Better transfer of knowledge and &quot;cross-pollination&quot; between counties and districts among the staff that are performing the work. Encourages staff cohesiveness, increases professionalism, builds teams.</td>
<td>$</td>
<td>****</td>
<td></td>
</tr>
</tbody>
</table>

#### Legend

- $ = No direct cost; management effort/time only.
- $$$ = No Efficiency Gained
- $$$ = Minor Efficiency Gained
- $$$ = Moderate Efficiency Gained
- $5-$5000 = Efficiently Gained
- $5-$10,000 = Significant and/or Substantial Gain
- $5-$20,000 = Substantial Immediate and Long-term Gain
**Glossary**

**Area**  Descriptions of work environments, access issues, or vegetation compositions. Areas can influence a maintenance approach or the equipment chosen to perform the intended operation.

**As Needed**  An operation that will occur when a threshold for action is reached. Depending on the goal, as needed can vary. For example, action threshold for vegetation at the road edge is 18". The operation is needed at that point to maintain proper sight distance for traveling motorists.

**Bare Patch**  Bare soil that is exposed from equipment ruts, after machinery scrubs the vegetation away, or after herbicides take effect and kill unwanted weeds leaving bare soil behind.

**Basal Bark Application**  Basal bark application usually combines the herbicide with penetrant oil and applies the mixture directly to the bark of a standing tree. For trees that are less than 6 inches in diameter and have smooth bark, this method is frequently successful. However, it is important that the lower 12 to 18 inches of the stem be treated on all sides with the herbicide/oil mixture. Adequate coverage is essential, since treating only one side of the stem will result in controlling only half of the tree. Basal applications can be made any time of the year, but are most effective during the dormant season when leaves are not present. Basal applications will not provide rapid control. Herbicide injury is often not observed until several weeks after treatment and total control may require several months. Additionally, basal treatment is not effective on older trees with thick bark. For older trees, other application techniques should be employed.

**Bat Wing Mower**  Mower with articulating deck that can be useful for terrains, that varies in grade. Batwing mowers are useful along ditches as the deck will conform to the terrain and provide a closer cut without scalping. Also, bat wings are useful for reducing deck size when needed for tighter areas.

**Biological**  The control of a pest by the introduction of a natural enemy or predator. Grazing animals, insects, nematodes, fungus, or bacteria can be used for biological controls.
**Boom Sprayer**
A constructed frame that positions several nozzles in a row. The design is to provide even, thorough herbicide coverage of large turf areas with minimal waste, off-site herbicide travel, and more predictable material costs upon proper calibration. Physical objects or extreme terrain can cause issues for larger boom sprayers that cannot be operator adjusted. Boom sprayers can extend coverage areas by adding boomless sprayer extension nozzles.

**Boomless Nozzle**
Boomless nozzles are ideal for edge of road spraying, rough terrain, or used as an extension of a boom sprayer. Boomless nozzles are cheaper, more versatile, and easier to operate but are subject to overapplication, uneven coverage, and off-site herbicide drift. Plan operations around weather. Use drift control products.

**Broadleaf**
Dicotyledon (dicot) plants that typically have broad leaves and a deep tap root. Broad leaves include herbaceous and woody plants.

**Brush**
Woody plants often found growing along a wood line. Brush typically has multiple stems/trunks ranging from 1–6" and are usually no larger than 20' tall. Brush is often densely populated woody plants of various species. Invasive species such as bush honeysuckle can form dense brush thickets that are difficult to maintain. Brush is usually the result of natural processes and is generally not desirable due to encroachment issues and difficulty of management.

**Chemical Control**
Chemical control in weed management is the use of synthetic or naturally occurring compounds that are applied to noxious and invasive weed species with the intent of killing those plants.

**Chipper**
Chippers are used to mulch tree branches and other wood debris. Chippers generally consist of a powered feed mechanism, knives mounted on a rotating disc or drum, and an internal combustion engine. Typically, employees feed branches into the infeed chute by hand. Feed rollers at the end of the infeed chute grab the branches and force them into the chipper knives. The chipper knives generally rotate from 1,000 to 2,000 revolutions per minute. The drum and its knives chip the branches and force the chips through a discharge chute.

**Contact Foliar Herbicide**
Herbicide that is applied to the leaves of plants and is only useful while plants are green and actively growing. Plant injury occurs where the product is applied and works down into the root system under the right conditions.

**Control**
An activity that discourages, weakens, reduces, or eliminates unwanted vegetation.
**Crane**

A truck that has a telescoping crane which aids in tree removal. Combined with a bucket truck it provides a faster and safer, albeit more expensive, method to remove sections of, or whole trees. An excellent tool in tight working spaces.

**Cultural Control**

Modifying the growing environment to reduce the prevalence of unwanted pests. Examples include changing soil pH or fertility levels, irrigation practices, amount of sunlight, temperature, or the use of pavement or mats.

**Current ODOT Process**

A description of ODOT's current vegetation management processes given a specific operation. The description of ODOT's current processes is related to field observations made by Davey Resource Group research personnel and is reflective of district survey results on vegetation management operations. Generalizations have been made of ODOT's current vegetation management operations to account for the majority of operational approaches to roadside vegetation management.

**Cut-Stump Application**

This technique is employed after cutting down a tree to eliminate or greatly reduce re-sprouts from the cut surface. The herbicide should be applied to the cut surface as quickly as possible after the sawdust has been removed. If applied immediately, an herbicide/water solution is sufficient. If herbicide treatment is delayed and the cut surface has begun to dry, an herbicide/basal oil mixture must be used and applied to the top and around the collar of the stump. A tracer dye should be included to ensure treatment of all individual stumps.

**Disc Harrow Cultivator**

An agricultural tool that can be outfitted to a swing arm boom and be used to maintain bare ground gravel strips on the edge of the road.

**Drop Zone**

Refers to the area around a tree that is being pruned or removed. Care should be taken to minimize safety risk exposure in the drop zone while tree work is being performed.

**Extendable Arm Mower**

Also referred to as Boom Mower. Mower deck is mounted on an extendable arm boom. This setup is useful for over the guardrail mowing, or mowing steep slopes and uneven terrain from stable ground. Know your equipment reach capabilities so that targeted vegetation can be reached with the extendable arm without putting the driving unit on unsafe terrain.
**Feller Buncher**
A mobile machine, either rubber tired or tracked, with a power plant, operator enclosure, that may have an articulating extendable arm onto which a felling head is attached. The felling head consists of grappling devices and either a disc saw or chain saw. The operator moves the machine into position in front of a tree and maneuvers the felling head to the tree trunk. The saw severs the tree from the stump and the grappling devices wrap around the tree. The machine then takes the severed vertical tree and lowers it into a horizontal position onto a pile of trees on the ground. The feller buncher can take down one large tree or bunch up several small trees for removal with one cut.

**Fixed Object**
A stationary object adjacent to the traveling roadway such as guardrails, signs, bridge support structures, culverts, utility poles, etc. Vegetation management around fixed objects should aim to keep vegetation from obscuring the fixed objects. Fixed objects that are not visible are considered hazards to errant recovering vehicles that leave the roadway.

**Flail Mower**
Used to deal with heavier grass/scrub which a normal lawn mower could not cope with. Some smaller models are self-powered, but many are PTO driven implements, which can attach to the three-point hitches found on the rear of most tractors. This type of mower is best used to provide a rough cut to taller grass where contact with loose debris may be possible such as roadsides. Flail mowers are less likely to throw debris into the roadway than rotary mowers as the revolutions of the cutting surface spin parallel to the direction of mower travel. If a flail strikes an immovable object, it simply bounces off. Other rotary-type mowers have a tendency to grab and throw the object out of the mower deck if it is small enough.

**Foliar Application**
Directs an herbicide/water mixture directly onto the leaves of a plant. This technique can be highly effective on smaller vegetation (6 to 8 feet in height). Auxin-type herbicides (such as triclopyr) are generally most effective early in the season while enzyme-inhibiting herbicides (imazapyr and others) are most effective in the late summer or fall. Glyphosate is most effective in late summer or fall—after blooming, but prior to change in leaf color. Adequate control with foliar applications can be difficult to accomplish. This is because complete coverage of all foliage is essential for control, but over-application (that leads to spray runoff) will reduce effectiveness. Therefore, foliar applications commonly require multiple follow-up treatments before control is accomplished. It is important to control spray drift when making foliar applications.
Forestry Bucket Truck

Used to lift men and tools into the tree canopy. Typical lift heights range from 40 to 100 feet (12.2 to 30.5m). Standard features include two stabilizers and a power take-off (PTO) powered by the truck engine to operate the lift hydraulics, which raises the boom and bucket. Forestry Bucket Trucks are outfitted with OSHA specified safety equipment that is unique to the tree care and forestry industries.

Forestry Mulcher

A hydraulically-powered attachment that features a multi-toothed cutting wheel. The cutting wheel turns at a high rate of speed and, in the process, grinds down through trees and brush. Most models can shred shrubs and trees up to 6-8” in diameter. It can be used to reduce branches, foliage, and other unmarketable forest byproducts into mulch and chips or as a vegetation management tool for clearing away trees and brush from the sides of highways to reduce understory vegetation. Rocks and tree debris thrown through the air can reach 300–500’ so be mindful of surroundings when in use. To optimize the ability of the attachment, pair it with an appropriately powered machine.

Goal

A desired outcome of a vegetation management approach. For example a goal would be to remove a tree or to trim a tree.

Grapple

A grapple is a hooked or claw-like tool similar to a jaw used to grasp or clench something and move it. A standard grapple attachment is comprised of upper or lower jaws pivotally connected near the rear and having multiple elongated angular-shaped tines that open and close by a single actuator. The tines are used to dislodge, lift, and carry debris such as logs, slabs of concrete, wooden posts, rocks, and other hard-to-grab materials.

Grass

Monocotyledon (monocot) plants that have fibrous root systems, slender leaves with veins that follow the leaf margin. Grasses are almost always herbaceous with a few exceptions.

Hack and Squirt Application

The hack and squirt technique is ideal for control of large trees that cannot be managed with basal applications. This method requires that you use a small ax, machete, or hatchet to cut through the thick bark and into the sapwood. When hacking, it should be done in a downward motion, leaving a “cup” to hold the herbicide solution. If the cut does not hold herbicide solution, it will leak out and become ineffective. After hacking the entire circumference of the tree, 1 squirt (approximately 1 ml) should be placed in each cut. The addition of a basal oil is not required for this procedure. This method of application is advantageous because it is highly selective and injury to surrounding species is not common. It can also be done at any time during the year, but treatment of some species in the spring can be reduced because of heavy sap flow pushing the herbicide from the cut surfaces. Rainfall soon after application will also wash the herbicide away and limit uptake.
Hazard Tree
A structurally unsound tree that could strike a target when it fails.

Herbicide
Chemical pesticides that are specifically made for killing, injuring, or controlling vegetation.

Indiana Bat
The Indiana bat (Myotis sodalis) is a medium-sized mouse-eared bat native to North America. It lives primarily in eastern and Midwestern states and in parts of the south of the United States. The Indiana bat is gray, black, or chestnut in color and is 1.2–2 inches and weighs 4.5–9.5 grams (0.16–0.34 oz.). It is similar in appearance to the more common little brown bat but is distinguished by its feet size, toe hair length, pink lips, and a keel on the calcar.

Indiana Bat Breeding Season
Breeding occurs in and around hibernacula in fall. During the breeding season, Indiana bats undergo a phenomenon known as swarming. During this activity, large numbers of bats fly in and out of caves from sunset to sunrise. Swarming mainly occurs during August and September and is thought to be an integral part of mating. Bats have been observed copulating in caves until early October. During the swarming/breeding period, very few bats are found roosting within the hibernacula during the day. Limited mating may also occur at the end of hibernation. Clearing of trees greater than or equal to 5" diameter at breast height is prohibited between April 1st and September 30th in areas of summer habitat and is prohibited between March 15th and November 15th in fall swarming habitat.

Integrated Vegetation Management (IVM)
A system of managing plant communities by which managers identify compatible and incompatible vegetation, consider action thresholds, evaluate control methods, and select and implement controls to achieve specific objectives. The choice of control methods is based on the anticipated effectiveness, environmental impact, site characteristics, safety, security, economics, and other factors.

Invasive Weed
Invasive weeds are common and widespread in Ohio, but are not prohibited by law. Invasive weeds are aggressive, fast growing, and usually out-compete native vegetation. Invasive weeds are a large problem for roadside maintenance programs. A list of invasive weeds is maintained by the Ohio Invasive Species Council (OIPC).

ISA
International Society of Arboriculture.

ISA Certified Arborist
Individuals who have achieved a level of knowledge in the art and science of tree care through experience and by passing a comprehensive examination developed by some of the nation’s leading experts on tree care. Certified Arborists must also continue their education to maintain their certification and adhere to a Code of Ethics. Therefore, they are more likely to be up-to-date on the latest techniques in arboriculture.
ISA Certified Tree Worker

Individuals who possess knowledge and skill proven through testing to safely and productively provide quality tree care. Certified Tree Workers must continue their education to maintain their certification and adhere to a Code of Ethics. Therefore, they are more likely to be up-to-date on the latest techniques in arboriculture.

IVM Follow-Up

Additional steps that may be necessary or beneficial beyond the Recommended Improvement. IVM follow-up is not factored into operational cost, but may be highly beneficial in obtaining long-term control over undesirable vegetation and will ultimately reduce maintenance needs.

Large Tree

Woody plants that are typically single stemmed. Large trees are generally over 20' tall, >6" diameter at breast height. Large trees in Ohio can reach >100' in height.

Lighting Bucket Truck

Used to lift men and/or materials to lighting and sign equipment. Typical lift heights range from 15 to 40 feet (4.6 to 12.2m). Standard features include two stabilizers and a power take-off (PTO) powered by the truck engine to operate the lift hydraulics, which raises the boom and bucket. A lighting bucket truck is not set up with proper safety equipment that permits safe tree maintenance operations.

Maintained Turf

Maintained turf includes all areas that are actively mowed and trimmed. The goal for maintained turf should be to establish grasses and to discourage broadleaf weeds and woody weeds. ODOT maintained turf currently contains grass, broadleaf, and woody plants.

Mechanical Control

Consists of using machines or other human-made tools to suppress weeds. Mulchers, mowers, cultivators, saws, etc., are all examples of tools commonly used to mechanically manage vegetation.

Medium Sized Tree

Trees that reach a mature height range of 31’–45’.

Mow Cycle/Trim Cycle

The time between mowing or trimming events. Longer intervals between cycles generally indicate successful IVM improvements.

Mud Mats

Used to drive off road onto muddy ground to prevent getting stuck and reduce ground disturbance. They spread out the weight of the vehicle, thereby reducing ground pressure.

Non-Selective Herbicide

Herbicide that kills or injures all vegetation.

Noxious/Prohibited Weed

Noxious plants are prohibited by the Federal, State, or Local Government.
<table>
<thead>
<tr>
<th><strong>Off Road</strong></th>
<th>Work that is done completely off the paved hard surface of the road. Off-road terrain can vary from turf to woods and from flat to varying slopes.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>On Road</strong></td>
<td>Work is done primarily from the hard surface of the road where at least 2 tires remain on the hard surface. This work can be done from a traveling lane, or on the shoulder with proper traffic control.</td>
</tr>
<tr>
<td><strong>Operational Cost</strong></td>
<td>Operational cost is a price range evaluation for a given operation that factors all labor, equipment, and material costs.</td>
</tr>
<tr>
<td><strong>Organic Herbicide</strong></td>
<td>Chemicals that are derived from natural or organic materials, such as citric acid, clove oil, or vinegar.</td>
</tr>
<tr>
<td><strong>Potential Benefits</strong></td>
<td>Davey Resource Group's assessment of the benefits related to acting on a Recommended Improvement. Benefits are most often related to improvements in production, cost, length of control, and safety and aesthetics.</td>
</tr>
<tr>
<td><strong>Personnel Required</strong></td>
<td>The minimum number of people required to staff the Recommended Improvement.</td>
</tr>
<tr>
<td><strong>Plant Growth Regulator (PGR)</strong></td>
<td>Herbicides that are labeled to stunt the growth of plants rather than killing them. Certain PGRs affect all plants while some only affect grasses. Always read labels before applying an herbicide as a PGR.</td>
</tr>
<tr>
<td><strong>Pre-Emergent Herbicide</strong></td>
<td>Prevent seeds from germinating, but do not harm existing plants. This type of herbicide is especially useful in establishing shrub installations. Without an herbicide program that involves pre-emergent control, it is very difficult to establish a shrub planting. Once shrubs fill in at maturity, they will on their own prevent weeds from growing by shading and outcompeting them.</td>
</tr>
<tr>
<td><strong>Purchase Price</strong></td>
<td>Purchase price is only evaluated on materials, equipment, or attachments that ODOT does not currently own or frequently implement.</td>
</tr>
<tr>
<td><strong>Rail Trimmer</strong></td>
<td>A mower attachment that is specifically designed to mow vegetation under guardrails and cable rails and to articulate around rail posts eliminating the need for manual string trimming. Use of a guardrail mower by a skilled operator should roughly double the production of manual string trimming crews while improving safety by reducing manual labor at the edge of the road.</td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Residual Herbicide</td>
<td>Herbicides that are active in the soil and are often taken in through plant roots to kill the entire plant. Residual herbicides can provide control for longer windows of time, but can interfere with re-planting areas that have been treated with residual herbicides.</td>
</tr>
<tr>
<td>Return on Investment (ROI)</td>
<td>A performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments.</td>
</tr>
<tr>
<td>Road Edge</td>
<td>Area directly adjacent to the road. Guardrails are found on the road edge which may be maintained as a bare ground area or as an area where vegetation is allowed to grow to the pavement edge to prevent erosion.</td>
</tr>
<tr>
<td>Root Grafted</td>
<td>Refers to trees that have connected roots. This may occur between same species trees and can result in off-target herbicide damage to trees that were not treated with herbicide. Use caution when using cut-stump or basal bark applications if nearby desirable trees exist.</td>
</tr>
<tr>
<td>Rotary Mower</td>
<td>Machinery that uses a rotating straight blade or blades to cut vegetation. In agriculture a rotary mower takes the form of a piece of tractor machinery that is often pulled behind the tractor and powered by the PTO. Rotary mowers use thick blades of sharpened metal to cut thick grass, heavy bushes, weeds, and small trees. Due to the high torque and power associated with the implement, shields made of hanging heavy chain or thick vinyl or rubber are often provided around the discharge chute to control flying debris. Rotary mowers are known to throw debris further and more frequently into traffic when compared to flail mowers.</td>
</tr>
<tr>
<td>Selective Herbicide</td>
<td>Herbicides that are formulated to control a specific weed or type of weeds. Selective herbicides in general can control specific woody weeds, broadleaf weeds, and/or grassy weeds. Selective herbicides can be useful in areas where control of one plant is desired, but preservation of another plant is the goal.</td>
</tr>
<tr>
<td>Shrubs</td>
<td>Woody plants that are often planted and maintained for aesthetics or zone separation. Once established, shrubs can effectively suppress weeds and trees from growing in areas that can cause maintenance concerns. Shrubs are often planted on slopes or areas that are difficult to access for routine maintenance.</td>
</tr>
<tr>
<td>Skid Sprayer &amp; Hose Reel</td>
<td>A spray tank mounted on a frame usually with a pump motor, hose reel, and gun attached for easy outfitting into existing ODOT trucks. Size of skid sprayers and tanks should be based on payload and bed size of available ODOT trucks.</td>
</tr>
</tbody>
</table>
Skid Steer Loader

Skid-steers are typically four-wheel vehicles with the wheels mechanically locked in synchronization on each side, and the left-side drive wheels can be driven independently of the right-side drive wheels. The wheels typically have no separate steering mechanism and hold a fixed straight alignment on the body of the machine. By turning the left and right wheel pairs at different speeds, the machine turns by skidding, or dragging its fixed-orientation wheels across the ground. Grapple or loader attachments are useful in forestry operations for loading materials into chippers.

Small Tree

Woody plants that are typically single-stemmed and have the ability to grow over 20’ tall. Small trees are generally <6” diameter at breast height.

String Trimmer

Gas-powered hand tool with a spinning head and nylon line that cuts vegetation in areas that larger machinery cannot access or adequately maneuver around. Metal or serrated cutting heads can be outfitted to handle larger weeds or small woody weeds.

Susceptible

Easily affected, influenced, or harmed by something. When targeting specific plants for control, ensure that control measures are scheduled around plant susceptibility that may revolve around the plant life cycle or environmental factors.

Telescoping Saw Truck

High volume tree trimmer with circular saw blade at the apex of a telescoping arm with a reach of 75’. These units are generally not precise enough to make proper cuts and are best utilized off road. If used on road, proper finish cuts should be made by a follow-up crew in a bucket truck. Jarraff or Sky Trim can be wheeled or tracked.

Timing/Frequency

Refers to the time of year and the number of times per year needed for successful control.

Tree Mulcher

Large forestry mulcher head usually attached to extendable excavator arm. Fecon Bull Hog and Brown Brontosaurus are examples of Tree Mulchers. Tree mulchers have more horsepower, greater reach, and can process larger tree diameters than forestry mulchers. Tree mulchers remove trees by chipping and grinding all debris down to stump in one process. Just like a forestry mulcher, the advantage to this type of device is there is usually no waste to remove from the site once a tree has been removed.

TrucKat

An extendable arm mower unit that is directly mounted to a truck chassis eliminating the need for a tractor and trailer on roadside mow operations.

Turf

Mowable areas that are primarily comprised of herbaceous grass species mixed with broadleaf weeds and occasional woody weeds. Desirable turf is comprised of grass species only.
| **Water Sprouts** | Vigorous, upright, epicormic shoots that grow from latent buds in older wood. Water sprouts are often forced into growth just below large pruning wounds, particularly when branches have been cut to stubs. Without exception, water sprouts should be removed as soon as possible. Water sprouts can grow 10–15 feet in one year and are seldom firmly attached to the trunk or branch from which they arise. |
| **Weed** | An undesirable plant found growing where it should not be. |
| **Weed Flamer/Burner** | A tractor-mounted unit that uses heat to kill or control weeds. Flames or infrared heat is applied at high enough temperatures to kill weeds and live vegetation quickly with minimal risk of wild fires. |
| **Weed Mat** | Synthetic mats usually made from plastic or rubber that can be placed under guardrails and tightly around guardrail posts preventing weeds from having a place to take hold. Mats require annual debris removal maintenance so that weeds do not begin to grow in the accumulation of debris that land on the weed mats. |
| **Wet-Blade Mower** | A mower that has an herbicide tank incorporated into the unit. The herbicide is applied directly to the mower blade so that as the mower is cutting, herbicide is simultaneously being applied. This setup is especially good for areas where public opinion of herbicide use is low and there is a need for discrete herbicide application methods. |
| **Woody** | Weeds, shrubs and trees that have woody stems, or are entirely woody. Woody growth is referred to as secondary growth that reinforces a plant's structure and allows it to grow quite large. Woody plants are perennial. |
Literature Search/References


BASF. "Research, Resources, Results." http://bettervm.basf.us/frequently-asked-questions/case-studies/research-resources-results.html.


BASF. *Frequency Herbicide*.


Bayer: Esplanade EZ; EPA Reg. No. 432-1528. Research Triangle Park, NC.


Bradley, Kevin, and Andrew Kendig, 2011. "Weed and Brush Control Guide for Forages, Pastures, and Noncropland." University of Missouri Extension


Brenton, R. K. 2003. *Imazapyr (Stalker* or Chopper* Herbicide); Considerations for the Control of Invasive Plants.* CalEPPC.


Dow AgroSciences. Chemical Side Trim.
DuPont. “Give native grasses room to grow.” Perspective® Herbicide. Last modified 2013. perspective.dupont.com


Iowa Department of Transportation. 2003. *Iowa’s Living Roadway Plant Profiler.*

Iowa Department of Transportation. 2004. *Roadside Vegetation Q&A Answers to Your Questions About the Iowa Department of Transportation’s Roadside Vegetation Program.*


Ohio Department of Agriculture, 2008. “*Pesticide Regulation, Industrial Vegetation Control – Commercial Category 5*”

Ohio Department of Agriculture, Division of Plant Industry, 2013, “*Summary of Plant Protection Regulations*”

Ohio Department of Natural Resources. *Fighting Invasive Plants in Ohio*.


Ohio Department of Natural Resources Division of Natural Areas and Preserves, 2000, “*Ohio’s Invasive Plant Species*”

Ohio Department of Natural Resources Division of Natural Areas & Preserves, The Nature and District Conservancy, Columbus & Franklin County Metro Park. *Alternatives to Ohio’s Invasive Plant Species*. Columbus, OH: Ohio Division of Wildlife, 2001.


Ohio Invasive Plant Council, 2010. *Invasive Plants of Ohio Factsheet 1, Amur, Morrow’s and Tatarian Honeysuckles*.


Oregon State University and Intertox, Inc. 2003. 2,4-D: Roadside Vegetation Management Herbicide Fact Sheet. Washington State Department of Transportation.


Swanigan, R. Roadside IVM. Missouri DOT.


Tree Care Industry Magazine. Sept 2012.


United States Fish and Wildlife Service, Federal Highway Administration, and Ohio Department of Transportation. 2006. Biological Assessment for the Federally Endangered Indiana Bat (Myotis sodalis).


University of Georgia - Warnell School of Forestry and Natural Resources and College of Agricultural and Environmental Sciences – Department of Entomology. Invasive.org—Center for Invasive Species and Ecosystem Health. Last updated: 4/13/2009. http://www.invasive.org/species/list.cfm?id=54

University of Kentucky 2006. Combinations of Diuron, Flumioxazin, Glyphosate, and Sulfentrazone for Total Vegetation Control.

University of Minnesota Extension. 2007. The Best Plants for 30 Tough Sites.


Washington State Department of Transportation. 2003. 2, 4-D Roadside Vegetation Management Fact Sheet.


*Weed and Brush Problems Circular E-958.* Oklahoma Cooperative Extension Service Division of Agricultural Sciences and Natural Resources Oklahoma State University.


**Interviews**


Evans, L, Senior Vice President Operations, Davey Tree Surgery Company, October 7, 2013.


Stevens, L, Area Manager, Davey Tree Surgery Company, October 7, 2013 and December 18, 2013.

