Evaluating Vegetation Management Practices for Woody and Herbaceous Vegetation
2018 Purdue Road School
Project Team

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Jill Martindale

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Josh Wallace, District 8  Scott Lucas, Central Office Maintenance

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Brad McBride, Site Manager
Scott Larson, Biologist
Introduction: How Did We Get Here?

Challenged with managing vegetation along nearly 43,000 lane miles throughout Ohio’s diverse landscapes, ODOT sought to improve and expand its roadside integrated vegetation management (RIVM) program.

ODOT’s Office of Statewide Planning and Research with a Technical Advisory Committee developed a research project and solicited assistance through a request for proposal.

Davey Resource Group, a division of The Davey Expert Company, was selected to complete the research project.
Project Objectives

Implement New and Improved Vegetation Management

Increase Efficiency, Effectiveness, and Reduce Costs

- Decrease the amount of noxious and problem weeds on the ROW
- Better safety for workers and traveling public
- Extend maintenance cycles for herbaceous and woody vegetation
- Make use of new and more effective chemical methods for vegetation management
- Utilize better mechanical methods for vegetation management
- Improve the abilities of workers to utilize equipment and herbicides properly

Implement New and Improved Vegetation Management
Phase I to Phase II

Phase I
Evaluate, Research, Assess, and Recommend RIVM Methods
August 2013 – February 2014

Phase II
Test Recommended IVM Methods
May 2014 – November 2016
Phase II Project Scope

**TASK 1**
Field Days and Technical Briefs

**TASK 2**
Guide for RIVM of Prohibited Noxious Weeds in Ohio

**TASK 3**
Field Testing of Mechanical and Chemical Methods
Task 1. Field Days and Technical Briefs

Conducted nine field days and presented technical briefs to share the project’s goals, implementation, and successes with ODOT staff.

Recommend controls for managing noxious weeds along state maintained right-of-way (ROW).

- Noxious Weed Identification and Control
- Applicator Guidance and Worksheets
- Glossary

The Guide for Roadside Integrated Vegetation Management of Prohibited Noxious Weeds in Ohio can be viewed here:

http://daveytree.uberflip.com/i/795219-odot-guide-for-rivm
**Musk Thistle (Carduus nutans)**

**Description**

Musk thistle, or nodding thistle, is a biennial or winter annual weed. Mature plants can reach up to 6 feet tall with multiple erect stems that bolt from a basal rosette. Leaves are spine tipped with hairs only on the broad center leaf vein. The flower is a round 2" flower that tends to bend or "nod".

**Where to Find:**

Typically musk thistle is found in dry areas particularly slopes around guardrails and in difficult to mow areas. It can be found in most counties in Ohio but is most prominent in the southern region.

**When to Find:**

Midsummer to early fall is the easiest time of year to identify musk thistle. Look for vivid pink rose colored, globe-shaped flowers.

**Seasonal Identification**

**Spring Identification — Difficult**

Roolettes can be found as low-growing mounds. At the rosette stage, distinguishing musk thistle from other thistles can be difficult. The key to identifying musk thistle is its broad whitish center leaf vein. A new growth stage can be observed in late spring as musk thistle begins to grow vertical stems. This growth stage is known as the bolting phase.

**Summer Identification — Moderate to Easy**

After stem elongation (bolting), round, globe-shaped flower buds develop during early summer and may be confused with bull thistle. Seeds form one month after flowering.

**Fall Identification — Easy to Moderate**

Fully mature plants begin to decline. Look for remnant, fluffly seed heads, fully formed multiple stems, and smooth, spine tipped, winged leaves. As musk thistle declines and withers, it becomes more difficult to distinguish from bull thistle.

**Winter Identification — Difficult**

Musk thistle is difficult to locate in mowed areas. Unmowed areas are easier to locate dead weed skeletons. Redbud in spring to determine the level of seed distribution and germination. Rosettes that germinate in warmer late fall and early winter can be found growing in winter.

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**Seasonal Identification**

- **Spring:** Rosette is identified by leaf and white center mid-vein.
- **Early Summer:** Young developing flower develops as globe shaped balls with lime shaped flower bracts.
- **Summer:** Stems are hairless near flower head, but have winged spikes on the lower stems. Leaf has winged spike tips, but is hairless on leaf surfaces.
- **Summer:** Mature flowers are pink rose colored and bend to head or nod.
- **Late Summer to Fall:** Mature flowers develop into fluffly seed heads.
- **Fall:** Identified by the nodding seed head which is dispersed by the wind.
Applicator Guidance

**Calibration Guidance for Spray Truck Broadcast Herbicide Applications**

When planning a broadcast application with a spray truck, equipment calibration is needed to properly substantiate the equipment outputs. The spray truck outputs are based on the spray nozzles pattern width and pattern pressure and speed setting.

Once the nozzle width is determined and flow rate, there is one more step to take. Follow the application method in the schematic pattern to check the schematic pattern to make sure it is a spaying the intended width. For this task, practice on dry pavement (preferably before fall), measure the pattern on the ground, and make sure there is no bounding present. Always make sure to exercise field going out on the style of way to make sure the pattern is proper.

**One Acre Conversion Chart**

<table>
<thead>
<tr>
<th>Feet</th>
<th>Meters</th>
<th>Square Feet</th>
<th>Feet</th>
<th>Meters</th>
<th>Square Feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>1.8</td>
<td>36</td>
<td>10</td>
<td>3.0</td>
<td>30</td>
</tr>
<tr>
<td>10</td>
<td>3.1</td>
<td>30.5</td>
<td>16</td>
<td>4.9</td>
<td>78</td>
</tr>
<tr>
<td>20</td>
<td>6.1</td>
<td>122</td>
<td>30</td>
<td>9.1</td>
<td>273</td>
</tr>
<tr>
<td>40</td>
<td>12.2</td>
<td>484</td>
<td>50</td>
<td>15.2</td>
<td>760</td>
</tr>
</tbody>
</table>

The following worksheet can be used to determine the time required to spray one acre for a week. It is essential that the worksheet is filled in to determine the spraying pattern that is needed. There are four steps in the procedure. The worksheet is a tool for the operator, and flow rates will be used to ensure that the applicator has the appropriate flow rates to spray the area.

**Spray Truck Work Load Calibration Worksheet**

1. [Flow rate can be used to determine the area to spray per hour.]
2. [Flow rate can be used to determine the area to spray per hour.]
3. [Flow rate can be used to determine the area to spray per hour.]
4. [Flow rate can be used to determine the area to spray per hour.]
5. [Flow rate can be used to determine the area to spray per hour.]

**Calibration Guidance for Directed Herbicide Applications**

The following chart and worksheet are intended to help operators calibrate and calibrate applications to 100 gallons per acre (GPA). It is an important to know what the gallons per minute (GPM) flows rate as to determine the time it takes to treat 1 acre. Proper calibration and understanding of equipment flow rates help to avoid over-application of herbicides. The charts below are quick reference charts for various calibration activities. These charts should be used to verify the worksheet calculations are accurate. Use the worksheet to determine the flow rate and time it should take to spray an area of 1,000 square feet. Time for each applicator to complete and time is allowed to spray an area of 1,000 square feet. This means you can add up the amount of time calculated in the worksheet below (line 5 of worksheet). The photo below demonstrates how to set up a practice area.

**Flow Rate Spray Time for 1 Gallon**

<table>
<thead>
<tr>
<th>Flow Rate (Gallons Per Minute)</th>
<th>Time to Spray 1 Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10 minutes</td>
</tr>
<tr>
<td>2</td>
<td>5 minutes</td>
</tr>
<tr>
<td>3</td>
<td>3.5 minutes</td>
</tr>
<tr>
<td>4</td>
<td>2 minutes</td>
</tr>
</tbody>
</table>

**Flow Rate Spray Time for 2 Gallons**

<table>
<thead>
<tr>
<th>Flow Rate (Gallons Per Minute)</th>
<th>Time to Spray 1 Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20 minutes</td>
</tr>
<tr>
<td>2</td>
<td>10 minutes</td>
</tr>
<tr>
<td>3</td>
<td>6.5 minutes</td>
</tr>
<tr>
<td>4</td>
<td>4 minutes</td>
</tr>
</tbody>
</table>

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5. [Flow rate can be used to determine the area to spray per hour.]
Task 3. Field Test of Mechanical and Chemical Methods

Seven Districts participated in a total of 25 tests
Research Approach: Zone Testing Goals

Zone One: Eliminate or Reduce Mechanical Removal
Zone Two: Reduce Mowing
Zone Three: Remove Noxious Weeds and Brush, and Prevent Regrowth
Zone Four: Remove Trees and Prevent Regrowth

The following results and recommendations are summarized from the final report Evaluating Vegetation Management Practices for Woody and Herbaceous Vegetation, located here: http://cdm16007.contentdm.oclc.org/cdm/ref/collection/p267401ccp2/id/14763
Tests

- Maintain Bare Ground under Guardrail or Cable Rail with Spray Truck and Boomless Nozzle
- Maintain Vegetation under Cable Rail or Guardrail with Guardrail Mower
Vegetation Results

*Rodeo® + EsplAnade® 200 SC + Oust® or Perspective®*
- 1 application per year in spring
- In two years of testing vegetation coverage was reduced to ≈ 0%

*Rodeo®*
- 3 applications per year
- Applications last ≈ 60 days before the vegetation needs retreatment
- Proper timing is critical to obtain vegetation control

*Guardrail Mower*
- 3-4 mows per year
- Vegetation is not controlled but rather maintained
- Vegetation quickly grows back after a mow event and can overtake roadside hardware
- Best use is for immediate sight distance restoration
Equipment Results

*Spray Truck with Boomless Nozzles*

- **Speed**
  - 9.04 mph
- **Acres per Hour (6’ nozzle)**
  - 6.57 hr.
- **Labor Hours per Mile**
  - 0.11
- **Labor Cost per Mile per Year**
  - $6.30 (Rodeo® 3 times per year)
  - $2.10 (Oust® or Perspective® 1 time per year)
- **Initial Investment**
  - $8,073.00
- **Return on Investment Compared to String Trimming**
  - 13 miles to accomplish
  - 1 hour to accomplish
Equipment Results

Guardrail Mower
- Speed
  - 1.03 mph
- Labor Hours per Mile
  - 0.99 hr.
- Labor Cost per Mile per Year
  - $75.64 (3 times per year)
- Initial Investment
  - $48,650.00 (mower head only)
  - $143,538.00 (mower head and tractor)
- Return on Investment Compared to String Trimming
  - 87 miles to accomplish (mower head only)
- Return on Investment Compared to String Trimming
  - 256 miles to accomplish (mower head and tractor)

String Trimmer Crew (SOP)
- Speed
  - 0.32 mph
- Labor Hours per Mile
  - 8.32 hr.
- Labor Cost per Mile per Year
  - $635.65 (3 times per year)
Zone Two – Operational Zone

Tests

- Maintain Turf in Open Areas with Spray Truck and Boomless Nozzle
- Maintain Turf under Guardrail or Cable Rail with Spray Truck and Boomless Nozzle
- Maintain Turf at Road Edge, no Rail with Spray Truck and Boomless Nozzle
- Maintain Turf with Batwing Wetblade™ System
- Maintain Turf on Slope or over Guardrail with Spray Truck and Boomless Nozzle
- Maintain Turf or General Vegetation Maintenance on Steep Slopes with Slope Mower
Vegetation Results: Plant Growth Regulator (PGR)

**PGR**
- Testing of PGR was in addition to broadleaf herbicides to control weed presence in turf
- PGR allows for up to 60 days of control
- PGR maintained grass height to an average of <12 inches 60 days after application
- Mowing was reduced by 1-2 mows per year, based on skipping a spring mow and/or early summer mow

**Plateau®**
- Spring broadcast application
- Plateau® at 4oz./acre recommended every other year
Vegetation Results: Broadleaf Weed Control

**Broadleaf Herbicides**
- Tested in all six Zone Two tests
- Timing and persistence are critical for a successful IVM program

**Triclopyr 3**
- Rate per Acre - 64 oz.
- Herbicide Cost per Acre - $7.35

**Perspective®**
- Rate per Acre - 5 oz.
- Herbicide Cost per Acre - $4.60

**Milestone®**
- Rate per Acre - 7 oz.
- Herbicide Cost per Acre - $6.56
Vegetation Results: Slopes and Hard to Reach Areas

Mechanical vs. Herbicide vs. Unmaintained

Mowing Occurred 2 Times per Year

Foliar Herbicide Occurred 1 Time per Year

Milestone®
- Rate per Acre - 7 oz.
- Cost per Acre - $6.56

Mowing - Kut Kwick
- Cost per Acre - $2.10
- Cost per Acre per year - $40.11

Mowing - Alamo Traxx™ RF
- Cost per Acre - $3.16
- Cost per Acre per year - $60.36
Equipment Results

*Spray Truck with Boomless Nozzles, and Skid Sprayer*

- **Speed (avg.)**
  - 9.24 mph
- **Acres per Hour**
  - 11.25-12 ac. (10’ nozzle)
  - 24.47-26.24 ac. (22’ nozzle)
- **Labor Hours per Acre**
  - 0.08-0.09 hr. (10’ nozzle)
  - 0.03-0.04 hr. (22’ nozzle)
- **Labor Cost per Acre**
  - $1.59-1.72 (10’ nozzle)
  - $0.55-0.76 (22’ nozzle)
- **Initial Investment**
  - $8,073.00
- **Return on Investment (Spray Truck w/ 10’ Nozzle)**
  - 39 acres to accomplish compared to string trimming
  - 4 hours to accomplish compared to string trimming
- **Return on Investment (Spray Truck w/ 22’ Nozzle)**
  - 135 acres to accomplish compared to mowing with Alamo Traxx™ RF
  - 5 hours to accomplish compared to mowing with Alamo Traxx™ RF
Equipment Results

**Batwing Wetblade™ System**
- Discrete herbicide application to areas where spray truck can’t reach
- Speed: **2.0 mph**
- Acres per Hour: **3.61 ac.**
- Labor Hours per Acre: **.30 hr.**
- Labor Cost per Acre: **$5.71**
- Initial Investment: **$40,287.00**
- Return on Investment Compared to SOP Batwing Mower:
  - 8,739 Acres to Accomplish
  - 2,421 Hours to Accomplish

**Kut Kwick Super Slope Master**
- Maintaining slopes that require mowing for maintenance or aesthetics
- Speed: **9.04 mph**
- Acres per Hour: **0.64 ac.**
- Labor Hours per Acre: **1.58 hr.**
- Labor Cost per Acre per Year: **$40.11 (mow 2 times per year)**
- Initial Investment: **$36,755.00**
- Return on Investment Compared to Alamo Traxx™
  - 1,816 Acres to Accomplish
  - 1,729 hours to Accomplish
Zone Three – Transition Zone

Tests

• Noxious Weed Control
  o Johnsongrass
  o Japanese Knotweed
  o Poison Hemlock
  o Kudzu

• Selective Brush Control with Foliar Application

• Autumn Olive Control with Foliar Application

• Brush Control < 1” with Flail Mower and Herbicide Application

• Brush Control with Rotary Wetblade™ System

• Brush Control >1” with Forestry Mulcher and Herbicide Application

• Selective Brush Control with Basal Bark Application

• Tree-of-Heaven Control with Basal Bark Application
Vegetation Results: Noxious & Invasive Plants

Johnsongrass (*Sorghum halepense*)
- Mid-summer foliar directed spray gun application (when Johnsongrass reaches 18-24” in height, just before seed head formation)
- Outrider® at 0.75 oz./acre or Rodeo® at 192 oz./acre

Japanese Knotweed (*Fallopia japonica var. japonica*)
- Fall foliar directed spray gun application
- Ecomazapyr 2 SL at 64 oz./acre

Poison Hemlock (*Conium maculatum*)
- Early spring directed spray gun application
- Perspective® at 7 oz./acre or Milestone® 7 oz./acre

Kudzu (*Pueraria montana var. lobata*)
- Late summer directed spray gun application
- Streamline® at 9.5 oz./acre or Milestone® 7 oz./acre
Vegetation Results: Brush & Small Tree Control

*Autumn Olive (Elaeagnus umbellata)*

- Late Summer Foliar Directed Spray Gun Application
- Followed by Directed Backpack Spot Spray
- Broadleaf Herbicides
  - Triclopyr 4 at 256 oz./acre + Streamline® at 9.5 oz./acre
  - Triclopyr 4 at 256 oz./acre + Milestone® at 7 oz./acre

*Flail Mower and Herbicide Application*

- Winter Mow + Ground Application
  - Tordon® K at 64 oz./acre
- Spring Foliar Directed Spray Gun Application
  - Streamline® at 11.5 oz./acre

*Rotary Wetblade™ System*

- Mow + Simultaneous Herbicide Cut Stump Application
  - 60 days of significant brush reduction
  - A second application is advised
Vegetation Results: Brush & Small Tree Control

Forestry Mulcher

- Mechanical Removal Followed by Ground Application
  - Tordon® K at 64 oz./ac
- Foliar Directed Spray Gun Application
  - Ecomazapyr 2 SL at 96 oz./ac

Foliar

- Foliar Directed Spray Gun Application
  - Ecomazapyr 2 SL at 96 oz./ac.
  - Rodeo® at 192 oz./ac.
  - Triclopyr 3 328 oz./ac

Basal Bark

- No Removal Necessary
- Winter Basal Bark Application
  - Triclopyr 4 with basal oil at 1:5 ratio per gallon

Basal Bark Tree-of-Heaven (Ailanthus altissima)

- No Removal Necessary
- Winter Basal Bark Application
  - Triclopyr 4 with basal oil at 1:5 ratio per gallon
Equipment Results

**Spray Truck with Spray Gun**
- Acres per Hour: **0.41 - 1.11 ac.**
- Labor Hours per Acre: **.91 - 2.44 hr.**
- Labor Cost per Acre: **$17.30 - 46.60**
- 3 Year Labor Cost per Acre: **$90.04**
- Herbicide Cost per Acre: **$11.10 - 37.67**
- Initial Investment: **$4,425.00**
- Return on Investment (3-year Maintenance Assumed):
  - 2 - 84 acres to accomplish
  - 8 - 292 hours to accomplish

**4-Gallon Backpack Sprayer for Basal Bark and Spot Treatments**
- Acres per Hour: **0.10 - 0.23 ac.**
- Labor Hours per Acre: **4.99 - 13.56 hr.**
- Labor Cost per Acre: **$95.31 - 258.94**
- Initial Investment: **$89.33**
Equipment Results

Removal of Brush or Small Trees
Forestry Mulcher:
• Acres per Hour: **0.18 ac.**
• Labor Hours per Acre: **6.94 hr.**
• Labor Cost per Acre: **$132.55**
• Initial Investment: **$86,098.36**

Manual Crew:
• Acres per Hour: **0.18 ac.**
• Labor Hours per Acre: **202.89 hr.**
• Labor Cost per Acre: **$3,875.10**

**Rotary Wetblade™ System**
• Acres per Hour: **0.33 ac.**
• Labor Hours per Acre: **3.26 hr.**
• Labor Cost per Acre: **$62.27**
• Initial Investment: **$19,708.00**
• Return on Investment Compared to SOP Rotary Mower:
  o **99 acres to accomplish**
  o **1,028 acres to accomplish**
Zone Four – Undisturbed Zone

**Tests**

- Tree Maintenance with Foliar Application
- Tree Maintenance, Equipment On-Road
- Tree Maintenance, Equipment Off-Road
- Tree Removal, Equipment On-Road
- Tree Removal, Equipment Off-Road
- Tree Removal with Tree Mulcher
Vegetation Results: Tree Maintenance

Chemical Side Trim
- Directed Foliar Application
  - Krenite® S at 512 oz./ac or $100.67/ac

Trim On-Road
- Forestry Bucket Truck for Natural Target Pruning
- SkyTrim for Efficiency

Trim Off-Road
- Vermeer Chipper
  - Pro: SOP, with a skilled crew this can be efficient
  - Con: Efficiency of this equipment is dependent on the crew size and skill
- Bandit Chipper
  - Pro: Single operator, can chip larger material
  - Con: Initial investment is high with a very long return on investment
Vegetation Results: Tree Removal

**Brown Brontosaurus**
- Cost: $678.05/ac.
- One Operator and One Spotter

**On-Road/Off-Road Removal**
- Sky Trim and Brush Chipper Cost: $2,688.07/ac. (avg.)
- Forestry Bucket Cost: $4,544.46/ac.
- Manual Crew Cost: $2,505.50/ac.

**Efficiency**
- Crew size and skill are main components to efficient tree work
- Larger crews do not always make the job more efficient

**Safety**
- Training and consistent operation of specialized equipment will lead to more knowledgeable staff operating this equipment
- Smaller crew sizes will put less workers near the fall zone
Vegetation Results: Tree Maintenance Equipment

**Forestry Bucket Truck**
- Miles per Hour: **.02 mph**
- Labor Hours per Mile: **216.65 hr.**
- Labor Cost per Mile: **$4,138.02**
- Initial Investment: **$147,273.00**
- No Significant Difference in Total Labor Hours or Job Length Between Forestry Bucket and All-Terrain Tree Trimmer
- Leaves the Most Natural Target Pruned Branches

**Spray Truck with Skid Sprayer**
- Miles per Hour: **.62 mph**
- Labor Hours per Mile: **1.77 hr.**
- Labor Cost per Mile: **$33.81**
- Herbicide Cost per Acre: **$22.05 - 100.67**
- Initial Investment: **$4,425.00**
- Return on Investment Compared to Trim with Forestry Bucket:
  - **1.16 miles to accomplish**
  - **2.05 hours to accomplish**
Vegetation Results: Tree Removal Equipment

**Brown Brontosaurus**
- Acres per Hour: **.06 ac.**
- Labor Hours per Acre: **35.50 hr.**
- Labor Cost per Acre: **$678.05**
- Initial Investment: **$207,416.00 (excavator + head)**
- Return on Investment Compared to Forestry Bucket Truck:
  - 1.08 acres to accomplish
  - 1,800 hours to accomplish

**All-Terrain Tree Trimmer + Clean-Up W/Chipper**
- Acres per Hour: **.04 ac.**
- Labor Hours per Acre: **151.21 – 188.09 hr.**
- Labor Cost per Acre: **$2,888.03 – 3,592.52**
- Herbicide Cost per Acre: $22.05 - 100.67
- Initial Investment:
  - $192,000.000 (All-terrain Tree Trimmer)
  - $42,383.00 (Brush Chipper)
  - $284,567.00 (Whole Tree Chipper)
- Return on Investment Compared to Forestry Bucket Truck:
  - 126 – 283 acres to accomplish
  - 2,517 – 5,666 hours to accomplish
Recommendations for Implementation

Implement a comprehensive, proactive RIVM program

• Maintenance of Management Zones
• Provide Training and Educational Programs
• Establish an Adaptive Management Program
Maintenance of Management Zones

Zone One

- Spray Truck with Skid Sprayer and Boomless Nozzles
- Achieve Bare Ground
- Trim Vegetation Under Guardrails or Cable Rails with Guardrail Mower

Zone Two

- Spray Truck with Skid Sprayer and Boomless Nozzles
- Broadleaf and Turf Height Control
- Maintain Slopes with Spray Truck

Zone Three

- Spray Truck with Skid Sprayer and Diamond Wetblade™ mower or similar equipment
- Noxious Weed Control
- Brush Control

Zone Four

- Specialized Tree Equipment; Brown Brontosaurus
- Tree Maintenance
- Tree Removal
Training and Educational Programs

- Routine and Specialized Training and Educational Programs
- Herbicide Use Training and Equipment in the Districts
- Job-Site Practices and Training for Tree Work
- Guide for RIVM of Prohibited Noxious Weeds in Ohio
Adaptive Management Program

- Roadside Vegetation Inventory
- Asset Inventory
- Roadside IVM Plan for Each District
- GIS-Based Work Planner Software
- Cultural Control Methods
- Utilization of Equipment
- Use of Contractors
The Guide for Roadside Integrated Vegetation Management of Prohibited Noxious Weeds in Ohio can be viewed here:

http://davetree.uberflip.com/i/795219-odot-guide-for-rivm

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