Objectives for Using Herbicides

- Site Preparation
- Release from Residual Woody Vegetation
- Release from Herbaceous Vegetation
- Mid-Rotation Release from Competing Vegetation (Crop Tree)
- Right-of-Way Maintenance

How Herbicides May Control Vegetation

- Kills top and roots --- translocation to roots to reduce sprouting
- Kill on contact --- roots still viable
- Applied to soil & taken in by plant
- Hormone-type herbicides --- disrupts bio-chemistry in plant --- selectivity

Mechanisms for Herbicides to be Effective

- Adsorption --- surface
- Absorption --- throughout
- Translocation
Timing of Application

Factors

- Stage of Plant Development
- Condition of Leaves
- Growth Stage
- Soil Moisture

Selectivity

Why Some Species are Affected or Not

- Differential Wetting
- Biochemical Differences
- Phenological Differences / Timing
- Selective Placement
- Morphological Selectivity

Examples

- Differential Wetting (leaves/needles/cuticle)
- Biochemical Differences (how chemical works within plant)
- Phenological Differences (timing of plant growth or part activity)
- Selective Placement (leaves/stems/buds)
- Morphological Activity (plant meristem activity)
Chemical Application Techniques

- Foliar Spray --- absorbed by leaves
- Basal Spray --- absorbed via bark
- Stump Spray
- Soil Applied
- Girdling & Injection of stem

Based in chemical absorption and timing of application

Measuring and Evaluation Effectiveness?

- When to apply? Timing
- Was the treatment applied correctly? Technique
- Was the treatment a success? Result
  Biological and Economically
- Minimize other potential impacts?

Safety

- Label Instructions
- Weather Problems
- Equipment and Nozzles (Application)
- Chemical Precautions
- On-Site and Off-Site Impacts
On-Site Impacts

- Non-Target Organisms
- Soil Health
- Ecosystem Recovery

Off-Site Impacts

- Drift
- Leaching
- Runoff
- Landscape Impacts

Use of Chemicals

“Most problem with pesticides arise from two categories of ignorance about their chemistry and biological effects. One form is hysteria on the part of the public, and the other is heedlessness or stupidity of complacent users. Education is the best solution to both problems. The public is not required to educate itself, but users are.”

Fear of Herbicide Toxicity

- Compared to agricultural herbicides that are applied several times a year, year after year
- Compared to common cleaning chemicals found under the sink
- Mechanical Methods Do Damage and Injure Trees!

Fear of Herbicide Toxicity

- Most forestry herbicides are over the counter - low toxicity
- Most applied once, perhaps twice during a rotation over many years
- Most dissipate within the environment within hours or a few days

How to Apply Herbicides

- Helicopter
- Ground Equipment
  - Tractor
  - Skidder
  - Injection
  - Hack and Squirt
- Backpack
  - Directed spray
  - Bands or circles
  - Bark application
  - Basal spray & thinline
  - Oil-based
  - Spot gun
Nozzles --- It’s a Science

- Nozzles affects Droplet Size as well as volume and spread
- Example: Pressure on droplet size
- Minimal herbicide to accomplish the job
- Experience and Practice

What do we put in the tank?

- Carrier (water or oil)
  - Aqueous sprays
  - Oil sprays
  - Invert emulsions
- Herbicide
- Adjuvant (increases the effectiveness)
  - Surfactants
  - Spreader-Stickers
  - Cuticle penetration
  - Buffers
  - Ammonium salts

CHEMISTRY!!!
Making Prescriptions

- Define goals
- Know your crop and site
- Identify weeds --- only use herbicides effective for weeds to control
- Know research results
- Read the label, re-read the label, and follow the label

Making Prescriptions

- Read and heed the MSDS and label instructions - Material Safety Data Sheet
- Use correct volume and application
- Follow up on efficacy --- Did you have desired results? Why or Why not?

MATERIAL SAFETY DATA SHEET

Dow AgroSciences
GARLON® 4 HERBICIDE

E. PRODUCT AND COMPANY IDENTIFICATION
PRODUCT: Garlon® 4 Herbicide
COMPANY IDENTIFICATION: Dow AgroSciences
Indianapolis, IN 46250-1193

F. COMPOSITION/INFORMATION ON INGREDIENTS

Inhalation: Avoid breathing dust. Keep area well ventilated. Do not inhale dust. If dust is inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing has stopped, consult a physician.

Eye Contact: Avoid contact with eyes. Rinse eyes thoroughly with water.

Skin Contact: Avoid contact with skin. If skin irritation occurs, consult a physician.

Ingestion: Avoid swallowing. Seek medical advice if swallowed. Flush out with plenty of water.


G. HAZARDOUS IDENTIFICATIONS

This product is classified as a hazardous substance.

1. EXPLOSIVE PROPERTIES

2. VOLATILITY

3. COMBUSTIBILITY

4. FLAMMABILITY

5. TOXICITY TO LIVING ORGANISMS

6. CORROSIVITY

7. CARCINOGENESIS

8. REACTIVITY

9. REVERSIBILITY OF EFFECTS

10. ENVIRONMENTAL HAZARD

11. OTHER HAZARDS

H. PRECAUTIONARY STATEMENTS

I. REGULATORY INFORMATION

J. FIRST AID MEASURES

K. SPILL OR LEAK PROCEDURE

L. STORAGE AND DISPOSAL

M. TRANSPORTATION

N. LEGAL CONSIDERATIONS

O. PREPARATION

P. CALCULATIONS

Q. FORMULATIONS

R. REFERENCES

S. ADDITIONAL INFORMATION
MSDS Sheet Contains
http://www.msds.com/

1. Product and Company ID
2. Info on Ingredients
3. Potential Hazardous ID
4. First Aid
5. Fire Fighting Measures
6. Accidental Release Measures
7. Handling and Storage
8. Exposure Control / Personal Protection
9. Physical & Chemical Properties
10. Stability & Reactivity
11. Toxicological Info
12. Ecological Info
13. Disposal Considerations
14. Transport Info
15. Regulatory Info

Agriculture vs Forest Herbicides

- Why formulated --- (cost)
- Frequency of use
- Only a few herbicides used in forestry
- Most do not persist in the environment
- Herbicide safety and environmental effects
  ---- Ag vs. Forestry

Herbicides

- Imazapyr
  - Chopper - BASF – Ester formulation
  - Arsenal AC - BASF – Amine formulation
  - Imidazolinone family
  - Inhibits branched amino acid synthesis
    - ALS (or AHAS)
      - Acetolactase synthetase
    - Amino Acids --- isoleucine, leucine, valine
**Herbicides**

- **Imazapyr** *(continued)*
  - Used to release pine from hardwoods
    - Broadleaf vs needle receptivity
  - Some herbaceous control
  - Delayed response --- total effectiveness in 2nd growing season
  - Weak on locust
  - Some movement in the soil

- **Glyphosate** *(continued)*
  - Roundup (not registered for forestry) - Monsanto
  - Accord – DowAgro
  - Rodeo – Monsanto (aquatic label)
  - Various generics
  - Family of its own
  - Inhibits aromatic amino acid synthesis
    - EPSP
      - 5-enolpyruvyshikimate-3-phosphate synthase
      - Tryptophan, tyrosine, phenylanaline
  - Apply during active growth, but after full leaf out
  - Weak on holly, maple, hickory, blackgum
  - Impacts green, elongating shoots when young
  - Originally formulated for grass control
Herbicides

- **Triclopyr** - DowAgro
  - Garlon 4 – DowAgro – Ester (injection)
  - Garlon 3A – DowAgro – Amine (foliar)
  - Pyridinecarboxylic acid family
    - Phenoxys
  - Behaves like auxin (IAA)
  - Over stimulates cell metabolism

- **Triclopyr** - DowAgro (continued)
  - No soil movement
  - Weak on maple
  - Can be applied as foliar spray (amine) or basal spray, thinline or cut stump (ester/oil)

- **Hexazinone** - DuPont
  - Velpar L - Liquid
  - Velpar ULW - Granule
  - Oustar (+ sulfometuron) – Soluble granules
  - Triazine family
  - Inhibits photosynthesis by blocking electron transport which leads to lipid peroxidation and cellular disintegration
Herbicides

**Hexazinone** – DuPont (continued)
- Spot soil applied (grid balls or spot spray) or injected (girdle frills)
- Good for control of oaks, maple, black cherry, sweetgum
- Yellow-poplar is resistant

Herbicides

**Sulfometuron** - DuPont
- Oust XP – Sulfonyleurea family
- Has both pre-emerge & post-emerge properties — herbaceous and woody control — soil active
- Used primarily in hardwood plantings in former crop or pasture fields
- Inhibits branched amino acid synthesis
  - ALS (or AHAS) — Acetolactate synthetase
  - Amino Acids - Isoleucine, leucine, valine

Herbicides

**Metsulfuron** - DuPont
- Escort XP
- Sulfonyleurea family
- Kudzu control and pine release
- Inhibits branched amino acid synthesis
  - ALS (or AHAS)
    - Acetolactate synthetase
  - Amino Acids - Isoleucine, leucine, valine
Herbicides

- **Clopyralid**
  - Transline – DowAgro
  - Pyridinecarboxylic acid family
  - Effective only on *composites & legumes*
  - Behaves like auxin (IAA)
    - Over stimulates cell metabolism

Herbicides

- **2,4-D** (2,4-dichlorophenoxyacetic acid)
  - Various brands (read the label)
  - Phenoxyacetic acid family
  - Control of broadleafs (annuals/perennials)
  - Behaves like auxin (IAA)
    - Over stimulates cell metabolism

Herbicides

- **Picloram**
  - Tordon - Dow-Agro
    - Various formulations
  - Pyridinecarboxylic acid family
  - Behaves like auxin (IAA)
    - Over stimulates cell metabolism
  - Long Residual effects — several weeks
  - Weak in holly, maple, beech, dogwood
Banned Herbicide

- **2,4,5-T** (2,4,5-trichlorophenoxyacetic acid)
  - Registered in about all crops and uses
  - Defoliant, Cheap
  - Agent Orange
  - Dioxin — toxic substance in manufacture of chemical
  - Banned about 1980 — Residuals were a big problem

Herbicides

- Surfactants
  - Entry II (ethoxylated tallow amine)
    - Original Surfactant in Roundup
    - Excellent safety on pine
      - Cannot penetrate the cuticle of pine but can hardwood
    - Used for Release
  - Timbersurf 90
  - NU-FILM-IR
  - Sun-it II (methoxylated sunflower oil)

Herbicides

- Tank mixes
  - Synergies
    - Less of both
    - Complementary control
    - Rule rather than the Exception to obtain broad-spectrum (multi-species) control
Herbicides for Hardwoods

- Many are the same as herbicides for pine
- Formulated from crop herbicides for plantations
- Injection and basal sprays for natural stands
- Some herbicides have tendency to flashback ---- root contacts
- Mix of species --- target vs. non-target species --- difficult and complex with many species encountered in hardwood systems

Certification

- Sustainable Forest Initiative (SFI)
  - Use registered herbicides/pesticides
  - Follow label
- Forest Stewardship Council (FSC)
  - Herbicides are OK, but their “dependence” should be reduced.
  - No transgenics (GMOs)

Transgenics --- Genetically Modified Organisms (GMOs)

- Hysteria Without Substance (If you don’t like herbicides then you will hate GMO’s!)
- The Need for Sterility
- Resurrection of a Species (American Chestnut)
- Evaluation
- Economics
- Ethics
- Hazard Potential
Herbaceous weed control is critical during the first growing season.

Stem diameter is generally more responsive to weed control than height, BUT height does increase (# of growth flushes and elongation of flushes).

As stands develop (5 to 8 yrs), herbaceous vegetation becomes less limiting and woody competition becomes more detrimental.

Untreated (undesirable? – depends on objectives) competition will restrict growth & yield of desired species. Woody control at 5 to 7 years can increase volumes at ages 20 to 25 years by an average of 30%.

In a pine plantation, a given amount of undesirable basal area (hardwood) displaces 1.5 to 2.5 times the basal area of desired species (pine). For example, 20 ft² of hardwood basal area displaces 30 to 50 ft² of desirable pine basal area.

Example Rx

- **Pine Site Preparation**
  - Several Herbicides Available — Imazapyr, Glyphosate, Trichlopyr, Sulfometuron depending on weed complex
  - Tank mix of Imazapyr and Glyphosate
  - Use lower rates for herbaceous weed control and higher rates for woody control
  - Apply during full leaf until mid-September
Manual Herbicide Application Methods

Five year old red oak being overtopped by yellow-poplar

What are Herbicides?

• Pesticides
  – Rodenticides
  – Insecticides
  – Fungicides
  – Herbicides

• Herbicides are the least toxic form of pesticides
• Herbicides are chemicals used to kill plants
Laws and Regulations

- Federal Insecticide, Fungicide, and Rodenticides Act (FIFRA)
- Restricted vs. Non-Restricted use Herbicides
- Licensing - Private Applicator vs. Commercial Applicator

Why Use Herbicides

- Safety
- Effectiveness
- Longevity
- Target specific
- Easy to use
- Minimal residual stand damage

Some Advantages of Manual Application

- Applicable on small or large ownerships
- Applicable on steep rugged topography
- Only requires simple tools
- Landowners can apply on own land
Ways Herbicides can be used to Manage Forest Vegetation

- Crop tree release
- Cull tree removal
- Controlling undesirable understories
- Site Preparation prior to planting
- Controlling competing vegetation around individual stems
- Controlling invasive plants

Common Manual Herbicide Application Methods

- Stem injection and cut stub treatment
- Basal spray
- Cut-stump
- Foliar spray

Stem Injection
Stem Injection Materials

- Graduated cylinder
- Plastic containers
- Label containers

Mixing Herbicides

- Graduated cylinder
- Plastic containers
- Label containers

Stem Injection

- Stems >1 inch dbh
  - 50% glyphosate product
- For crop tree release
  - 50% Garlon 3A
- Control of maple use Arsenal 6% or Arsenal AC 3%.
Hack-and-Squirt

- Make incisions waist high
- One incision per inch of dbh
- Keep incisions level

Stem Injection

- Incisions spaced too wide
- Older herbicides (2,4-D and Tordon) do not translocate as well as modern herbicides

If the Crop Tree and the Injected Trees are the Same Species, Use 50% Garlon 3A
Basal sprouts on a top-killed striped maple after being injected with Glyphosate, use Arsenal when controlling maple

Cut-Stub Treatment

• Use on stems less than 1 inch dbh
• Spray cut surface

Using stem injection to control an undesirable beech understory to regenerate black cherry and red oak
Summary --- Stem Injection

- Applicable to stems >1.0 in. dbh
- Applied after sap flow in the spring (leaf out) to November 1
- Use 50-percent solution of a glyphosate product (42% a.i.) or Garlon 3A in water.
- When controlling maple use 6% Arsenal or 3% Arsenal AC and water
- Treatment cost $75-$150/ac

Basal Spray

- Use 10% solution of Garlon 4 in oil carrier
- Wet lower 12-15 inches of the stem
- Apply anytime of the year stems are dry
- Effective on stems less than 6 inches in dbh and thin barked
- Usually on species such as beech & maple
Beech understory <6.0 in. dbh basal sprayed with 10% solution Garlon 4

Autumn olive 2 weeks after basal spraying with a 10% solution of Garlon 4

Spray completely around stems 12-15 inches above ground line.

Basal Spray Summary
• Apply any time of the year stems are dry
• Use 10% solution of Garlon 4 in an oil carrier
• Spray lower 12-15 inches of the stem to point on runoff, entirely encircle the stem
• Applicable to stems <6.0 dbh and <1,000 stems/acre
• Mid-story control of thin-bark species such as maple and beech
• Treatment costs $120-$175/acre
Cut-Stump Treatment

• Apply herbicide solution to outer 2 in. of cut stump
• Use 50% solution of glyphosate product
• Controls stump sprouting and attached root suckers
• Treat stumps as soon as possible after cutting

Undesirable beech/maple understory that will prevent establishment of desirable regeneration
Beech root sprouts attached to parent tree root

Beech stumps treated with a glyphosate herbicide containing dye

Beech root sprout mortality around treated beech stump
Untreated beech stump sprouts

Treated beech stumps do not sprout

Cut-Stump Summary

- Spray outer 2 inches of the stump
- Best to apply from leaf out to Nov. 1, growing season
- Do not apply during heavy sap flow, February through May
- Use 50% glyphosate or 6% Arsenal
- Treatment costs $40-$60/acre
- Especially effective on root sprouting species

Foliar Spray
Foliar Spray

- 2% solution of glyphosate product in water
- Add Oust to solution for better control of herbaceous weeds
- Use 3% Garlon 4 and water on waxy leafed species
- Escort highly effective on Multiflora rose

Adjuvants

- Adjuvants are agents like surfactants added to herbicides to increase their effectiveness
- Adjuvants can increase herbicide effectiveness by improving adhesion, coverage and penetration into plants.

Effects of Surfactant on Surface Tension of Spray Droplets
Spraying a fern bed with a 2% solution of glyphosate and 2 oz. of Oust XP per acre

Red oak seedlings released from fern using Oust

Red oak seedlings damaged by Oust treatment

Foliar spraying autumn olive with a 2% solution of Arsenal AC in water plus surfactant
Rhododendron and Mt. laurel sprayed with 3% solution of Garlon 4 and 0.5 percent solution of Cide-Kick in a water carrier

Foliar Spray Summary

• Use a 2% solution of a glyphosate product that contains a surfactant
• Treat plants in full leaf
• Logistically treat vegetation less than 6 ft. tall
• Completely wet foliage
• Add Oust for better herbaceous weed control
• Glyphosate products more effective later in season
• Check label for invasive species control