HERBICIDE MODE OF ACTION FOR FORESTRY HERBICIDES

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WHAT IS HERBICIDE MODE OF ACTION??

- The way a pesticide impacts the biochemical processes responsible for its effect on plant growth
- Simply put. The process by which the herbicide controls the plant

DO ALL HERBICIDES HAVE THE SAME MODE OF ACTION??

- No
- There are many different modes of action
- Different modes of action can have a profound effect on how and when certain herbicides are used
- They can also have a significant effect on how well the herbicide controls the target vegetation
- Some modes of action can be incompatible with another and vice versa
- The use of the same mode of action over time can lead to herbicide resistance

MODE OF ACTION CAN HAVE SIGNIFICANT EFFECTS ON REFORESTATION ACTIVITIES

- Timing of application
- Method of application
- Need for adjuvants or other herbicides
- Rotation of herbicide products to avoid resistance
- It is important to understand how herbicides work to maximize the efficacy and efficiency of your vegetation management program!

TERMINOLOGY

- *Preemergent (root absorbed) herbicides*
  - Applied to soil before weeds are present and are be taken up by plant roots
  - Hexazinone (Velpar DF), Atrazine (Aatrex), Cleantraxx, Esplanade F
- *Post emergent (foliar or stem absorbed) herbicides*
  - Applied to plant leaves or stems
  - Triclopyr (Garlon), Chopper (imazapyr), Accord (glyphosate)

TERMINOLOGY

- *Residual herbicides* – can control plants with root absorption from the soil solution
  - Atrazine, aminopyralid (Milestone), hexazinone (Velpar, Velossa)
- *Contact herbicides* - controls or suppresses most plants on contact (not residual)
  - paraquat
- *Systemic herbicide* - will move throughout the plant in the xylem or phloem
  - Triclopyr (Garlon), aminopyralid (Milestone), clopyralid (Transline), imazapyr (Chopper), glyphosate(Accord), 2,4-D

TERMINOLOGY

- *Herbicide Resistance*
  - "the inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type. In a plant, resistance may be naturally occurring or induced by such techniques as genetic engineering or selection of variants produced by tissue culture or mutagenesis."
- *Herbicide Tolerance*
  - "the inherent ability of a species to survive and reproduce after herbicide treatment. This implies that there was no selection or genetic manipulation to make the plant tolerant; it is naturally tolerant."

Source: *Weed Technology* 12 (4): 789. 1998

WHAT MODES OF ACTION DO WE HAVE AVAILABLE IN FORESTRY??

- ALS inhibitors (acetolactase synthase)
- Photosynthesis inhibitors
- PPO inhibitors (protoporphyrinogen oxidase)
- Growth Regulators
- CBI's (cellulose biosynthase inhibitors)
- EPSP inibitors (5-enolpyruvylshikimate-3-phosphate)

ALS INHIBITORS IN FORESTRY

- Imazapyr (Chopper/Arsenal)
  - Imadizolinone family
- Sulfometuron (Oust)
  - Sulfonylurea family
- Metsulfuron (Escort – Not in Ca)
  - Sulfonylurea family
- Penoxsulam (1/2 of Cleantraxx)
  - triazolopyrimidine family

ALS INHIBITORS IN FORESTRY

- Inhibits the ALS enzyme in plants responsible for the formation of three essential amino acids valine, leucine and isoleucine
- Soil and foliar activity
- Active at the growing meristems
- Extremely low use rates
- Very systemic herbicides and highly translocatable
- Tend to be highly effective herbicides
- Plants can develop resistance (perennial ryegrass, Russian thistle)
- Very compatible with EPSP inhibitors

ALS INHIBITOR SYMPTOMOLOGY

- Rapid inhibition of root & shoot growth
- Vein reddening
- Chlorosis
- Terminal bud necrosis
- Little leaves, "witches broom"
- Slow, whole plant necrosis (2-4 weeks)

IMAZAPYR DAMAGE ON PINE

- Typical imazapyr damage on pine
- Severe bud and needle stunting

PHOTOSYNTHESIS INHIBITORS IN FORESTRY

- Hexazinone (Velpar Df, Velossa)
- Atrazine (Aatrex)
  - Both hexazinone and atrazine are in the triazine herbicide family

PHOTOSYNTHESIS INHIBITORS IN FORESTRY

- Inhibits photosynthesis in plants by disrupting the Hill Reaction (the light dependant transfer of electrons by chloroplasts that results in the liberation of oxygen)
- Simply put, the plant cannot make food for itself
- Mainly soil active with limited foliar activity
- One of the oldest modes of action
- Symptomology is slow to appear.
- Symptoms rapidly proliferate with heat stress

SYMPTOMOLOGY OF PHOTOSYNTHESIS INHIBITING HERBICIDES

- Chlorosis of the older leaves, concentrated around the veins which remain green
- Later necrosis of the leaves & plant

HEXAZINONE SYMPTOMS ON PINE

- Note browning of needles from the tips inward.
- Classic hexazinone injury
- Increases rapidly with heat stress

EPSP INHIBITORS

- Glyphosate (Accord XRT II, Razor, Buccaneer, etc)
  - Glycine family

EPSP INHIBITORS

- Mode of action is very similar to ALS inhibitors
- Controls plants by inhibiting the enzyme EPSP which is responsible for the production of three essential aromatic amino acids (tyrosene, tryptophan and phenylalanine)
- Extremely systemic and highly translocatable
- Non selective herbicide
- Works extremely well with ALS inhibitors
- Foliar activity only
- Also prone to resistance issues (Italian ryegrass, marestail, hairy fleabane, etc)

GLYPHOSATE DAMAGE ON PINE

- Random browning of needles
- Drooping needles around bud

GROWTH REGULATORS IN FORESTRY

- Tryclopyr (Garlon 3, Garlon 4 Ultra)
  - Pyradine family
- 2,4-D
  - Phenoxy family
- Clopyralid (Transline)
  - Pyradine family
- Aminopyralid (Milestone)
  - Pyradine family
- Fluroxypyr (Vista)
  - Pyradine family

GROWTH REGULATORS IN FORESTRY

- Growth regulator herbicides used in forestry are referred to as synthetic auxin type herbicides
- They mimic the growth regulator effect of naturally occurring auxin in plants
- In extremely small doses, they can stimulate plant growth, at normal use rates the cause rapid cell wall expansion and death.
- Growth regulators basically cause the plant to grow itself to death
- Symptoms are obvious for growth regulators including twisting and curling of leaves and stems.
- Some growth regulators can hinder other herbicides activity on some species when tank mixed (i.e. glyphosate with triclopyr or 2,4-D on deciduous brush)

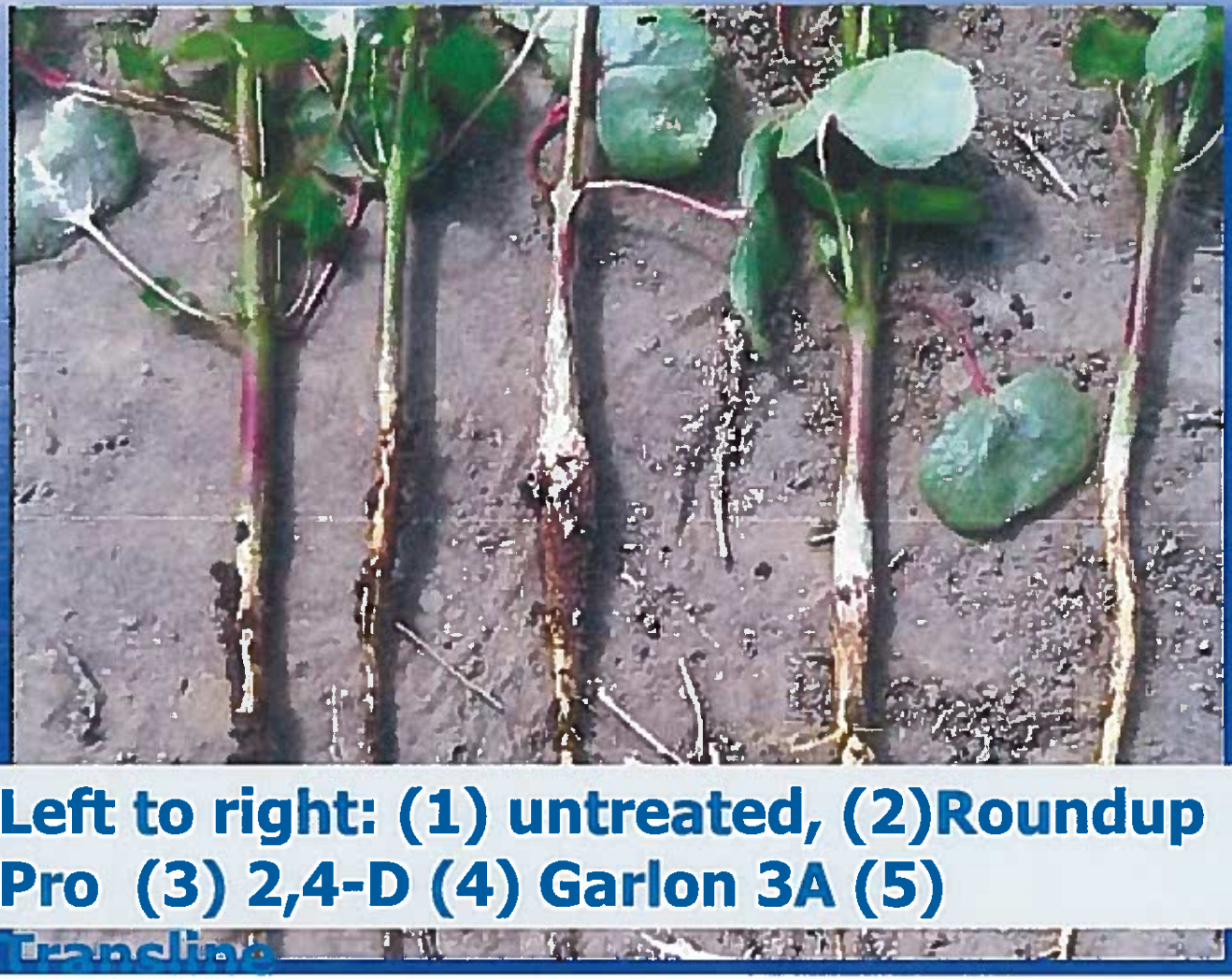
SYMPTOMOLOGY OF PLANT GROWTH REGULATOR HERBICIDES

- Meristematic tissues
- Epinasty
  - Twisting, cupping, and curling from uneven cell growth
- Stem cracking

2,4-D drift on grapes

SYMPTOMOLOGY OF PLANT GROWTH REGULATOR HERBICIDES

- Root callus or swelling



Left to right: (1) untreated, (2)Roundup Pro (3) 2,4-D (4) Garlon 3A (5) Transline

AUXIN HERBICIDE DAMAGE ON WHITE PINE

- Note twisting and curling of stems

PPO INHIBITORS IN FORESTRY

- Oxyfluorfen (1/2 of Cleantraxx, Goal, Goaltender
  - Diphenyl ether family

PPO INHIBITORS IN FORESTRY

- PPO inhibitors control plants by inhibiting the PPO enzyme produced in the chloroplast that is needed to produce PPIX which is a precursor molecule for chlorophyll needed for photosynthesis and heme needed for electron transfer chains
- They also destroy lipids and protein membranes which cause cell leakage and drying of plant tissues
- Symptoms include necrosis of leaves and stems
- Foliar and soil activity
- Activity increases with light, temperature and humidity
- Generally controls annual broadleaves and some grasses

PPO INHIBITOR SYMPTOMOLGY

- Symptoms develop very quickly (few hours to couple of days)
- Activity indicated by initial water soaked appearance on foliage; followed by rapid wilting, "burning," leaf speckling, browning and subsequent death.

CBI'S IN FORESTRY

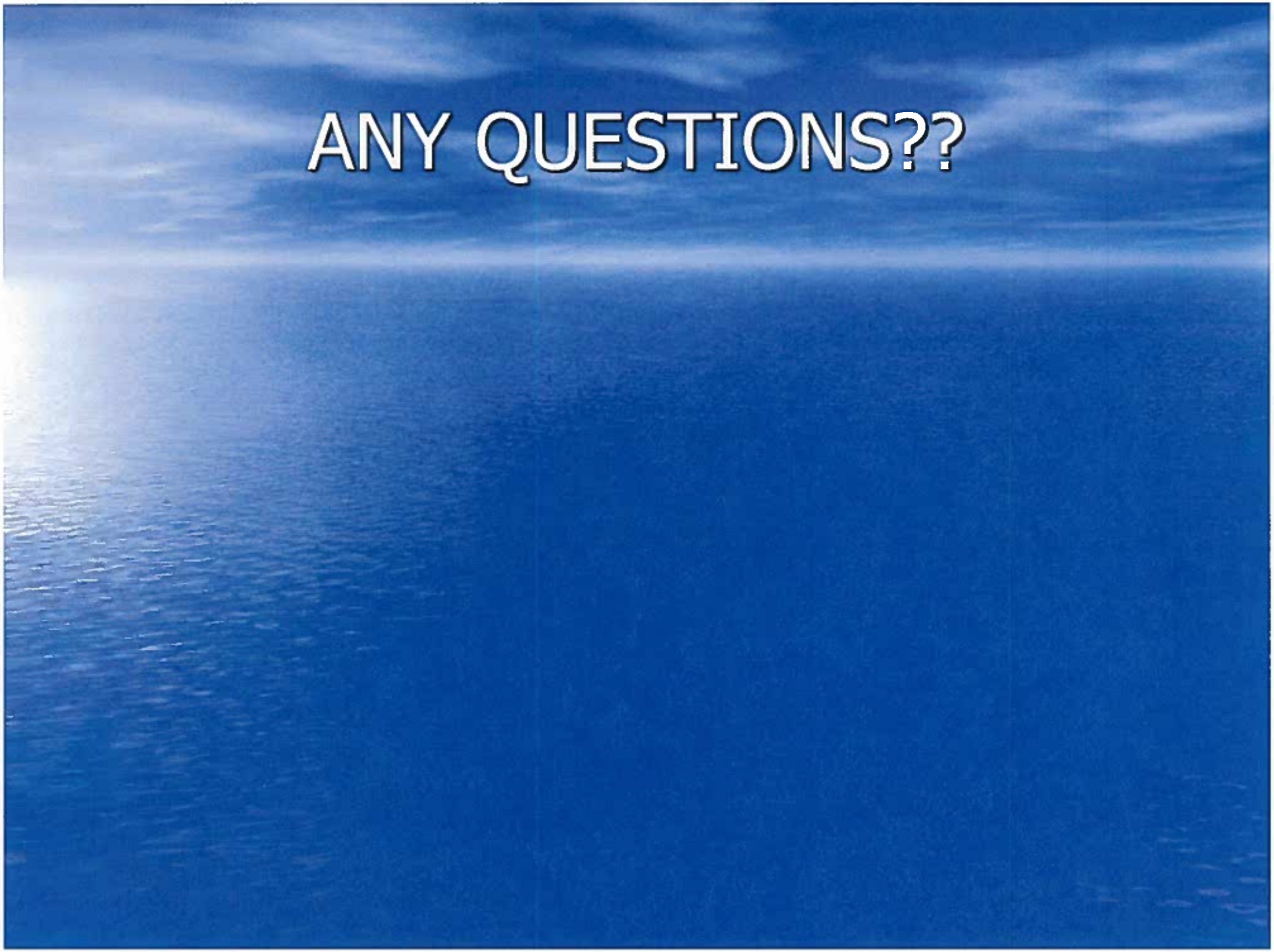
- Indaziflam (Esplanade F)
  - Fluoroalkyltriazine family

CBI'S IN FORESTRY

- The newest mode of action
- Indaziflam is the most active CBI found to date
- Predominantly pre-emergent activity
- Inhibits crystalline cellulose depostion in the plant cell wall affecting cell wall formation, division and elongation
  - Meristems
  - Expanding cells
  - Growing roots
- Cellulose synthesis process is complex and still poorly understood
- Little or no effect on mature leaves and tissues

WHY UNDERSTAND HERBICIDE MODE OF ACTION??

- Make better prescriptions and get better results (economically too!)
  - which group of weeds will be susceptible?
  - how can you maximize application efficacy?
- Need to know what symptoms to look for when assessing performance issues
- Enables recognition of typical symptomology to evaluate or diagnose plant injury
- Need to manage to avoid herbicide resistance
- Determine compatability


ANY QUESTIONS??