

IVM Decision Matrix

This draft decision matrix is intended to provide leaders various weed control options.

Integrated Vegetation Management (IVM) Definitions:

Weed: A plant that is not valued where it is located and usually exhibits vigorous growth and competes with more desirable plants. Most simply put, “A weed is a plant out of place.”

Invasive plant species: An invasive species is a species that is not native to a specific location and has a tendency to spread to a degree that causes damage to the environment, human economy or human health.

Method: Determine acceptable aesthetic/economic/environmental injury level.

Potential Cost: Determines amount of control and associated costs needed to reach the desired control outcome.

Pro's: Illustrate the positive aspect(s) that are derived from the control effort.

Con's: Illustrate the negative aspect(s) of the vegetation management effort(s).

PREVENTION										
Method	Cost	PPE	Training	Chemical Review	Agency Findings	Frequency	Impact & Environmental Considerations	Pro's	Con's	Other
	<ul style="list-style-type: none"> • Cost of cleaning vehicles and equipment of attached weed seeds after each site. • Cost to remove weeds before seed set. • For new plantings; the cost to eliminate all plants growing in the area either by soil solarization, smothering or pre-emergent herbicide application. 	<ul style="list-style-type: none"> • PPE is generally not required for equipment cleaning procedures. • When herbicides are used for prevention management the labels are the law. 	<ul style="list-style-type: none"> • No significant training is needed in order to implement this procedure. • Gain required training through UF/IFAS or from in-house sources. 	Numerous EPA registered pre-emergent herbicides are labeled for Florida.	NA	As directed by label for best control.	No adverse impacts are created from cleaning equipment.	<ul style="list-style-type: none"> • Cleaning vehicles and equipment to prevent the spread of weed seed and weed plant parts from one area to another. • Prevention also includes removing weeds before they can form seed heads or spread by other means. 	Possible extra staff commitment needed at certain times to tackle weeds prior to seed set.	NA

CULTURAL CONTROLS

(Cultural controls are management practices that reduce the incidence of weed infestations.)

Method	Cost	PPE	Training	Chemical Review	Agency Findings	Frequency	Impact & Environmental Considerations	Pro's	Con's	Other
Mulch & Weed Barriers	<ul style="list-style-type: none"> Cost of mulch Application time 	Generally, no PPE is required to implement cultural controls.	No special training required.	No chemicals involved.	Rubber mulches may contain heavy metals, such as cadmium.	Mulch must be replaced as needed due to oxidation of vegetation materials.	Soil improvement.	<ul style="list-style-type: none"> Assumed to be less costly than herbicide but, no research available. Builds soil. 	<ul style="list-style-type: none"> Continuous up keep. Cost Availability 	Transportation of bulky material.
Increased Planting Density at Time of the Landscape Design Stage	<ul style="list-style-type: none"> Cost of additional plants Labor to install 	NA	No special training required.	NA	None	Once	Greater planting density could help to reduce weed recruitment.	Greater planting density will suppress weed encroachment.	Greater planting density will increase the initial planting cost.	

BIOLOGICAL CONTROLS

(Biological control is the use of living organisms to manage pests. This method rarely results in complete eradication of weeds.)

Method	Cost	PPE	Training	Chemical Review	Agency Findings	Frequency	Impact & Environmental Considerations	Pro's	Con's	Other
Animal Grazing	<ul style="list-style-type: none"> Upkeep Housing Leasing Insurance Training Transportation of animals 	No PPE required for managing animal grazing.	Animal husbandry training may be required.	No chemicals involved.	NA	Frequency depends on the weed sources and species.	Animal droppings could be a nutrient and bacterial problem within close proximity to surface waters.	<ul style="list-style-type: none"> Sheep, Goats, and Pigs can be effective in bio-mass consumption. Droppings provide nutrients. 	<ul style="list-style-type: none"> Animal droppings can pollute stormwater. Animals can be unsightly, disruptive and unselective in weed consumption. 	<ul style="list-style-type: none"> PETA Public reaction Animal interactions (dogs/coyotes)
Beneficial Insects	Distribution cost.	No PPE required for beneficial insect control(s).	Special training is required in order to familiarize new staff with the identification of beneficial insects.	No chemicals involved.	U.S.D.A. and EPA are required to approve introduced insect species.	Continuous exposure is required.	U.S.D.A. and E.P.A. reviews must provide approval prior to the introduction of beneficial insect.	<ul style="list-style-type: none"> Biological control insects offer long term control of susceptible weed species. Examples include air potato beetle, Melaleuca psyllid. 	There is always the possibility of the introduced insect could become a pest.	Release of a bio control insect for Brazilian pepper is awaited.

MECHANICAL/PHYSICAL CONTROLS

(These controls physically disrupt the weed, including hand-pulling, hoeing, mowing, tilling, intentional flooding, etc.)

Method	Cost	PPE	Training	Chemical Review	Agency Findings	Frequency	Impact & Environmental Considerations	Pro's	Con's	Other
Line Trimming	<ul style="list-style-type: none"> Fuel String Batter Wear and tear costs 	<ul style="list-style-type: none"> Eye, ear, and leg protection should be provided. Follow manufacture's safety guidelines. 	Carefully read the owner's operating manual.	NA	NA	Varies due to plant growth rate.	Internal combustion engine emissions.	Weed reduced in size without chemical intervention.	<ul style="list-style-type: none"> Adjacent plants could be damaged. Labor intensive. Not long lasting. 	<ul style="list-style-type: none"> Heavy to carry long distances-made for small areas. In conjunction with monitoring
Flame Weeding	<ul style="list-style-type: none"> Purchase Training Fuel 	Body and eye protection	Carefully read the owner's manual.	NA	NA	Only burns off the above soil portion of the plant.	Combustion of propane gas.	<ul style="list-style-type: none"> No chemical weed control. Less labor than hand pulling. 	<ul style="list-style-type: none"> Potential for injury, upkeep, effectiveness, training. Adjacent plants can be burned. Infrastructure/ transportation Risk of starting a fire. 	Not much in urban use, mostly farms.
Steaming	<ul style="list-style-type: none"> Purchase Training Fuel 	<ul style="list-style-type: none"> Charged steam is very dangerous to bare skin. Read and obey all manufacturer's directions. 	Carefully read and heed the manufacturer's directions.	No chemical involved.	NA	Steam treatment provides only top kill of the target plant.	NA	Seems to work better than flame weeding due to better foliage penetration.	<ul style="list-style-type: none"> Soil communities are negatively impacted. Potential for injury by user. 	Purchase of unit maybe difficult.
Hot Water Weed Control Device(s)	Over 80 degrees Celsius/176 degrees Fahrenheit.	<ul style="list-style-type: none"> Hot water is very dangerous to bare skin. Read and obey all manufactures directions if you are using a hot water sprayer. 	Carefully read and heed the manufacturer's directions.	No chemical involved.	NA	Hot water provides only top kill of the target plant.	NA	Can be highly productive if equipment can deliver large amounts of hot water.	<ul style="list-style-type: none"> Few to any users of this method. Commercial machinery required and training 	Application unit may be difficult to find.
Infrared Radiation Lasers, Microwaves, Ultra-sonic, Robotic	Cost of operation has not been determined.	Not determined.	Not determined.	No Chemicals	NA	As Needed	Undetermined.	<ul style="list-style-type: none"> Could be the future. Technology may provide a low impact high result solution. 	<ul style="list-style-type: none"> Experimentation needed. Destruction of other untargeted communities (soil, plant or insect). 	Unknown.
Hand Pulling	Labor intensive, slow, and difficult.	Gloves	None required.	No Chemicals.	NA	As needed	NA	No chemical, transportation of machinery costs minimal.	Not possible with larger vegetation and in some environments, risk of worker injury, cost(s).	<ul style="list-style-type: none"> HR concerns Securing employees to do the job.
Aquatic Vegetation Harvester	Very large initial cost.	Life jackets would be required.	OSHA and manufacture's training.	NA	NA	As needed to help support herbicide treatments.	The harvester will collect some fish with each load.	Provides quick "tangible" removal of aquatic weed populations.	Provides only a temporary physical mowing of (<i>Hydrilla spp.</i>). The root structure remains.	<ul style="list-style-type: none"> Very large initial expense.

CHEMICAL CONTROLS

(Chemical control involves the use of herbicides to manage vegetative pests. These include selective, non-selective, contact, systemic and pre-emergent.)

Chemical Herbicides Option(s)	Costs	PPE	Training	Chemical Review	Agency Findings	Frequency	Impact & Environmental Considerations	Pros	Cons	Other
Chemical herbicides are generally classified as either “selective” or “non-selective.” Selective herbicides provide a control of weeds that is discriminatory. As a result, they will not kill all vegetation species by design. Non-selective herbicides are labeled and designed to kill nearly all weeds indiscriminately.	Cost of herbicide chemical(s), application equipment, maintenance of application equipment, calibration time, loading time, application time, post application clean-up time, cost of adjuvants and PPE.	Follow the manufacturer’s directions for the minimum required PPE.	Participate in all Federal, State and local required licensing requirements. Also include Extension Service commercial CEU training.	All herbicides listed in this section are currently registered for use by the E.P.A. in Florida when used as labeled.	The registration for each herbicide can be found on the E.P.A.’s website.	As needed based on labeling, soil, precipitation and weed growth rate.	Environmental consequences have been incorporated within the E.P.A.’s registration procedure.	<ul style="list-style-type: none"> Large areas can be treated relatively quickly. A small amount of staff can manage relatively large areas of vegetation. Systemic herbicides can provide excellent control on perennial weed populations. 	<ul style="list-style-type: none"> Chemical treatments are dependent on favorable weather conditions. Herbicides can pose a toxic risk to the handlers, the public and non-target organisms. “Treated areas may need to be cordoned off until the area becomes safe for use again.” Long-term use of selective and non-selective herbicides can create increased resistance within the existing weed population(s). 	With careful timing and effective application, chemical herbicides can provide “cost effective” long-term control of both annual and perennial weed populations.

Signal Word(s) Key for Red, Yellow and Green: **Red** = Danger **Orange** = Warning **Green** = Caution

Terrestrial Synthetic and Organic Herbicide Cost Analysis (Per Acre) Material Cost Only							
Common and Trade Names of Herbicides	Cost per Acre	Signal Word/ LD50 Rating	Synthetic/Organic	Selective/Non-Selective	Systemic/Non-Systemic	Personal Protection Equipment	Best Management Practices/Safety/Unknown(s)
Glufosinate ammonium, Cheetah; (24.5% a.i.) (\$104.95/gallon) (29.0 ounces per acre)	\$82.64/acre	Warning 1,500mg/Kg Oral	Synthetic	Non-Selective	Systemic	Coveralls worn over short sleeved shirt and pants, chemical resistant gloves, chemical resistant socks and footwear, protective eyewear.	Eye protection is extremely important for the safety of the cornea.
Diquat (37.3%-52.6% a.i.) (\$95.55/gallon)	\$24.00/acre	Caution 120mg/Kg Oral	Synthetic	Non-Selective	Non-Systemic	Coveralls over short sleeved shirt, long pants, chemical resistant gloves, chemical resistant shoes, socks, protective eyewear and an approved respirator	Eye safety is "extremely important" for the protection of the cornea.
Glyphosate, Round-up, Round-up Custom; (41.7% a.i.) (2.7 ounces per gallon) (400 square feet per gallon) (\$54.49/gallon)	\$125.00/acre	Caution 5,600mg/kg Oral	Synthetic	Non-Selective	Systemic	Long sleeve shirt, long pants, shoes and socks	Do not use during temperature inversions. Do not enter the treated area until completely dry.
Triclopyr (Ester), Garlon 4E; 61.6% a.i.)	\$101.78/acre	Caution 1,581mg/Kg Oral	Synthetic	Selective	Systemic	Long sleeved shirt, long pants, nitrile gloves, shoes and socks	
Imazapyr, Arsenal; (52.6% a.i.)	\$31.30/acre	Caution 5,000mg/Kg Oral	Synthetic	Selective/Non-Selective	Systemic	Long sleeved shirt, long pants, shoes, socks, chemical resistant gloves	Lethal danger exists to trees and shrubs from unintended "root absorption" within the targeted treatment area.
2,4-D, (46.8% a.i.) (2.84 gallons per acre)	\$61.42/acre	Danger 521mg/Kg Oral	Synthetic	Selective	Systemic	Goggles, long sleeved shirt, long pants, chemical resistant gloves and apron	Causes irreversible eye (cornea) damage. Mixer and applicator must wear full eye protection.
Acetic Acid, (20% a.i.) (35-gallons per Acre) (\$11.72 per 2.5 gallons)	\$164.00/acre	Danger 3,310mg/Kg Oral (Caustic)	Organic	Non-Selective	Non-Systemic	No label directives unless labeled at 40% concentrate.	"Highly corrosive" and dangerous to eyes. Do <u>not</u> enter the treated area(s) until all sprayed surfaces are completely dry.
Ammonium nonanoate, Mirimichi Green Herbicide 40.8%	\$1,480.00/acre	Warning >5,000mg/Kg Oral	Synthetic	Non-Selective		Long sleeved shirt, full face shield, chemical resistant gloves and boots	May cause permanent eye (cornea) damage. The mixer and applicator must wear full eye protection.
Imazaquin, Image; (3.3% and 70% a.i.) use (3.75 ounces) per 1,000 square feet for the 3.3% concentrate or (0.26 ounces) per 1,000 square feet for the 70% concentrate.	\$181.49/acre	Caution /4,703mg/Kg Oral	Synthetic	Selective	Systemic	Long sleeved shirt, long pants, waterproof gloves, shoes plus socks and protective eyewear	For best results add a "non-ionic" surfactant at the rate of 0.25%.
Suppress Herbicide E.C. (47% Caprylic Acid a.i. and 21% Capric Acid a.i.) \$209.00/gallon (4 ounces per 3-gallons of water)	No cost has been established	Warning 10,000mg/Kg Oral	Organic	Non-Selective	Non-Systemic	Protective eyewear, coveralls worn over short sleeved shirt and short pants, shoes and socks and chemical resistant gloves	Do not re-enter the treated area until it is completely dry. Apply with continuous agitation. This is a contact herbicide and requires complete coverage.
Avenger Weed Killer Concentrate (d-limonene (Citrus oil) (70% a.i.) \$92.69/gallon (16 ounces per gallon of water)	No (unit/area) cost has been established at this time.	Caution 4,400mg/Kg Oral	Organic	Non-Selective	Non-Systemic	Long sleeved shirt and long pants, shoes plus socks and eye protection	Do not re-enter sprayed area until it is completely dry. This is a contact herbicide and requires complete coverage.

Weed-Zap (45% Clove Oil a.i. 45% Cinnamon Oil a.i.) \$92.69/Gallon (6.4 ounces per gallon of water)	No unit/area cost has been established at this time.	No signal word shown	Organic	Non-Selective	Non-Systemic	Long sleeved shirt and pants, shoes, socks, gloves and protective eyewear	Readily burns skin on contact. This is a contact herbicide and requires complete coverage with no systemic effects.
Whack Out Weeds (aka, WOW). (4.5% Peppermint Oil, 3.5% Potassium Sorbate, 3.5% Sodium Chloride).	(6-16) ounces of the concentrate per gallon of water per 1,000-1,500 square feet of coverage.	No signal word has been issued based on the FIFRA 25b "Exemption."	Organic	Non-Selective	Labeled as systemic	Safety glasses, dust mask and gloves.	Use "extra caution" to prevent contact with the eyes.

Signal Word(s) Key for Red, Yellow and Green: **Red = Danger** **Orange = Warning** **Green = Caution**

Aquatic/Wetlands Chemical Herbicide Cost Analysis (Per Acre or Acre Foot) "Material Cost Only"							
*Note that all of the listed Aquatic/Wetlands Herbicides are Synthetic Compounds and are not derived from Organic Compounds							
Common and Trade Names of Herbicides	Cost per Acre	Signal Word/ LD50 Rating	Synthetic/ Organic	Selective/ Non-Selective	Systemic/ Non-Systemic	Personal Protection Equipment	Best Management Practices/Safety
2,4-D/Aqua-cide (47.3% concentrate) at 2.84 gallon per acre	\$61.42/acre	Danger 521mg/Kg Oral	Synthetic	Selective	Systemic	Goggles, long sleeved shirt, long pants, chemical resistant gloves and apron	Causes irreversible eye damage. Mixer and applicator must wear eye protection.
Procella COR-EC (15 fluid ounces per acre foot) (26.5% a.i.)	No unit cost has been found as of this date	Caution 5,000mg/Kg Oral	Synthetic	Selective	Systemic	Long sleeved shirt, long pants, shoes, socks, protective eyewear and waterproof gloves	Must follow label for waiting period days before irrigation.
Flouridone/Sonar (41.7%concentrate) (\$1,475.00 per gallon of concentrate)	\$92.19/acre foot	Caution > 5,000mg/Kg Oral	Synthetic	Selective	Systemic	No PPE listed	Applicator must adhere to the "water withdraw concentration restrictions" as shown on the label.
Round-up Custom, Glyphosate/Aquaneat, Rodeo (53.8% concentrate) (\$72.98 per 2.5 Gallons of concentrate) (294 ounces per acre)	\$66.99/acre	Caution 5,600mg/Kg Oral	Synthetic	Non-selective	Systemic	Long sleeve shirt, long pants, shoes and socks	Do not use during temperature inversions when drift could remain aloft.
Imazapyr/Habitat (4-pints per acre) (52.6% concentrate a.i.) (\$379.95 per 2.5 gallons)	\$75.99/acre	Caution 5,000mg/Kg Oral	Synthetic	Can be selective based on application method.	Systemic	Long sleeved shirt, long pants, shoes, socks, chemical resistant gloves	No entry until the sprayed surfaces are dry. Very destructive to trees through root absorption.
Endothall/Aquathol/Aquathol k/Aquathol Super k (40.3% concentrate) a.i. at (2.6 gallons per acre foot)	\$720.00/acre foot	Danger 51mg/Kg Oral	Synthetic	Selective	Systemic	Long sleeved shirt, long pants, shoes, socks, chemical resistant gloves, protective eyewear and NIOSH approved respirator	Applicator must adhere to the potable water concentration restriction(s) as shown on the label.
Diquat/Tribune/Reward (37.3% a.i.) at (1.0 gallon per acre)	\$159.00/acre or acre foot	Caution 120mg/Kg Oral	Synthetic	Non-Selective	Non-Systemic	Coveralls over short sleeved shirt, long pants, chemical resistant gloves, chemical resistant shoes, socks, protective eyewear, and an approved respirator	Irreversible eye damage risk to mixer and applicator.
Triclopyr/Garlon-3A/Element 3 (44.4% a.i.) at (\$67.85/gallon)	\$400.00/acre	Danger 680mg/Kg Oral	Synthetic	Selective	Systemic	Long sleeved shirt, long pants, shoes, socks, protective eyewear, chemical resistant gloves	Very dangerous to eye cornea. Mixer and applicator must wear full eye protection.
Water-tints/Aqua-shade	\$7.75-\$8.00 per acre foot	No signal word	Can be synthetic	NA	Non-Systemic	NA	NA

*The above data was derived from the EPA registered direction rates of “technical grade” herbicide products based on the available “wholesale cost” of the chosen product(s).

All of the herbicides listed above are non-restricted pesticides based on current EPA registration(s). In some cases, an organic herbicide may not require EPA registration.

Please find additional data on Apiary toxicology issues at <http://www.ncagr.gov/pollinators/NCPollinatorProtection.htm>

Glossary of Chemical Terms and Activities, Including Possible “Unintended Consequences” Of Selected Synthetic and Organic Herbicides

Acetic Acid: Acetic Acid kills targeted weeds by the “corrosive removal” of the plant’s external cuticle followed by rapid desiccation and oxidation.

Analogue: A herbicide compound that is chemically parallel to those of the targeted plant.

Capric Acid: Is a saturated “fatty acid” compound.

Diquat: Diquat is a liquid fast acting “contact herbicide” that rapidly interferes with photosynthesis and damages cell walls.

Endothall: Endothall is a “contact herbicide” that prevents listed plants from making “essential proteins.”

Flouridone: Flouridone is an herbicide that is applied to a water body by diffusion. Flouridone inhibits the listed plants from producing protective chlorophyll, and this results in damage to the targeted plant from metabolic “over-heating.”

Glufosinate ammonium: Glufosinate ammonium is a systemic herbicide that kills the targeted plant by corroding and dissolving “external and internal” plant structures. The guard cells of the stomata are destroyed as well. As a result, the target plant dies as a result of gas exchange failure.

Glyphosate: Glyphosate is an analogue liquid “systemic herbicide” that inhibits the Shikimate-enzyme pathway from dispersing (amino-acids/proteins) to required regions of growth, resulting in starvation.

LD/50: The LD/50 rating of an herbicide indicates the Lethal Dose of an active ingredient that kills 50% of the targeted test animals based on a “milligram per kilogram ratio.” Male laboratory rats are usually the targeted test animal used to determine an LD/50 rating of a chemical.

Non-Targeted: Non-Targeted, refers to applying a herbicide to a plant that was not part of the planned weed control effort.

Non-Systemic: In the context of the IVM program, non-systemic means that the applied herbicide has primarily a “topical effect” and does not actively enter into the target plant’s vascular system.

Organic: Having the characteristics of; or derived from “living organisms.”

Procella: Aquatic herbicide. An EPA registered label has not been located at this time. Procella distribution is controlled by the manufacture, as a result labeling is not available to the public at this time.

Synthetic: Produced by “chemical synthesis.” Not derived from living organisms.

Systemic: In the context of the IVM program, systemic means that the applied herbicide has the ability to enter and move throughout the target plant’s vascular system.

Targeted: Targeted refers to the plant species that are part of the planned weed control effort.

Traffic Light (Pesticide Toxicity to Bees): A comprehensive collection of pesticides accessed for their influence on Apiary species. <http://www.ncagr.gov/pollinators/NCPollinatorProtection.htm>

Triclopyr: Triclopyr is an analogue liquid “systemic herbicide” that mimics the growth regulators of dicot plants and kills targeted weeds by over-loading them with synthetic auxin growth stimulation.

2,4-D: 2,4-D is an analogue herbicide that mimics plant “grown auxins” in various “broad-leafed” plant species. As a result, 2,4-D creates a highly accelerated rate of growth in selected broad-leafed weeds that is unsustainable. Currently it is believed that 2,4-D kills targeted plant species by over-loading them with auxin growth stimulation, resulting in injury caused by abnormal “cellular contortion and rupturing” of plant structures within the growing sections of vulnerable plants.