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 | **Sustainable Agriculture** | **Unit H** | **Integrated Pest Management** |
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| **ESSENTIAL STANDARD:** | **8.00** | **10%** |  | **Pest Management** |
| *Objective:* | *8.01* | *4%* | *C2* | Identify pests, diseases, and weeds that are prominent in agricultural production systems in North Carolina. |

1. Insects and Bugs-
	1. Insects
		1. 3 body fragments- can have wings and legs attached to thorax
		2. 6 legs
		3. Various mouthparts
			1. Toothed
			2. Siphoning (like a straw/proboscis)
			3. Rasping sucking (break skin of leaf)
			4. Piercing sucking (like a needle)
		4. Various life cycles
			1. Complete- egg, larva, pupa, adult
			2. Incomplete- egg, nymph, adult
	2. Bugs
		1. A bug is defined by most as something that is not an insect but maybe small with multiple legs
		2. Examples can include:
			1. Arachnids (spiders)
			2. Arthrpods
	3. Greenhouse
		1. Aphid- small wingless or winged creature that is light green to dark colored. Known as plant lice. Secretes a sticky material called “honeydew” that attracts ants. Pierces and sucks sap. Transmits disease. Can reproduce asexually and explode in population quickly.
		2. Mealybug- small wingless creature that resembles a powder or cottony material. Does not fly but is found in the axils of the leaf and stem. Secretes a sticky substance that can grow a black fungus called “smut.” Piercing and sucking mouthpart.
		3. Thrip- extremely small flying insect that has a rasping-sucking mouthpart (chews and then sucks up the sap). Found on upper and underside of the leaves. Leaves tissue damage all over the leaf, resembles a gray or somewhat transparent look to leaf. Attracted to brightly colored flowers. Transmits disease. Can sometimes be felt on the skin of plant workers.
		4. Whitefly- very small, white, flying insect. Found most commonly on the undersides of leaves. When plant is disturbed, the little whitefly will come out. Piercing sucking mouthpart that is also a disease transmitter, called a vector.
		5. Spider Mites- extremely small bug (not a true insect) with eight legs. Pierces and sucks from the underside of the leaf. Will create a very small webbing when a plant is infested. Depletes the leaves of color.
	4. Livestock
		1. Flies- range in species. Can be vectors or parasitic. Can cause severe damage to the hide of an animal, leading to economic loss for leather products of livestock.
		2. Mosquitoes- disease transmission.
		3. Ticks (not a true insect)- an external, 8-legged parasite that transmits disease. Ranges in size and color.
	5. Agronomy and Horticulture
		1. Grasshopper- Chewing mouthparts that can devastate a crop. Jumping and flying leads to a widespread problem.
		2. Japanese Beetles and grubs- Adults and larvae cause a number of issues in crops. Their chewing mouthparts can devastate production. In addition, moles and voles will hunt the larvae (grubs) that live in the soil and be detrimental to soil and roots of crops.
		3. Tomato Hornworm- The larvae of this moth is large (the size of an adult finger when mature), green in color, and has a sharp horn. Their chewing mouthparts can remove hundreds of leaves a day.
		4. Slugs- not an insect but a mollusk. These are voracious eaters especially at night. Although they are slow, they remove entire plants or pieces of plants while growers sleep.
	6. Agroforestry
		1. Wooly Adelgid- a microscopic insect that attacks trees like Canadian Hemlocks. These insects are causing devastation to these trees around the country. Identified by small, white egg sacs that resemble tufts of cotton that cling to the undersides of the tree branches. It may inject a toxin into the tree sap and ultimately the tree loses its needles.
		2. Asian Longhorn Beetle- adult is distinctive with a long (1-1 ½”), black body and white spots, can have blue feet and long antennae. Adult and larva devastate trees by burrowing into the tree and eating the wood. Trees include: ash, birch, maple, chestnut and golden rain tree.
		3. Emerald Ash Borer- is a linear and slightly cylindrical, metallic green insect that is killing ash trees around the USA. It was imported from Asia to Michigan in 2002. During its larval stage the EAB feed on the conductive tissue of the tree, thus disturbing the transfer of water and nutrients and ultimately killing Ash trees.
		4. Gypsy Moth- from Europe and Asia brought to Boston. Most damage seems to impact dominant oak species through defoliation of trees. Larvae are very fuzzy or hairy and brown. They feed during the night and rest in bark crevices during the day.
		5. Caterpillars- those chewing insects are the larvae of moths and butterflies. The tentworm causes significant damage to various trees by defoliating branches and removing leaves that are needed for nutrient production (photosynthesis).
2. Mammals
	1. Greenhouse and Horticulture
		1. Moles and Voles- are small rodents. A mole is a mouse-like garden pest that inhabits the soil. Moles feed upon worms, grubs, and adult insects. Voles are mice that will eat the base of trees, shrubs, bulbs, and turfgrass (these are vegetarians unlike the carnivorous mole).
		2. Birds- Crows and other birds can cause damage on some crops. Although birds are wanted in the ecosystem for biodiversity, pollination and more, they must be kept from damaging crops. Framing or caging plants is an easy and ecofriendly way of keeping out feathered “foe.”
		3. Deer- one of the most deadly to plants. Deer are vegetarians and feast upon ornamental and food production plants. Fencing and repellants are some of the best ways to combat deer. In addition, harvesting deer through legal hunting is another method of control.
		4. Woodchucks- burrow under structures and eat plants of all shapes and sizes. Woodchucks can also be dangerous because of the damage they cause to the soil. Their dens and burrows can lead to soft pockets in the earth that a tractor tire can sink into and injure farm workers.
	2. Agronomy, Agroforestry, and Livestock
		1. Opossum- Opossums are rodent-like and can cause serious injury to poultry, mushrooms, fruits, vegetables, and grains. They are disease carriers and should be removed with care.
		2. Raccoon- These relatives of panda bears are nocturnal. They are known to prey upon poultry. They also cause severe damage to corn and other agronomic plantings. They are disease carriers and should be removed or handled with care.
		3. Fox- These furry, beautifully tailed creatures dominate in the evening. They are known for preying upon poultry, eggs, and rabbits. They are also disease carriers and should be removed or handled with care.
		4. Coyote and domestic dogs- These animals prey on big game, livestock, and poultry. Coyotes are the most common and serious predator of livestock in the US. They usually kill with a bite in the throat. They also have been known to cause damage to drip irrigation as they chew holes in plastic pipes. Domestic dogs are problematic to sheep and goats.
		5. Predatory birds- Hawks, owls, crows, gulls, and herons can kill other poultry, fish and an endless list of agronomic or agroforestry crops.
3. Diseases
	1. Horticulture
		1. Damping Off- A fungal disease that attacks the stem of seedlings and leaves the seedlings limp and lieing flat on the soil or media. Once damping off strikes it is untreatable. It can be prevented.
		2. Blight- A bacterial disease that attacks foliage and stems and often makes tips or pieces of the plant appear to be burned or necrotic.
		3. Botrytis- A fungal disease that causes a mold on foliage or fruit. Often associated with lack of circulation and warm temperatures. Particularly problematic in postharvest shipments, as well.
		4. Leaf Spot- A fungal or bacterial lesion found on leaves.
		5. Mildew- A fungal problem that attacks the plant and leaves a variety of films on the surface of the plants.
	2. Livestock
		1. Rabies- A fatal disease if no treatment is received. Behavioral changes and progressive paralysis leads to death. This can be spread through wildlife like raccoons, opossums and bats to livestock and ultimately humans.
		2. Bluetongue- Ruminant animals, like sheep, llamas, goats, and cattle are at risk. The mucus linings of the mouth and nose and the coronary band of the food change. This virus is caused by a type of biting midge.
		3. Foot and Mouth Disease- Cloven animals like sheep, cattle, pigs, and goats are at risk to this infectious virus. It causes fever, blisters (of the mouth and feet) and all animals ultimately appear very lame or have difficulty standing if they can at all.
		4. Bird flu- This impacts birds and is a highly contagious virus that impacts the respiratory, digestive, and/or nervous system. It may also pose a threat to people and other animals under certain circumstances.
	3. Agronomy
		1. Smut- A fungal disease that leaves blisters with black spores. Often found on corn.
		2. Rust- A fungal disease the causes red-orange colonies on stem and leaf tissue.
		3. Mosaic- A patchwork of green and yellow mottling that is found on stem and leaf tissue. A well-known type of mosaic is Tobacco Mosaic Virus (TMV) that can be spread by cigarette smokers to other plants, as well.
		4. Wilt- A bacterial disease that inhabits the translocation (movement) of water and nutrients in the vascular tissue (xylem and phloem) of the plant. This causes the plant to appear wilted regardless of water availability.
	4. Agroforestry
		1. Galls- Tumor-like growths that are often the result of insects laying eggs in plant tissue. A cancer then develops around the eggs and larvae from the hatched eggs will emerge from the gall.
		2. Canker Rot- A fungi that causes serious decay and cull in hardwoods, particularly oaks. Fungi will kill the heartwood, cambium, and sapwood.
		3. Anthracnose- A fungus that causes damage in various trees like the Dogwood. Found often in cool, wet spring and fall weather. Drought and winter injury weaken trees and increase disease severity. Consecutive years of the disease results in tree death.
		4. Slime- A bole or trunk rot that is observed on the external bark. The tree attempts to compartmentalize damage and makes a “weeping” sap from the rotting point. Weeping liquid (fermented sap) is alcohol based and toxic to new wood.
4. Weeds and Plants
	1. Horticulture and Agronomy
		1. Nutsedge- A sedge (grass-like plant) that is native to warm, water-logged soils and often indicates soils that are poor in drainage or irrigation is too frequent. Once established, they will tolerate normal irrigation or drought. Their leaves are thick and stiff and have a rhizome with a tuber below ground.
		2. Oxallis- A clover-like plant that inhabits greenhouses, nurseries, and gardens. Oxallis is often found in containers. It is rhizomotous and stoloniferous.
		3. Chickweed- A cool-season annual weed that has hairy or non-hairy leaves adorned with very small white flowers.
		4. Henbit- A cool-season annual weed with square stems and purple flowers. Part of the Labiatae family, it is a relative of coleus and mint.
		5. Pigweed- Erect summer annuals that germinate from seeds during late winter. Forms dense mats of glassy green leaves and light colored edges with pink or red stems.
		6. Kudzu- Part of the pea family, climbing perennial vines that are so aggressive it climbs over other plant material and shades it to the point of death. Kudzu spreads by stolons. It was originally introduced to farmers in the 1930’s as a way of treating and preventing soil erosion. Southern farmers were given eight dollars an hour to sow topsoil with the invasive vine.
	2. Livestock- poisonous plants
		1. Goat weed- Animals with white hair or skin have photosensitization. This leads to blistering and scabs on that area. If animals eat, move to area with little light.
		2. White Snake root- Leads to convulsions and death in all livestock, pungent odor in breath.
			1. Death in 2-3 days for cattle and horses
			2. Nursing calves can be poisoned through milk (dangerous to humans, as well, killed Abraham Lincoln’s mother “milk sickness”)
			3. Lactating animals should be milked and milk thrown away.
			4. Treat with nutrients and fluids.
		3. Nightshade- When ingested there are gastrointestinal and nervous signs (narcosis, diarrhea, death by respiratory paralysis). Treat with atropine and fast acting laxative.
		4. Carolina Jessamine- One of the most poisonous in North Carolina. Known to kill young honeybees, as well.
			1. Abortion in cows.
			2. Muscle limpness and “limp neck” in turkeys.
			3. Slow breathing and dilation of pupils.
			4. Strong coffee or tea for animal until veterinary help arrives. Morphine is said to be an antidote.
	3. Agroforestry
		1. Microstegium- Also known as Japanese stiltgrass is an annual grass adopted to low light levels and an invasive of the forest floor. Grows to 2-3 feet tall and is capable of rooting at each node. Commonly invades along roads and both disturbed and undisturbed habitat.
		2. Smilax- Also known as Catbrier, a very tough, perennial vine with prickles (thorn-like outgrowths on the stems) and waxy, heart shaped leaves. Vines have berries that birds enjoy. Has extremely woody and tough rhizomes and a deep tap root.
		3. Tree of Heaven- A deciduous tree that may reach 80 feet tall and 6 feet wide. It has compound leaves that smell like peanut butter when crushed. Rapid growing and spread by wind and water.

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 | **Sustainable Agriculture** | **Unit H** | **Integrated Pest Management** |
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| **ESSENTIAL STANDARD:** | **8.00** | **10%** |  | **Pest Management** |
| *Objective:* | *8.02* | *6%* | *C3* | Apply appropriate techniques and technologies to minimize the incidences of pests, diseases, and weeds in sustainable agriculture. |

1. IPM- Integrated Pest Management is an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices.
	1. Goals of using IPM
		1. Increase farm profitability
		2. Improve environmental quality
		3. Improve public image of agriculture
	2. Why practice IPM?
		1. Saves money
		2. Pesticides can be ineffective
		3. Keeps a healthy and balanced ecosystem
		4. Provides a good image/marketing for a farm
2. Components of IPM program
	1. Initial information gathering- obtain an identification of the pest and problem.
		1. What is the pest?
		2. Insect, weed, disease, animal, or cultural issue?
	2. Monitoring- Observe the livestock, crop, or agroforestry site at regular intervals.
		1. Scout and keep records of what is found
		2. Check for changes to the target organism as well as its surroundings
	3. Establish injury and threshold levels
		1. What can the grower tolerate and still make a profit?
		2. Is there enough of a pest problem that action must be taken?
	4. Record-keeping
		1. Keep records of what is seen, decisions that are made, actions that are taken and results
		2. Record all interactions
	5. Employ least-toxic treatments first
		1. Select pest management approaches and specific methods according to the selected criteria
		2. Prevention is always better than treatment
		3. Criteria for selecting treatment strategies
			1. Least-disruptive of natural controls
			2. Least-toxic to human health
			3. Least-toxic to non-target organisms
			4. Most likely to produce a permanent reduction in the environment’s ability to support that pest
			5. Most cost-effective in the short and long term
	6. Evaluation
		1. Inspect after treatment action has been taken
		2. Reflect and record
3. Tactics of an IPM program
	1. Scouting and monitoring- Scouting a routine and systematic way to gather information and pests and crops. Monitoring of pests can be done through:
		1. Sticky traps
		2. Hand-lens
		3. Maps of spaces
		4. Trained personal
		5. Support labs for diagnosis
		6. Resource information
		7. Field microscope
		8. Soil thermometer
		9. Flagging tape and colored flags
		10. Record-keeping system
	2. Biological
		1. Use of natural enemies- predators, parasites, pathogens, and competitors
			1. Insects
				1. Carnivores that will prey upon other insects. These insects usually have chewing mouthparts like: Praying Mantis, Green Lacewing Bugs, and Lady Bugs.
				2. Use banker plants. These are a self- contained sustainable system that supplies a non-pest prey species to support a continual source of natural enemies that disperse into the crop in search of other pests. They are a mini-rearing system for the natural enemy.

Example would be an ornamental pepper plant placed in a greenhouse with some of the unwanted pest and several of the parasitic beneficial insects

This plant can also be something that attracts the pest, example would be a petunia for thrips or marigolds for spider mites

* + - 1. Fungus- some beneficial fungi can attack insects and kill them.
			2. Parasitic Wasps- lay eggs on other pests. Eggs hatch and kill the host organism.
			3. Parasitic Mites- lay eggs in other mites. Eggs hatch and kill the host organism.
			4. Birds- eat insects (larvae and adult stages).
			5. Mammals
				1. Cats and some dogs can be used around greenhouses and fields to help control the population of vermin (rats, mice, and moles).
				2. Humans can harvest through controlled practices of hunting the selection and removal of deer, nuisance coyotes, and other mammals.
				3. Natural predators (like coyotes, bears, and wolves) of deer, woodchucks, opossums and raccoons can be used to control nuisance mammalian pests.
		1. Animals employed to control weeds
			1. Goats and geese have been heavily employed by farmers and agroforesters and horticulturists alike to control invasive species like kudzu in areas where agricultural production is wanted.
			2. Goats can be brought in by various goat farmers and allowed to graze for hours, a day, or what is ever needed to clear an area.
			3. Goats are selective in their eating habits and will not remove every plant, but they do remove most.
	1. Chemical pesticides
		1. Selected and applied only when needed and in a way that is most effective.
		2. Insects, Mammals, and Plants
			1. Stomach- organism eats the material and it attacks the pest’s system leading to death of pest.
			2. Contact- chemical is sprayed directly on the pest organism and kills it.
			3. Systemic- chemical is inside of a food source for the pest organism. The pest ingests the food source with the poison and it kills the pest.
			4. Bait stations- lure in insects or mammals to kill only the target pest.
			5. Growth Regulators- used on insects and plants to change or prevent growth.
		3. Diseases
			1. Fungicides- Used to kill fungus.
				1. Bleach- not suggested for use around many living organisms (plants, animals)
				2. Peroxides are often used and is considered organic
				3. Copper can be used to kill fungus and is also an organic option
		4. Weeds
			1. Herbicide- kills or prevents plant growth
			2. Selective- kills only certain types of vegetation
			3. Non-selective- kills all vegetation
			4. Pre-emergent- prevents seeds from germinating
			5. Post emergent- attacks seedlings and adult plant material
			6. Organic and inorganic- organic is from once living materials and inorganic is a synthetic or entirely human made herbicide
			7. Spot-spray- apply to a few weeds instead of an entire area
	2. Cultural
		1. Practices that reduce pest establishment, reproduction, dispersal and survival
		2. Plant health
			1. Proper nutrition
			2. Proper planting techniques
			3. Proper timing
			4. Proper irrigation techniques and management
			5. Use plants with superior genetics
		3. Combatting insects
			1. Washing and disinfecting
			2. Wearing gloves
			3. Removing dead, damaged, and diseased plants
			4. Disinfecting person before entering agricultural area (prevents spread of new insects into the space)
		4. Mammals
			1. Remove breeding grounds
			2. Remove food sources
			3. Keep areas clean
		5. Diseases
			1. Space plants
			2. Increase air circulation
			3. Reduce irrigation applications
			4. Water plants in the morning, not after 3pm when possible
			5. Keep animals properly fed and watered
			6. Crop rotation
		6. Weeds
			1. Use irrigation practices that encourage plant growth only where watered, fewer weeds to pick
			2. Planting a cover crop or living mulch beneath the target plant to reduce weed population (example would be strawberries or squash)
	3. Mechanical and Physical Controls
		1. Kill a pest directly or make the environment unsuitable for it to survive
		2. Insects
			1. Screens
			2. Traps
			3. Mulch
		3. Mammals
			1. Traps
			2. Human harvesting (hunting)
		4. Diseases
			1. Increase fan circulation
			2. Run cooler temperatures or use shade cloths to help lower the temperature.
			3. Soil sterilization- using the heat from the sun and a plastic cover over the soil to “cook” the pathogens
			4. Exclusion and quarantine
		5. Weeds
			1. Pick and pull weeds
			2. Suffocating weeds with a layer of cardboard
			3. Mulch
			4. Plasticulture- growing plants with plastic as a mulching material
			5. Flaming of weeds- use a propane tank and flash with a flame to kill.
			6. Plant cover crops to suppress other weed populations.
			7. Soil sterilization- using the heat from the sun and a plastic cover over the soil to “cook” the weeds
	4. Natural
		1. Topographic controls
			1. Mountains and hills
			2. Bodies of water: lakes, ponds, rivers, and creeks. These make it difficult for animals to cross or for weeds and diseases to travel over.
			3. Tree or large shrub barriers and screens. Placing a barrier or border of trees and shrubs around a crop or landscape can help to detour pests from getting in.
		2. Climatic factors
			1. Wind
			2. Rain
			3. Snow
			4. Wind
			5. Drought
			6. Sunshine
		3. Most natural forms of pest control in the IPM were already in place or were there as the land had formed. Some of the forms can be planted or placed by man.
	5. Genetic (often considered part of cultural)
		1. Insects: Using insect resistant varieties like Bt Corn.
		2. Mammals: Breeding in animals to make them more resistant or tougher for an area being farmed. Kiko goats and Boer goats have superior genetics for North Carolina goat meat production.
		3. Diseases: Use plants that have disease resistance. The Mountain Series of tomatoes have been bred to withstand the tough pathogens of North Carolina. They were developed at the Fletcher Extension Research Station with NCSU.
		4. Weeds: Fight weeds with plants that can out compete weeds. Cover crops like Tillage Radish® is a cover crop that produces a dense canopy of foliar growth for the fall and winter and will yield a less weedy seedbed in early spring.
	6. Quarantine or eradication
		1. Government agencies regulate quarantine and eradication programs (federal and state laws to prevent the introduction or movement of pests)
		2. Quarantine is a program to prevent the entry into pest free areas
			1. Often at borders and in airports or areas with customs persons and cargo is examined for agricultural pests
			2. People are not permitted in North Carolina to move firewood to prevent the spread of the Emerald Ash Borer
		3. Eradication is the total elimination of a pest from an area
			1. The cotton boll weevil was eradicated due to a federal law that only certain persons can grow cotton and must have a permit to do so
			2. A homeowner or a garden center may not grow or sell cotton plants. This is illegal and the intention is to ensure that the cotton boll weevil does not become a problem in areas all over the United States.