

## **3E453 – Pest Management Journeyman**

### **Module 2, Lesson 1, Task 1 (8.3.1 & 8.3.2) Animal and Plant Biology**

#### **Slide 1.1 – Introductory Slide**

#### **Slide 1.2 – Lesson Title Slide**

3E4X3 Career Development Course

8.3.1 & 8.3.2 Animal and Plant Biology

#### **Slide 1.3 – Instructions**

Welcome to the Animal and Plant Biology lesson.

- Upon completion of this lesson, you must be able to successfully identify basic facts and principles about Animal and Plant Biology with at least a 75% accuracy.

#### **Overview**

In this section, we will cover the following topics:

- Overview of Biology
- Taxonomy Classification
- Classes of Arthropods
- Morphology
- Physical Characteristics of Animals or Insects
- Insect Physiology
- Insect Life Cycles
- Insects and Temperatures
- Insect Communication
- Sociality in Insects
- Plant Biology
- Different Plant Types
- Plant Anatomy
- Plant Reproduction
- Plant Development
- Plant Nutrition
- Plant Life Cycles

#### **Slide 2.1 – Overview Intro**

## **Slide 2.2 – Overview**

- Video Closed Captions

Ever since the first human swatted a housefly, man has been in contact with a variety of insects and other pests. The estimated number of insect species throughout the world ranges between 2 million and 10 million. Yes, there are way too many insects and too few entomologists. As a pest management journeyman, you do not need to know all of these species. However, these insects share certain traits and characteristics that will help you generalize the remaining species. Entomology is the study of these traits and characteristics. With this knowledge, you are in a better position to protect the health and even the survival of your fellow Airman. In this unit, we will describe the basic principles of pest management that apply to practically any pest management operation. Keep in mind, some pest management operations in the military may differ due to local combat mission and/or worldwide commitments.

## **Slide 2.3 – Takeaways**

- The estimated number of insect species throughout the world ranges between 2 million and 10 million
- As a pest management journeyman, you do not need to know all of these species
- These insects share certain traits and characteristics that will help you generalize the remaining species
- Entomology is the study of these traits and characteristics
- With this knowledge, you are in a better position to protect the health and even the survival of your fellow Airmen
- Some pest management operations in the military may differ due to local combat mission and/or worldwide commitments
- The basis for our lessons is the Headquarters Air Civil Engineer Support Agency's, Air Force Pest Management Handbook, Chapter 2, "Entomology Basic to Pest Management"

## **Slide 2.4 – Overview of Biology**

- Many insect, plant, vertebrate, and related pest species can seriously affect military operations by spreading disease, reducing the efficiency of military personnel, or destroying property.
- To clearly understand the methods of reducing the potential for such adverse results, you must have a basic knowledge of the pests you may encounter.
- You will find that military organizations often use terms that are from applied biology or entomology to describe pest management efforts.
- The reason for this is that operations are much broader than just the field of entomology
- These operations often involve other pests such as bats, birds, rodents, snails, snakes, and miscellaneous small animals.
- The term applied biology more correctly describes the range of pests encountered in military pest management work. Although this is true, insects and related arthropods make up most of the pest problems you will encounter; thus, this lesson emphasizes these.

## **Slide 3.1 – Taxonomy Classification Intro**

## Slide 3.2 – Taxonomy Classification

- Kingdom / Orders
  - The plant kingdom includes organisms that are characteristically immobile; they take in organic foods, possess chlorophyll, and have cell walls in addition to cell membranes.
  - The animal kingdom consists of free-moving organisms that generally assimilate organic foods, very rarely possess chlorophyll, have cell membranes, and lack cell walls.
  - The genus and species names of any given organism make up the scientific name for that specific organism.
  - Classification of the animal kingdom is based primarily on structural characteristics
  - They include kingdom, phylum, classes, orders, families, genera, and species
  - Genus and species names should always be printed in italics or underlined
- Scientific VS. Common Names
  - Although we may not use the scientific names in our daily conversation, scientific names are extremely important in pest management work because we must properly identify the pest.
  - Insects that are well known also will have a common name
  - For example:
    - German cockroach
    - Scientific name – *Blattella germanica*
    - Common name – German cockroach
  - Common names may vary dependent on the area or region the insect is prevalent
  - “Pillbug”, “potato bug”, and “roly-poly” are all common names for the *Armadillidium vulgare*
- Phylum
  - All insects including spiders, scorpions, ticks, mites, isopods, crustaceans, centipedes, millipedes, and other related animals belong to the phylum Arthropoda
  - Arthropoda in Greek means “jointed legs” and refers to the segmentation found on all arthropod legs
  - Arthropods have bilateral symmetry
  - The tendency to classify is inherent to humans
  - There are classifications for the types of people we associate with, the types of foods we eat, and even the clothes we wear
  - This ability to associate objects or ideas which are alike and to differentiate the unlike is a valuable attribute used to advance science and knowledge.
  - In simple terms, classification is a means used to sort and arrange things into related groups according to some logical system.
  - Every species of plant and animal has its own unique set of habits, capabilities, and forms
  - To determine whether a specimen belongs to a significant pest species, we mainly refer to its external characteristics
  - These include: Kingdom

## **Slide 4.1 – Classes of Arthropods Intro**

### **Slide 4.2 – Classes of Arthropods**

- Insects (Superclass Hexapoda, Class Insecta)
  - Six legs in three pairs
  - Three body regions: head, thorax, and abdomen
  - One or two pairs of wings; sometimes absent
  - One pair of antennae
  - Mostly terrestrial or freshwater, some marine
- Millipedes (Class Diplopoda)
  - Many legs; two pairs on most body segments
  - Wormlike cylindrical body segments
  - One pair of antennae
  - Terrestrial
- Spiders, Scorpions, Mites, Ticks (Class Arachnida)
  - Eight legs in four pairs
  - One or two body regions; if two the front is called a cephalothorax (head & chest), and the back, the abdomen
  - No antennae
  - Considered insect-like; not true insects because they do not have a head, thorax, abdomen and six legs
- Centipedes (Class Chilopoda)
  - Many legs; one pair on most body segments
  - Wormlike shape with flattened body
  - One pair of antennae
  - Characteristics in their exoskeletons, segmented bodies, and segmented legs
- Sowbugs, Pillbugs, Crayfish, Crabs (Class Crustacea)
  - 10 or more legs in pairs
  - Two body regions, called cephalothorax and abdomen
  - Two pairs of antennae
  - Mostly marine, some freshwater and terrestrial

## **Slide 5.1 – Morphology Intro**

### **Slide 5.2 – Morphology**

- DEFINITION:
  - Morphology is the study of the external form and structure of a living organism.
    - Insect morphology is useful in pest management because it allows pest managers to recognize differences and similarities among insects.
    - The study of morphology involves learning the different parts and names of an insect which can then be used in reference guides for identification and control procedures.

### **Slide 5.3 – Morphology**

Most insects develop through a process called metamorphosis. All insects share the following characteristics which include:

1. Two Antennae

2. Head
  - a. Mouth Parts
  - b. Antennae
  - c. Eyes
3. Abdomen
4. Thorax
  - a. Legs
  - b. Wings
5. Chitinous Exoskeleton
6. Legs

## **Slide 6.1 – Physical Characteristics of Animals or Insects Intro**

### **Slide 6.2 – Exoskeleton**

- The external skeleton of an animal or insect
- Protects and supports the insect's large organs, provides a framework for the attachment of muscles, and also helps to retain moisture within the body
- Often referred to as the cuticle, the exoskeleton gets its strength from a strong, resilient material called chitin
- Chitin consists of linked polysaccharides which are chains of sugars arranged in microscopic fibers
- These fibers run parallel to the surface of the exoskeleton and are stacked in layers like plywood which create a strong suit of armor for an insect
- The exoskeleton is waterproof from waxes that ooze out of the insect's surface through pores from the special glands below the cuticle
- Cuticle waterproofing is extremely important for insects; if an insect is exposed to dry environments it could easily harm them
- As insects grow, their exoskeletons do not stretch or expand so they must go through a process called molting
- Molting is the process of shedding and replacing their old skeletons with new, larger ones to grow into
- As insects molt they produce more chitin to develop their new hardened exoskeleton
- Different species of insects go through different stages of molts which are called instars
- Many insects go through multiple instars throughout their life span

### **Slide 6.3 – Head Region**

- Home of the brain and center of sensory perception
- The antennae serve as the principal of smell
- The mouthparts are used for taste and feel of potential food
- Insects have four basic mouthparts: chewing, piercing-sucking, sponging, and siphoning
- CHEWING
  - Chewing mouthparts are for insects that eat solid foods
  - Crickets, termites, cockroaches, beetles, and mantids all have chewing mouthparts

- Insect's mouth parts go side to side as opposed to a human's jaw that goes up and down
- Mandibles do the grinding, and the maxillae, labrum, and labium are used to handle the food before being swallowed
- CHEWING
  - Appendages known as maxillary palpi and labial palpi assist in the feeding process and are used to taste, smell, and feel food
  - Some insects have a mouthpart structure containing the salivary channel; the insect has a tongue-like appendage called the hypopharynx
- PIERCING-SUCKING
  - Mosquitoes, bed bugs, stink bugs, fleas, and lice all have piercing-sucking mouthparts
  - Allows insects to pierce the skin of plants, animals, fruits, seeds, and other food sources and suck up their food source
  - Blood-sucking insects, sap feeders, and predatory insects may have piercing-sucking mouth pieces
  - Like the sponging-type mouthparts, this feeding tube is also called a proboscis
- SPONGING
  - Many fly species, including the house fly, works like a mop or sponge by soaking up the liquids
  - The sponging part on the mouth piece is called the labellum, which flies will spit or egest salivary enzymes onto solid food, which become liquefied due to the enzymes and then is mopped up by the labellum
- SPONGING
  - The labrum and the labium join to form a feeding tube called a proboscis; the proboscis has a spongy tip called the labellum
  - To help dissolve soluble solid foods, the fly regurgitates a droplet of saliva onto the food. It then pumps the dissolved food solution through the proboscis as a liquid
- SIPHONING
  - Adult moths and butterflies are equipped with siphoning mouthparts
  - Much like the piercing-sucking mouthparts of bed bugs, siphoning mouthparts consist of a hollow channel for liquid foods
  - These mouth parts do not pierce, but are more like a flexible straw solely used for sucking nectar from flowers or to reach other liquids
- ANTENNAE
  - Antennae are sensory glands used to detect odors, chemicals, vibrations, and other stimuli
  - Insects, millipedes, and centipedes have one pair of antennae while most crustaceans have two pairs of antennae; arachnids have no antennae
  - Insects' antennae are greatly modified and have a variety of shapes that are helpful for identification
- EYES

- Insects have two types of eyes—simple or compound
- Simple eyes, known as ocelli are located on top of the head
- They are used to detect differences in light intensity and not for detecting shapes and motion
- Compound eyes are made of multiple eye units called ommatidia
- EYES
  - Each ommatidia has its own lens and some insects may have several thousand ommatidia
  - Used to detect motion and provide a wide scope of vision
  - The number, shape, location, and size of the eyes are used in identifying specific insect species
  - Example: a carpenter bee has two large compound eyes and three simple eyes

## Slide 6.4 – Thorax

- THORAX
  - The thorax is the middle body region of an insect
  - This is the body region that is associated with movement due to the wings and legs being attached to the region
  - In larval stages of insects it may be hard to determine the thorax regions but if one is able to identify where the legs are attached you will find the true thorax
- LEGS
  - The legs of insects may be short and strong for digging or lengthened for jumping and walking
- LEGS
  - The true legs of all insects are composed of six segments:
    - coxa
    - trochanter
    - femur
    - tibia
    - tarsus
    - pretarsus
- LEGS
  - The femur and tibia correspond to the human thigh and shin and tarsus has a function similar to the human foot
  - Many tarsal segments have pads or pulvilli which help the insect walk on smooth surfaces like glass
- WINGS
  - Insects normally have two pair of wings
  - Insect wings come in various shapes and sizes that are extremely useful in identifying insects
  - Insects that do not have wings are considered “apterous”. (Like lice, fleas and bed bugs)
  - Many insects are named based on their wing characteristics
- WINGS

- The suffix “-ptera” comes from the Latin word for wing, and is frequently used in order names
  - Diptera- two wings
  - Hemiptera – half wings
  - Lepidoptera – scaly wings
- WINGS
  - Wings are membranous extensions of the body wall with an upper and lower layer supported by reinforcing structures called veins
  - Veins provide support and transport blood and oxygen to the wings
  - The pattern of veins in an insect wing is known as venation
- WINGS
  - True flies (Diptera) do not have a second pair of wings but possess small rudimentary knobs called “halters” or balancers
  - Halters do not provide lift like wings but assist the insect in flight by providing balance and orientation

### **Slide 6.5 – Abdomen**

- The abdomen is the part of an insect that contains most of the organs for reproduction, digestion, excretion, and defense
- Can be composed of up to 11 segments and the last few segments are considered the cerci
- The cerci may act as a sensory organ and be used as pincers or claspers during mating
- The final abdominal segment of most females bears the ovipositor which is where the eggs are laid
- The ovipositor in many insects acts as a defensive organ such as ants, bees, and wasps having stingers
- Only females have ovipositor and only females are capable of stinging

### **Slide 7.1 – Insect Physiology Intro**

#### **Slide 7.2 – Insect Physiology**

Physiology is the branch of biology dealing with the normal functions and vital processes of living organisms.

Understanding a pest’s physiology will help you determine effective management procedures as you work to minimize adverse effects on non-target and animals.

- Respiratory System
  - Insects do not have lungs; they have tiny holes on the sides of their bodies called spiracles, where they take in oxygen
  - The oxygen is distributed through a system of tubes called tracheae
  - The system also carries waste carbon dioxide from body tissue
  - An insect’s respiratory system can be exploited as a weak point in their defense system because oily pesticides can physically clog the spiracles
- Circulatory System
  - Insects do not have blood but they do have something similar called hemolymph
  - Unlike the blood found in mammals, hemolymph flows freely throughout the body



- The hemolymph is circulated by a pump (the heart) and carries nutrients, salts, and hormones throughout the insect's body
- Nervous System
  - Insects have a nervous system much like the ones found in higher animals
  - The brain is in the head above the esophagus and is connected to a sub-brain by two nerve cords encircling the esophagus
  - The double cord extends backwards along the ventral surface of the body cavity
  - Each segment for the thorax has a nerve center or thoracic ganglion from which many nerves arise to serve the thoracic region
- Digestive System
  - This system consists of a tube and an alimentary canal that runs from the mouth to the anus
  - The canal is divided into a foregut, midgut, and hindgut
  - As insects eat food, the food passes through the esophagus or throat to the crop, which is an enlarged portion of the foregut to store food
  - Some insects have a proventriculus, or gizzard, where food is ground into finer particles
  - The food then passes to the midgut where digestion takes place
  - Undigested food will then pass through the intestine to the anus
- Reproductive System
  - Most insects have relatively short lifespans, however the reproduction rate can be very quick and numbers will quickly become overwhelming
  - A single bed bug can lay as many as 200-500 eggs over her adult life
  - Most female insects mate only once in their lives but are able to lay eggs multiple times
  - Few insects (mites, aphids and booklice) are able to reproduce parthenogenitically, which means they do not require fertilization from males
  - This allows reproduction to happen even more quickly
  - All insects develop eggs
  - Insects that lay eggs are considered oviparous
  - Insects that give birth to living larvae are viviparous

### **Slide 8.1 – Insect Life Cycles Intro**

### **Slide 8.2 – Metamorphosis**

- Understanding the process of reproduction and development is vital; this allows the pest manager to pick a control method that will attack the specific developmental stage.
- All insects go through a process called metamorphosis, which is the series of changes an insect passes through from an egg to an adult.
- The four types of metamorphosis are: complete metamorphosis, incomplete metamorphosis, gradual metamorphosis, and no metamorphosis.

### **Slide 8.3 – Metamorphosis**

- Complete Metamorphosis
  - EGG > LARVAE > PUPA > ADULT

- Emerge from an egg as larva, which is a different appearance from adult stage
  - Caterpillars, maggots, and grubs are all larva
  - The larva go through usually three to six instars before transforming into the pupal stage
  - During the pupal stage the insect does not feed, is mostly inactive, and develops adult characteristics
  - Example: bees, wasps, ants, flies, fleas, moths, beetles
- Incomplete Metamorphosis
  - EGG > NAIADS > ADULT
    - Naiads have a different body structure and a completely different mode of life than the adults do
    - Naiads live and develop in water as compared to the adults who live on dry land and can fly
  - EXAMPLE: dragonfly
- Gradual Metamorphosis
  - EGG > NYMPH > ADULT
    - Insects change gradually while undergoing multiple instars
    - Nymphs resemble adults except for their smaller size and absence of wings in wing-bearing species
    - Nymphs lack reproductive organs
  - EXAMPLES: earwigs, grasshoppers, cockroaches, bed bugs
- No Metamorphosis
  - EGG > YOUNG > ADULT
    - The insect will possess obvious structure of the adult and only change in size, color, and sexual maturity
  - EXAMPLES: silverfish, firebrats, and springtails

### **Slide 9.1 – Insects and Temperatures Intro**

### **Slide 9.2 – Insects and Temperatures**

- Insects are cold-blooded which means their body temperature and metabolic rate is largely determined by the temperature of their environment
- Climate temperatures in the environment can play a major role for predicting growth and developmental times in insects as well as how quickly they can reproduce
- Generally, insect development slows down when the environmental temperatures are cooler and it speeds up when the ambient temperature is warmer
- EXAMPLE: German cockroach nymphs require 50-55 days to complete development at 77 degrees Fahrenheit, but only require 33 days at 86 degrees Fahrenheit
- Insects will adapt to survive and will adjust to living conditions to protect themselves from freezing, or overheating and drying out

### **Slide 10.1 – Insect Communication Intro**

### **Slide 10.2 – Insect Communication**

- Insects can use sound to communicate but their sense of hearing is very poor

- Instead, the main way to communicate is through scents; chemicals that adhere to surfaces or within the air can be used
- Insects produce their own scents called semiochemical which can be used to communicate
- The two main types of semiochemicals are pheromones and allelochemicals

### **Slide 10.3 – Insect Communication**

- Pheromones
  - Pheromones are chemical substances that are secreted by insects in order to influence the behavior of the same species
  - Alarm pheromones are used as warning signals
  - Trail pheromones are used to mark paths so other insects can find resources such as food
  - Sex pheromones are used to locate an acceptable mate
  - Aggregation pheromones help individuals find others of the same species
- Allelochemicals
  - Allelochemicals are substances that are emitted by one species to influence the behavior of another species
  - Allomones help emitter by repelling or harming other species
  - Kairomones benefit the receiving species but harm the emitter, perhaps by alerting a predator to the location of its prey
  - Pheromones are increasingly being used in traps and baits to manipulate insects by attracting them and being able to control the targeted species

### **Slide 11.1 – Sociality in Insects Intro**

### **Slide 11.2 – Sociality in Insects**

- Most insects are considered loners, even though they live in close proximity to others of their kind, their social interaction is minimal
- Insect parents normally die before their young are hatched or they move on after their eggs are laid and do not come back to care for their offspring
- Ants, termites, wasps, and bees are different though and are eusocial insects and have evolved complex social behaviors such as living together, building nests, gathering food, and cooperating in caring for their young
- Eusocial insects display the following:
  - Cooperate to care for their young
  - Have a distinct division of labor among the different castes in the colony or nest
  - At any given time, at least two generations are present and active
- INSECT CASTE SYSTEM
  - Each caste performs a specific function in the colony:
    - Queen - reproduction
    - Workers - care for young, find food and protect the colony
    - Drones - mate with queen

### **Slide 12.1 – Plant Biology Intro**

### **Slide 12.2 – Overview of Plant Biology**

- Plants use water, light energy, and carbon dioxide to synthesize sugar/nutrients that serve as food for various animals
- In addition to synthesizing their own food, plants in different environments (aquatic, terrestrial etc.) play an important role in the production of oxygen making them essential to all life on earth
- Photosynthesis is the process in which plants use the sun's energy, carbon dioxide, and nutrients to produce energy to live
- Photosynthesis takes place in the chlorophyll, which is the green parts of a plant
- If pest managers can understand the biology of what it takes for plants to survive, they can employ control tactics to ensure they do not have the required conditions to survive

### **Slide 13.1 – Overview Intro**

### **Slide 13.2 – Different Plant Groups**

- OVERVIEW
  - Angiosperms
  - Gymnosperms
  - Non-Vascular Plants
  - Ferns and Lycophytes

### **Slide 13.3 – Gymnosperms**

- Gymnosperms are seed-bearing vascular plants. These plants do not bear fruits. Please review the diagram to the left which outlines the reproductive anatomy of a gymnosperm.

### **Slide 13.4 – Angiosperms**

Angiosperms are plants that produce flowers and bear fruits. Over 200,000 plants belong to this category.

Please review the diagram below which outlines the reproductive anatomy of an angiosperm.

- Stamem
  - Anther
  - Filament
- Petal
- Sepal
- Receptacle
- Pedicel
- Stigma
- Style
- Ovary
- Pistil
  - Ovule
- Embryo
- Zygote

### **Slide 13.5 – Non-Vascular Plants**

- Non-vascular plants include liverworts, mosses, and hornworts. The majority of non-vascular plants are small in size and characterized by poor transport systems. Please

review the diagram to the left which outlines the reproductive anatomy of non-vascular plants.

### **Slide 13.6 – Ferns and Lycophytes**

- Ferns and lycophytes are characterized by organisms that have a vascular system but do not produce seeds and flowers and are not woody in nature. Please review the diagram to the left which outlines the reproductive anatomy of ferns and lycophytes.

### **Slide 14.1 – Plant Anatomy Intro**

### **Slide 14.2 – General Parts of a Plant**

- Video Closed Captions

Roots anchor the entire plant and take up water and minerals required for growth and development of the plant. The stem provides support for the shoot system. The leaves contain chlorophyll and chloroplasts and where photosynthesis occurs. And the waxy layer on the surface of the leaf is referred to as the cuticle.

### **Slide 14.3 – Takeaway**

- LEAVES
  - Contain chlorophyll and chloroplasts and where photosynthesis occurs
- STEMS
  - Provides support for the shoot system
- ROOTS
  - Anchor the entire plant and take up water and minerals required for growth and development of the plant
- CUTICLE
  - Waxy layer on the surface of the leaf

### **Slide 14.4 – Specific Parts of a Plant**

- CUTICLE - waxy layer on the surface of the leaf
- UPPER/LOWER EPIDERMIS - protective cells found on the upper and lower side of a leaf
- PALISADE CELLS - elongated cells located below the upper epidermis and above the lower epidermis
  - Contain chloroplast
  - Photosynthesis take place here
- STOMATES - special openings or pores on the lower side of the leaf
  - Used for gas and vapor transfers
  - The pore offers a direct connection between the outside air and the air spaces of the internal tissue
- GUARD CELLS - two specialized epidermal cells that surround the stomata pore
- XYLEM - one of the two distinct tissues that makes up the vascular system
- Conducts water throughout the plant
- PHLOEM - found alongside of the xylem that forms the vascular system of the plant
- Conducts sugar throughout the plant

### **Slide 15.1 – Plant Reproduction Intro**

### **Slide 15.2 – Plant Reproduction**

- Plant reproduction is dependent on the type of plant or their environmental conditions

- Some plants reproduce through cell division of the parent cell; others require the participation of male and female organs

### **Slide 15.3 – Asexual Reproduction**

- Produced by a single parent:
  - FISSION – reproduction which a cell divides to produce cells that resemble the parent cell
  - BUDDING – reproduction where an outgrowth produced from one side of the parent organism breaks off to form a new organism
  - FRAGMENTATION – fragments of an organism break off and form a new organism
  - SPORULATION – reproduction that occurs in non-flowering plants
  - VEGETATIVE REPRODUCTION - form of asexual reproduction where a new plantlet develops that is identical to the parent plant
- COMMON MODES OF REPRODUCTION:
  - BULBS- specialized root bud of some perennials
  - RHIZOMES- grow below the ground stem of creeping perennials that emerge from the soil to form a new plant
  - STOLONS - also known as runners, that grow above the ground stems of creeping perennials that form its own root system and becomes an independent plant
  - CUTTINGS - a stem taken from a perennial plant and grown to produce its own root system

### **Slide 15.4 – Sexual Reproduction**

- Form of reproduction that involves the formation of a zygote following fusion of male and female reproductive cells known as gametes
- In flowering plants, flowers serve as reproductive units of the plant
- Flowers consist of the following parts:
  - CALYX consists of sepals
  - COROLLA contains the petals
  - ANDROECIUM - consists the stamens (reproductive organs of the male)
  - PISTIL - consisting of carpels stigma (reproductive organs of the female)
- Sexual reproduction starts following pollination
  - POLLINATION - male gametes in pollen from the same flower or a different flower (same species) are transported to the stigma which is the female part of the flower
  - SELF-POLLINATION - pollen of a plant pollinates the flower of the same plant. On the other hand, in cross-pollination, pollen of a plant pollinates the flower of another plant of the same species
- Following pollination, the pollen grain grows a thin tube that runs down the style towards the ovary
  - At the same time, the cell located in the pollen grain undergoes division to produce two male cells (gametes) that travel through the pollen tube to reach the female gamete in the ovule of the ovary

- Fertilization occurs when one of the male gametes fuses with the female gamete in the ovule thus uniting the haploid chromosomes of the two. The result is a fertilized egg (zygote) that contains a complete pair of chromosomes (diploid).
- The other male gamete fuses with the secondary nucleus to form a triploid endosperm nucleus. This, in turn, develops into an endosperm which is the source of food for the embryo.
- The embryo develops to produce a seed (dicotyledonous or monocotyledonous) which can develop to form a new plant when conditions are favorable.
- Depending on the plant, seeds may be contained within the fruits
- In non-flowering plants like mosses, male and female structures are produced during plant development for sexual reproduction

### **Slide 16.1 – Plant Development Intro**

### **Slide 16.2 – Plant Development**

- Seedlings
- Vegetative
- Seed Production
- Maturity

### **Slide 16.3 – Seedlings**

- Seedlings are small, delicate plantlets. The seeds are very susceptible to herbicides due to its delicate state and inability to recover from being harmed.

### **Slide 16.4 – Vegetative**

- Vegetative is the fast-growing stage; this is where the stems, roots, and leaves are produced. The uptake and movement of water and nutrients are fast and thorough.

### **Slide 16.5 – Seed Production**

- Seed production energy is directed to producing the flowers and the seed, and uptake of water and nutrients is slow and is directed mainly to the flower, fruit, and seed structures.

### **Slide 16.6 – Maturity**

- A plant has reached maturity when there is little or no energy production in the plant and there is little movement of water and nutrients.

### **Slide 17.1 – Plant Nutrition Intro**

### **Slide 17.2 – Plant Nutrition**

- Provides needed nutrients to grow in an unnatural environment
- When properly fertilized:
  - Plants maintain good color, density, and vigor
  - Does not easily succumb to insects, weeds, or diseases
- Under-fertilized plants are much more susceptible to environmental stresses such as drought

### **Slide 17.3 – Plant Nutrition**

1. Healthy leaf – Magnesium deficiency
2. Phosphate deficiency – Drought
3. Potassium deficiency – Fire blight

#### 4. Nitrogen deficiency – Chemical degradation

##### **Slide 17.4 – Magnesium**

- A magnesium deficiency looks very similar to a lack of iron, with pale leaves instead of vibrant green. However, with magnesium deficiency, the veins inside the leaves will stay a shade or two darker and greener than the rest of the leaf.

##### **Slide 17.5 – Phosphorous**

- A phosphorus deficiency will also turn older leaves yellow, but often causes dead, dark brown spots around the edges of the leaves, as well. Left untreated, the plant will also begin to shed the affected leaves.

##### **Slide 17.6 – Potassium**

- Yellowing leaves are also the first sign of a potassium deficiency. However, the difference here is that the new growth is affected as well as mature leaves. There will also often be small brown spots around the leaf edges, particularly on the youngest leaves.

##### **Slide 17.7 – Potassium**

- Yellowing leaves are also the first sign of a potassium deficiency. However, the difference here is that the new growth is affected as well as mature leaves. There will also often be small brown spots around the leaf edges, particularly on the youngest leaves.

##### **Slide 17.8 – Plant Nutrition**

- Nitrogen
- Phosphorus
- Potassium

##### **Slide 17.9 – Nitrogen**

- Most important element that a lawn needs
- Promotes rapid shoot growth
- Gives lawn a healthy color
- It is the element most often in short supply
- When nitrogen is lacking, growth stops and the lawn becomes pale and yellowish

##### **Slide 17.10 – Potassium**

- Strengthens lawn grasses
- Enables grasses to withstand traffic, resist disease, and conserve water

##### **Slide 17.11 – Phosphorus**

- Stimulates the early formation and strong growth of the roots and it is needed in lawns in small quantities

##### **Slide 17.12 – Plant Nutrition**

- Soil potential of hydrogen (pH) generally varies from around 3.5 (very acidic) to 8.5 (alkaline). A reading of 7.0 is considered neutral and the optimum for most plants is 6.5. Less than 7.0 is considered acid and more than 7.0 is alkaline
- To raise pH levels add pulverized limestone; to lower pH levels add sulfur

##### **Slide 18.1 – Plant Life Cycles**



### **Slide 18.2 – Annuals**

- Annuals are plants that have a 1-year life cycle.
- They grow from seed, mature, and produce seed in 1 year or less.
- There are two types of annual plants:
  - Summer annuals are plants that grow from seeds in the spring.
    - They grow mature, produce seed, and die before winter.
    - Examples include: crabgrass, foxtail, and cocklebur
  - Winter annuals are plants that grow from seeds in the fall.
    - They grow, mature, produce seed, and die before summer.
    - Examples include: cheat henbit, and annual bluegrass

### **Slide 18.3 – Biennials**

- Biennials are plants with a 2-year life cycle
  - In the first year they grow from seed and develop a heavy root and compact cluster of leaves called a rosette.
  - In the second year, they mature, produce seed, and die.
  - Examples include: mullein, burdock, and bull thistle

### **Slide 18.4 – Perennials**

- Most perennials grow from a seed: many species also produce tubers, bulbs, rhizomes, or stolon.
- Examples include: Johnson grass, dandelion, and plantain

### **Slide 19.1 – Course Completion**

Congratulations, you have completed the animal and plant biology lesson. Please click complete lesson to receive credit.

## **3E453 – Pest Management Journeyman**

### **Module 2, Lesson 2, Task 1 (10.7.1, 10.7.3, 10.7.4) Ornamental Pests**

#### **Slide 1.1 – Introductory Slide**

#### **Slide 1.2 – Lesson Title Slide**

3E4X3 Career Development Course

10.7.1, 10.7.3, 10.7.4 Ornamental Pests

#### **Slide 1.3 – Instructions**

Welcome to the lesson on Ornamental Pests.

- Upon completion, and without reference, you must be able to identify the relationship of basic facts and state general principles about identification and survey control measures for ornamental pests with at least 75% accuracy.

#### **Overview**

In this section, we will cover the following topics:

- Overview
- Pest Identification
- Types of Defoliators
- Survey Measures
- Control Measures

#### **Slide 2.2 – Overview**

- A wide variety of insects and related pests attack ornamentals and shade trees.
- These pests differ in their habitats during their life cycles, feeding preferences, and reproductive habits.
- You can divide defoliators and ornamental pests into three categories based on the way these pests feed: chewing, boring, or sucking.
- Each group of pests has distinct damage characteristics that will help you determine the pest type and the corresponding survey and management technique.

#### **Slide 3.2 – Pest Identification**

- Ornamental Defoliators

- Some insects, like the Japanese beetle, defoliate their host plant by skeletonizing the leaves (the beetles eat the fleshy portion of the leaf but not the leaf venation).
- Webworms, leaf rollers, leaf tiers, and tent caterpillars defoliate plants by consuming all or portions of the leaves and needles.
- Heavy infestations of defoliating ornamental pests may completely strip foliage resulting in the premature death of the ornamental.
- General Characteristics
  - All defoliators have chewing mouthparts.
  - The name defoliator comes from the fact that these pests remove the foliage from the plants they are infesting.
  - These types of ornamental pests eat the plant tissue (e.g., leaves, flowers, buds, and twigs).
  - You can often see the damage caused by ornamental pests by noticing the uneven or broken margins on the leaves, skeletonization of the leaves, and leaf mining damage.
  - Chewing insects can be moth and/or butterfly larval forms (caterpillars), adult beetles or their larvae, plus various other groups of insect pests.
  - The damage caused ranges from leaf notching, leaf mining, leaf skeletonizing, to girdling; damage signs will help you in properly identifying the ornamental pest you are dealing with.

## **Slide 4.2 – Types of Defoliators**

- General Defoliators
- Skeletonizers
- Webbing, Leaf Rolling Defoliators
- Bagworms

## **Slide 4.3 – General Defoliators**

- Overview
  - Many insects that defoliate ornamentals and shade trees are general feeders infesting many different hosts.
  - The more important and abundant ones are caterpillars such as tufted caterpillars (white-marked tussock moths), fall cankerworms (inchworms, loopers, measuring worms), forest tent caterpillars, and sawflies.
  - The damage they cause is characterized by large ragged holes or notches chewed in leaves or needles.
- White-Marked Tussock Moth
  - *Orgyia leucostigma* - one of our more important shade tree pests.
  - The small larvae are leaf skeletonizers at first, but as they grow, they eat most of the leaf tissues except the larger veins.

- Full-grown larvae are about 1 inch long, with a bright red head and a white to yellowish body with a dark streak along the back.
- On the prothorax and eighth abdominal segment is a pair of slender, “pencil” tufts  $\frac{1}{8}$  to  $\frac{1}{2}$  inch long
- Short ( $\frac{1}{8}$  inch) glands are on the mid-back of the sixth and seventh abdominal segments
- Adult female moths are wingless with gray oval bodies; Males have ash-gray wings with darker, wavy, somewhat indistinct bands crossing the forewings.
- Wingspread is about  $1\frac{1}{4}$  inches.

#### **Slide 4.4 – Skeletonizers**

- Elm Leaf Beetle
  - The adult elm leaf beetle (*Xanthogaleruca luteola*), is about  $\frac{1}{4}$  inch long and light yellow to brownish green.
  - It has several black spots on the thorax and a somewhat indefinite black or slate-colored stripe on the outer edge of each wing cover.
  - It is considered one of the most destructive pests of elm trees in the United States (US).
  - Foliage of infested trees has a generally yellow appearance, with many leaves skeletonized. Larvae are slug-like, yellow, with black spots and stripes.
- Leaf and Needle Miners
  - Leaf mining insects eat the tissues between the upper and lower surfaces of leaves and needles.
  - On deciduous (leafy) trees, they produce blotchy or irregular winding mines, thus causing brown patches or blotches on leaves.
  - When numerous, they will kill leaves and disfigure the plant
  - On conifers (trees that produce cones), they hollow out needles, which eventually gives the tree a scorched, burned appearance.
  - Left uncontrolled, these pests will retard tree growth and even kill trees in severe cases.

#### **Slide 4.5 – Webbing, Leaf Rolling Defoliators**

- Many important pests of ornamentals and shade trees construct webbed tents on limbs and branches of host trees.
- Others enclose themselves within rolled leaves or leaves tied and webbed together.
- The large ugly webs of rolled and tied leaves, combined with foliage stripping activities by caterpillars, add to the unsightly appearance of damaged trees.
- Webbing, leafyting, and leaf-rolling defoliators include fall webworms, Eastern tent caterpillars, leaf tiers/leaf rollers, spruce budworms, and case-bearers (bagworms).
- The webs and inhabitants are present from about mid-summer until fall.
- Larvae never leave the webs; when they need more food, they enlarge the webs to enclose more leaves.

- Full-grown larvae are about 1 to 1½ inches long with body colors varying from pale yellow to gray or brown.
- Long (¾-inch) silky setae (spines, stiff hairs, bristles, or bristle-like appendages of an arthropod) arising in groups from black, orange, and yellow warts cover the body.
- Adult moths are medium-sized with stout bodies and a wingspan of ¾ to 1½ inches.
- Their color is generally pure white, or wings may be marked with one to many small brown or black spots.

#### **Slide 4.6 – Bagworms**

- Bagworms are caterpillars which live in a silken cocoon-like bag.
- The bag is constructed with bits of leaves or stems attached from the host plant.
- The bag is about 2 inches long.
- It is mainly a pest of shade trees, shrubs, hedges, and evergreens of all kinds.
- They prefer junipers, cedars, and deciduous.
- The caterpillar feeds and remains inside the bag through the pupal stage.
- The adult male emerges from the bag as a moth.

#### **Slide 4.7 – Ornamental Pests Menu**

- Japanese Beetle
- Gypsy Moth
- Fall Cankerworm
- Forest Tent Caterpillar
- Eastern Tent Caterpillar
- Aphids

#### **Slide 4.8 – Japanese Beetles**

- Adult Japanese beetles (*Popillia japonica*) are almost ½ inch long.
- They are shiny metallic-green with coppery-brown wing covers and have seven white dots along each side of the abdomen.
- Adult beetles appear in May or June and persist for about six weeks.
- They are known for their destructive attacks on berries, orchard fruits, garden crops, ornamentals, and shade trees.
- The grub life stage feeds on roots of grasses and various other plants from August through October and again in the early spring.
- When mature, the grubs are about 1 inch long. They occur in varying numbers from southern Maine south to South Carolina and west to Ohio and West Virginia, with isolated colonies in several other states west to the Mississippi River.

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#### **Slide 4.9 – Gypsy Moth**

- The gypsy moth (*Lymantria dispar*) is an imported insect and is one of the most serious pests of both evergreens and deciduous shade trees.

- The small, pale brown caterpillars strip leaves from affected trees in May or June.
- Just one or two very heavy infestations can completely kill tree stands.
- These caterpillars have long yellow and brown hair tufts protruding from their sides and five pairs of bluish tubercles followed by five pairs of reddish tubercles.
- Mature caterpillars are 2 inches long.
- Adult moths appear in July; females are buff-colored with irregular dark markings across the wings; males are slightly smaller and dark brown in appearance.
- Since only males are good fliers, these pests spread mainly by wind-blown larvae, egg masses on vehicles, and infested material shipped to new locations.
- A major effort was made in the 1960s and 1970s to quarantine the gypsy moth and keep it confined to the New England area.
- While this effort did slow its spread, the gypsy moth has gradually moved into most mid-Atlantic and mid-western states.

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### Slide 4.10 – Forest Tent Caterpillar

- During outbreaks, which usually occur at intervals of 10 to 15 years, the forest tent caterpillar (*Malacosoma disstria*) defoliates millions of acres of forest.
- Tent caterpillars rarely kill their deciduous hosts, even after successive annual defoliations, so branch killing and loss of woody growth is the main type of damage.
- Forest tent caterpillars are unlike other *Malacosoma* because they do not construct tents, they form silk mats on the larger branches and on the main tree trunk where the older larvae rest when they are not feeding.
- Preferred hosts are aspen, maple, gum and oak trees, but they will also attack birch, basswood, cherry, elm, alder, willow and hazel.
- Full-grown larvae are 2 to 2½ inches long, have a bluish to brownish body color with somewhat diamond-shaped white spots in the middle of the back of each segment.
- Two thin, broken yellow lines extend along each side
- Adult moths have a tan color and a wingspread of 1 to 1¾ inches.
- Each front wing has either two thin dark parallel lines or a single broad dark band crossing the middle.

### Slide 4.11 – Eastern Tent Caterpillar

- *Malacosoma americanum* constructs large thick webs in the forks and crotches of trees.
- Caterpillars do not feed within the tent but congregate there during the night or in rainy weather.
- They often attack wild cherry, apple, peach, and plum trees.
- They are found throughout most of the eastern US. Eggs pass the winter in a dark brown collar-like mass attached to and often encircling small twigs; hatching occurs in early spring as soon as leaves begin to unfold.
- Young caterpillars select a nearby limb crotch and construct a tent.
- Full grown larvae are about two inches long and thinly covered with soft light brown hairs.

- There is a white stripe down the back, bordered by reddish-brown and yellow lines.
- Adult moths are light brown with two whitish stripes running longitudinally across each forewing.
- Females mate and deposit eggs on twigs in early summer.
- There is only one generation per year, with the egg stage lasting about nine months.

#### **Slide 4.12 – Fall Cankerworm**

- The fall cankerworms (inchworms or loopers) occur in nearly all parts of the northern US and as far west as Montana and south to the Carolinas and Missouri.
- The adult male has a wing span of approximately 1 inch (31 mm); wings are light gray with pale markings.
- Female fall cankerworm moths are light gray and wingless.
- The female deposits eggs in flat clusters on twigs in late fall.
- The cylindrical eggs are gray with brown cap-like tops.
- Larvae emerge in spring as plants begin to bud.
- The caterpillars have a pale to dark green head capsule, which is frequently mottled with black.
- Bodies are about 1 inch long and vary in color from pale green to brown, black, or reddish-green and typically have pale lines running down the length of the body and a dark stripe on the back.
- Caterpillars have three pairs of prolegs (short rudimentary legs); one pair is quite small and barely visible.
- The caterpillars feed for a period of 4 to 5 weeks before pupating in the soil below the infested tree, then emerge in November to repeat the life cycle.

#### **Slide 4.13 – Aphids**

- Aphids are small, piercing-sucking insects that are common pests of many plant species.
- One species of aphid called “green bugs” began to cause extensive injury to Kentucky bluegrass on lawns.
- Green bugs can become a serious problem because of their rapid reproduction rate.
- Populations build up very quickly, and thousands of these aphids may be found per square foot.
- Green bugs insert their mouthparts into leaf tissue and suck sap from the phloem.
- Further damage is caused as salivary fluids destroy the leaf tissue surrounding the area that is pierced by the insect’s beak.
- Diagnosis is simple because of the large numbers of green bugs present on leaves when turf grass injury occurs

#### **Slide 5.2 – Survey Measures**

- Surveillance
  - Individual pest characteristics require that you use species-specific surveillance and management techniques

- Many insects feed on leaves and/or needles of ornamentals and shade trees and thus are called defoliators
- Some insects, like the Japanese beetle, defoliate their host plant by skeletonizing the leaves
- Pests such as webworms, leaf-tiers/leaf-rollers, and tent caterpillars defoliate plants by consuming parts or all of the leaves and needles
- Main Concepts
  - Accurately identify the ornamental plant species
    - Most insects and diseases are plant-specific
    - Correctly identifying the ornamental plant speeds up the identification of the ornamental pest
  - Look for deviations from the standard ornamental landscape plantings
    - Compare the infested plants with other similar plants, particularly those of the same species within a given location
    - Characteristic differences in color or growth may show signs of the problem source
    - Damage patterns that are not similar to each other are good indicators of insect pests and/or the presence of diseases
    - Standard damage over a large area (perhaps several ornamental plant species) typically indicates major environmental stressors caused by physical injury (mower/animal girdling, over-pruning), poor drainage, or weather (hot/cold)
  - Capture a landscape image from a macro point of view
    - Try to capture a photo from far away to see if you can view any difference amongst the landscape
    - Many times it is easier to see the damage or discoloration from afar
  - Analyze the plant's subsurface root system
    - Document the root color; the roots may indicate the problems
    - Brown roots are an indication that the soil is dry or has the presence of toxic chemicals
    - Black roots usually reflect overly wet soil or the presence of root-rotting organisms
  - Analyze the plant's trunk and branches
    - Examine the trunk thoroughly for girdling wounds caused by lawn mowers/weed eaters, weather-related (lightning strikes, wind damage, temperature and moisture extremes) or other environmental and mechanical stressors
    - Wounds provide entrances for disease causing organisms and wood-rotting organisms
    - Large defects may indicate a potentially unsafe tree that may collapse during the next weather-related incident and cause additional damage
  - Document the arrangement and general appearance of affected leaves
    - Dead leaves at the top of the tree are usually the result of environmental or mechanical root stressors



- Twisted or curled leaves may indicate viral infection, insect feeding, or exposure to herbicides
  - The size and color of the foliage may tell a great deal about the plant's condition—stunted or excessive growth, yellowing of the leaves, or wilting
  - Make note of these and any other deviations from the norm for the ornamental species you are surveying
- Specific Procedures
  - Locate the infested ornamental plants or trees
  - Look for evidence of an infestation:
  - Japanese Beetles
    - Look for plants that may be completely defoliated
    - Leaves will have a skeletonized appearance
  - Bagworms
    - Look for silken cases or bags around tree tips and on facilities
  - Fall Webworms
    - First thing to look for are large webs over ends of branches on trees and shrubs
    - Trees may be fully defoliated in years of high caterpillar population
  - Eastern Tent Caterpillar
    - Look for webbing in the forks of the tree
  - Look for live pests
    - Adults can be seen during flight on leaves and branches
    - Larva will be seen on or around the plant
  - Once you have positively identified the ornamental pest species, determine control measures

## **Slide 6.2 – Structure of Matter**

- Elm Leaf Beetle Management
  - ELM LEAF BEETLE MANAGEMENT
    - Leaf beetles are easily managed with several insecticidal sprays or dusts.
    - Repeated applications may be necessary.
    - Follow product label directions and/or consult with your major command (MAJCOM) pest management consultant for specific recommendations during large-scale elm leaf beetle operations.
- Leaf & Needle Miner Management
  - LEAF AND NEEDLE MINER MANAGEMENT
    - Leaf and needle miners are difficult to control because they are concealed between the layers of the leaf.
    - Insecticidal sprays can be effective if coverage is thorough and repeat treatments are made when necessary.
    - You can control light infestations by hand-picking needles or twigs from the tree.

- General Defoliator Management
  - GENERAL DEFOLIATOR MANAGEMENT
    - Control general defoliators with insecticidal sprays, provided they are applied when the pests are vulnerable.
    - Polyhedral virus (biological insecticide) sprays readily control some species.
    - For gypsy moths, pheromone traps combined with insecticides or insect growth regulators and barriers of tacky materials placed on tree trunks can be effective for individual tree protection but are not practical for large-area management.
    - Focus your fall cankerworm controls on trapping the wingless females and/or spraying the active larvae once they start feeding on foliage.
    - Insecticidal suspensions containing a sticker/spreader are highly effective at controlling general defoliators.
- Webbing, Leaf-tying, Leaf-Rolling Defoliator, and Bagworm Management
  - WEBBING, LEAF-TYING, LEAF-ROLLING DEFOLIATOR, AND BAGWORM MANAGEMENT
    - Insects in webbed tents and in rolled or tied leaves usually can be managed by conventional insecticidal sprays as well as biological pesticides, such as *Bacillus Thuringiensis Israelis* (Bti).
    - Cultural and mechanical methods also are useful when infestations are confined to single limbs or branches on individual trees.
    - Not planting wild cherry trees, a preferred host of the eastern tent caterpillar, helps reduce this pest's population.
    - You can control these caterpillars together with leaftiers and leaf rollers by removing twigs and other plant debris in the fall.
    - Prune off and destroy caterpillar tents on trees or burn them in place.
    - Remove and destroy rolled and tied leaves to effectively manage light infestations on individual ornamental and shade trees or burn them in place.
    - Another option is for you to use pheromone traps to capture adult Tortricid moths.
    - Manage small populations of bagworms by hand-picking bags from affected hosts.
    - If this is not feasible, use pesticide sprays but only in the spring and early summer months when vulnerable larvae are feeding and exposed without bags.
    - Bti sprays are also effective against bagworms, tent caterpillars, and other caterpillars, which become diseased as they feed.
    - Cutworm management involves the use of simple preventive techniques and some chemical controls.
    - Preventive measures include rotating the soil and/or removing excess debris from the base of ornamental plantings—weeds and plant leaf litter to starve developing larvae.

- For small infestations, hand-pick caterpillars after dark.
- Handpick following a good rain or after thoroughly watering.
- Biological controls include the use of beneficial nematodes
- Use Trichogramma wasps to parasitize cutworm eggs/larvae.
- Diatomaceous earth sprinkled around the base of ornamental plants is also very effective.
- Focus your cutworm pesticidal control operations to late afternoon or evening treatments when the cutworms are actively feeding.

### **Slide 7.1 – Course Completion**

Congratulations, you have completed the ornamental pests lesson. Please click complete lesson to receive credit.

## **3E453 – Pest Management Journeyman**

### **Module 2, Lesson 3, Task 1 (10.8.1, 10.8.3, 10.8.4) Identify, Survey, & Control Measures**

#### **Slide 1.1 – Introductory Slide**

#### **Slide 1.2 – Lesson Title Slide**

3E4X3 Career Development Course

10.8.1, 10.8.3, 10.8.4 Identify, Survey, & Control Measures

#### **Slide 1.3 – Instructions**

Welcome to the Identify, Survey, & Control Measures lesson.

Upon completion of this lesson, you must be able to successfully identify basic facts and principles about Identify, Survey, & Control Measures with at least a 75% accuracy.

#### **Overview**

In this section, we will cover the following topics:

- Overview
- Common Turf Pests
- Survey Principles, Ornamental Pests
- Control Measures, Ornamental Pests

#### **Slide 2.1 – Turf Pests Overview Intro**

#### **Slide 2.2 – Turf Pests Overview**

- Insects and other pests often attack turf, damaging or even killing it
- We group many pests that destroy lawns and other grasses such as living in the soil or feeding on plant roots
- Others live above ground and feed on leaves and stems and survive by feeding on plant juices
- How seriously turf grass is injured by insects depends primarily on the size of the insect population present in the turf area

#### **Slide 3.1 – Common Turf Pests Intro**

#### **Slide 3.2 – Common Turf Pests - Grubs**

- GRUBS
  - Grubs are the larvae of beetles.

- Species can be identified by examining the arrangement of the hairs or spines on the grub's raster
- The majority of grubs that injure turf grass have one-year life cycles
- Weather affects grub populations.
  - Severe summer droughts with extremely dry soil causes many eggs to desiccate and be destroyed
  - Unusually cool summer weather can result in a decrease in mating and egg laying
  - Extremely wet soil conditions can contribute to disease
  - A deep frost can impact overwintering larvae
  - Grubs have chewing mouthparts and are capable of causing extensive damage to the turf grass root system
- When turf grass suffers severe root loss because of grubs, the plants wilt, turn yellow or brown, and eventually die.
  - A quick survey for grub infestation can be accomplished by cutting into the turf with a spade and examining the root zone
  - When the grub population averages more than 5 to 10 per square foot, insecticide treatment may be necessary
- Grub damage is most evident during the spring (April and May) and fall (September to November).
  - Insecticides are most effective in July and August when the young larvae have recently hatched out
  - Grubs become less susceptible to insecticides as they mature

### **Slide 3.3 – Common Turf Pests – White Grubs**

- WHITE GRUB
  - Grubs are the larva of many kinds of beetles which include the June and Japanese beetles
  - Most are white or gray with brown heads and dark hind parts
  - 1 & 1/2 inches long when fully grown
  - They have three pairs of legs, which distinguishes them from the legless billbug grub
  - Usually curled in a C shape
  - Grubs feed beneath the soil on the roots of grasses

### **Slide 3.4 – Common Turf Pests – Billbugs**

- BILLBUGS
  - Adult billbugs are weevils that are 1/5 to 3/8 inch in length
  - Vary in color from reddish-brown to black and have long snouts, the tip of which is equipped with a strong pair of mandibles
  - Head, thorax, and snout are almost as long as their wing covers
  - Adults burrow into grass stems and certain plant leaves for food
  - Females also deposit eggs in grass stems
  - Head, thorax, and snout are almost as long as their wing covers
  - Adults burrow into grass stems and certain plant leaves for food

- Females also deposit eggs in grass stems

### **Slide 3.5 – Common Turf Pests – Mole Crickets**

- MOLE CRICKETS
  - Possess three pairs of legs, have a three-segmented body, and a set of antennae
  - Their forelegs are modified for digging through the soil and resemble the front legs of a mole
  - Have cylindrical bodies about 1 ½-2 inches long
  - Head, thorax, and snout are almost as long as their wing covers
  - Adults burrow into grass stems and certain plant leaves for food
  - Females also deposit eggs in grass stems
  - Turfgrass may wilt and dry out because of mole crickets' root feeding and tunneling
    - As they burrow through the soil, plants can be uprooted
    - Damage can be severe, especially on newly seeded or sprigged turf
    - Mole crickets can be difficult to kill with insecticides
    - Tunneling deep into the soil can protect them from exposure to the chemicals
    - Applications give best control in the spring when the nymphs are small, closer to the surface, and relatively easy to kill
    - Spreading bait containing an insecticide on the turf is also an effective method of control

### **Slide 3.6 – Common Turf Pests – Ground Pearls**

- GROUND PEARLS
  - Ground pearls are scale insects that secrete a waxy material that covers and protects their bodies like a shell
  - Have piercing-sucking mouthparts and suck juices from turfgrass roots
  - Attach themselves to the roots by penetrating the tissue with their needle-like beaks and probably inject a toxin
  - Their life cycle is not fully understood, but it is usually completed in one year
  - Newly hatched nymphs, called crawlers, insert their beaks in roots
  - They then secrete the pearl-like shell around their bodies
  - Thousands of these cysts can be found in a pint (0.47 liter) of soil
  - Chemical control of ground pearls is very difficult
  - Have a protective shell
  - May feed as deep as 10 inches (25 centimeters) below the soil surface

### **Slide 3.7 – Common Turf Pests – Sod Webworms**

- SOD WEBWORMS
  - Sod webworms are actually caterpillars, the larvae of moths
  - Slender, grayish, black-spotted caterpillar about 3/4 inches long
  - Chews grass blades off just above the thatch line
  - After chewing the grass blade off they pull the blade into their silken tunnels to feed

- Feeds at night
- Hides during the day in shelters constructed of bits of grass and debris
- If disturbed, the adult moths fly in a zig zag pattern for short distances before settling again
- The caterpillars chew the leaves of turf grass plants with their mouthparts
- The adult moths do not feed on turf
- The caterpillars hide in the thatch during the day and feed on the grass foliage at night
- As they grow larger, they construct silk-lined tunnels in the thatch
- The sod webworm injures grass plants by chewing off leaves
- The caterpillars chew the leaves of turf grass plants with their mouthparts
  - The adult moths do not feed on turf
  - The caterpillars hide in the thatch during the day and feed on the grass foliage at night
  - As they grow larger, they construct silk-lined tunnels in the thatch
  - The sod webworm injures grass plants by chewing off leaves

### **Slide 3.8 – Common Turf Pests – Cutworms**

- CUTWORMS
  - Cutworms are caterpillars
  - Hide in their burrows in the soil during the day
  - Feed on foliage at night
  - Plump, smooth, and almost always curl up when disturbed
  - The caterpillars chew the leaves of turf grass plants with their mouthparts
  - The adult moths do not feed on turf
  - The caterpillars hide in the thatch during the day and feed on the grass foliage at night
  - As they grow larger, they construct silk-lined tunnels in the thatch
  - The sod webworm injures grass plants by chewing off leaves
  - The caterpillars chew the leaves of turf grass plants with their mouthparts
  - The adult moths do not feed on turf
  - The caterpillars hide in the thatch during the day and feed on the grass foliage at night
  - As they grow larger, they construct silk-lined tunnels in the thatch
  - The sod webworm injures grass plants by chewing off leaves

### **Slide 3.9 – Common Turf Pests – Forest Tent Caterpillar**

- FOREST TENT CATERPILLAR
  - During outbreaks, which usually occur at intervals of 10 to 15 years, the forest tent caterpillar (*Malacosoma disstria*) defoliates millions of acres of forest
  - Forest Tent Caterpillars rarely kill their deciduous hosts, even after successive annual defoliations, so branch killing and loss of woody growth is the main type of damage

- Forest Tent Caterpillars are unlike other Malacosoma because they do not construct tents; they form silk mats on the larger branches and on the main tree trunk where the older larvae rest when they are not feeding
- Preferred hosts are aspen, maple, gum and oak trees, but they will also attack birch, basswood, cherry, elm, alder, willow, and hazel
- Full-grown larvae are 2 - 2 1/2 inches long, have a bluish to brownish body color with somewhat diamond-shaped white spots in the middle of the back of each segment
- Two thin, broken yellow lines extend along each side
- Adult moths have a tan color and a wingspread of 1 to 1 3/4 inches
- Each front wing has either two thin dark parallel lines or a single broad dark band crossing the middle

### **Slide 3.10 – Common Turf Pests – Gypsy Moth**

- GYPSY MOTH
  - The gypsy moth (*Lymantria dispar*) is an imported insect and is one of the most serious pests of both evergreens and deciduous shade trees
  - The small, pale brown caterpillars strip leaves from affected trees in May or June
  - Just one or two very heavy infestations can completely kill tree stands
  - These caterpillars have long yellow and brown hair tufts protruding from their sides and five pairs of bluish tubercles followed by five pairs of reddish tubercles
  - Mature caterpillars are 2 inches long
  - Adult moths appear in July; females are buff-colored with irregular dark markings across the wings; males are slightly smaller and dark brown in appearance
  - Since only males are good fliers, these pests spread mainly by wind-blown larvae, egg masses on vehicles, and infested material shipped to new locations
  - A major effort was made in the 1960s and 1970s to quarantine the gypsy moth and keep it confined to the New England area
  - While this effort did slow its spread, the gypsy moth has gradually moved into most mid-Atlantic and mid-western states

### **Slide 3.11 – Common Turf Pests – Fall Cankerworm**

- FALL CANKERWORM
  - The fall cankerworms (inchworms or loopers) occur in nearly all parts of the northern US and as far west as Montana and south to the Carolinas and Missouri
  - The adult male has a wing span of approximately 1 inch (31 millimeters (mm)); wings are light gray with pale markings
  - Female fall cankerworm moths are light gray and wingless
  - The female deposits eggs in flat clusters on twigs in late fall
  - The cylindrical eggs are gray with brown cap-like tops
  - Larvae emerge in spring as plants begin to bud
  - The caterpillars have a pale to dark green head capsule, which is frequently mottled with black



- Bodies are about 1 inch long and vary in color from pale green to brown, black, or reddish-green and typically have pale lines running down the length of the body and a dark stripe on the back
- The caterpillars have a pale to dark green head capsule, which is frequently mottled with black
- Bodies are about 1 inch long and vary in color from pale green to brown, black, or reddish-green and typically have pale lines running down the length of the body and a dark stripe on the back

### **Slide 3.12 – Common Turf Pests – Webbing, Leaf Eating, & Leaf Rolling**

#### **Defoliators**

- Many important pests of ornamentals and shade trees construct webbed tents on limbs and branches of host trees
- Others enclose themselves within rolled leaves or leaves tied and webbed together
- The large ugly webs of rolled and tied leaves, combined with foliage stripping activities by caterpillars, add to the unsightly appearance of damaged trees
- Webbing, leaf-tying, and leaf-rolling defoliators include fall webworms, Eastern tent caterpillars, leaf-tiers/leaf rollers, spruce budworms, and case-bearers (bagworms)
- The webs and inhabitants are present from about mid-summer until fall
- Larvae never leave the webs; when they need more food, they enlarge the webs to enclose more leaves
- Full-grown larvae are about 1 to 1 1/2 inches long with body colors varying from pale yellow to gray or brown
- Long (3/8-inch) silky setae (spines, stiff hairs, bristles, or bristle-like appendages of an arthropod) arising in groups from black, orange, and yellow warts cover the body
- Adult moths are medium-sized with stout bodies and a wingspan of 7/8 to 1 1/2 inches
- Their color is generally pure white, or wings may be marked with one to many small brown or black spots

### **Slide 3.13 – Common Turf Pests – Eastern Tent Caterpillar**

- EASTERN TENT CATERPILLAR
  - *Malacosoma americanum* constructs large, thick webs in the forks and crotches of trees
  - Caterpillars do not feed within the tent but congregate there during the night or in rainy weather
  - Often attack wild cherry, apple, peach, and plum trees
  - Found throughout most of the eastern U.S. Eggs pass the winter in a dark brown collar-like mass attached to and often encircling small twigs; hatching occurs in early spring as soon as leaves begin to unfold
  - Young caterpillars select a nearby limb crotch and construct a tent
  - Full grown larvae are about two inches long and thinly covered with soft, light brown hairs
  - There is a white stripe down the back, bordered by reddish-brown and yellow lines

- Adult moths are light brown with two whitish stripes running longitudinally across each forewing
- Females mate and deposit eggs on twigs in early summer
- There is only one generation per year, with the egg stage lasting about nine months

### **Slide 3.14 – Ornamental Pests Identification – Japanese Beetle Identification**

- JAPANESE BEETLE IDENTIFICATION
  - Adult Japanese beetles (*Popillia japonica*) are almost a 1/2 inch long
  - They are shiny metallic-green with coppery-brown wing covers and have seven white dots along each side of the abdomen
  - Adult beetles appear in May or June and persist for about six weeks
  - Known for their destructive attacks on berries, orchard fruits, garden crops, ornamentals, and shade trees
  - The grub life stage feeds on roots of grasses and various other plants from August through October and again in the early spring
  - When mature, the grubs are about 1 inch long. They occur in varying numbers from southern Maine, south to South Carolina, and west to Ohio and West Virginia; with isolated colonies in several other states west to the Mississippi River

### **Slide 3.15 – Ornamental Pests Identification – Bagworms**

- BAGWORMS
  - Caterpillars which live in a silken cocoon-like bag
  - The bag is constructed with bits of leaves or stems attached from the host plant
  - The bag is about 2 inches long
  - Mainly a pest of shade trees, shrubs, hedges, and evergreens of all kinds
  - They prefer junipers, cedars, and deciduous
  - The caterpillar feeds and remains inside the bag through the pupal stage
  - Adult male emerges from the bag as a moth

### **Slide 3.16 – Common Turf Pests – Aphids**

- APHIDS
  - Aphids are small, piercing-sucking insects that are common pests of many plant species
  - One species of aphid called “green bugs” began to cause extensive injury to Kentucky bluegrass on lawns
  - Green bugs can become a serious problem because of their rapid reproduction rate
  - Populations build up very quickly, and thousands of these aphids may be found per square foot
  - Green bugs insert their mouthparts into leaf tissue and sucking sap from the phloem
  - Further damage is caused as salivary fluids destroy the leaf tissue surrounding the area that is pierced by the insect’s beak
  - Diagnosis is simple because of the large numbers of green bugs present on leaves when turf grass injury occurs

### **Slide 4.1 – Survey Principles, Ornamental Pests Intro**

### **Slide 4.2 – Survey Principles, Ornamental Pests**

- Surveillance
  - Individual pest characteristics require that you use species-specific surveillance and management techniques
  - Many insects feed on leaves and/or needles of ornamentals and shade trees and thus are called defoliators
  - Some insects, like the Japanese beetle, defoliate their host plant by skeletonizing the leaves
  - Pests such as webworms, leaftiers/leaf-rollers, and tent caterpillars defoliate plants by consuming parts or all of the leaves and needles
  - Surveys will help determine which species is causing damage and what controls must be implemented
  - Pest managers must be proficient in performing ornamental pest surveys
- Main Concepts
  - Accurately identify the ornamental plant species
    - Most insects and diseases are plant-specific
    - Correctly identifying the ornamental plant speeds up the identification of the ornamental pest
  - Look for deviations from the standard ornamental landscape plantings
    - Compare the infested plants with other similar plants, particularly those of the same species within a given location
    - Characteristic differences in color or growth may show signs of the problem source
  - Damage patterns that are not similar to each other are good indicators of insect pests and/or the presence of diseases
  - Standard damage over a large area (perhaps several ornamental plant species) typically indicates major environmental stressors caused by physical injury (mower/animal girdling, over-pruning), poor drainage, or weather (hot/cold)
  - Capture a landscape image from a macro point of view
    - Try to capture a photo from far away to see if you can resemble any difference amongst the landscape
    - Many times, it is easier to see the damage or discoloration from afar
  - Analyze the plant's subsurface root system
    - Document the root color; the roots may indicate the problems
    - Brown roots are an indication that the soil is dry or has the presence of toxic chemicals
    - Black roots usually reflect overly wet soil or the presence of root-rotting organisms
  - Analyze the plant's trunk and branches
    - Examine the trunk thoroughly for girdling wounds caused by lawn mowers/weed eaters, weather-related (lightning strikes, wind damage, temperature and moisture extremes) or other environmental and mechanical stressors
  - Wounds provide entrances for disease causing organisms and wood-rotting organisms

- Large defects may indicate a potentially unsafe tree that may collapse during the next weather-related incident and cause additional damage
- Document the arrangement and general appearance of affected leaves
  - Dead leaves at the top of the tree are usually the result of environmental or mechanical root stressors
  - Twisted or curled leaves may indicate viral infection, insect feeding, or exposure to herbicides
- The size and color of the foliage may tell a great deal about the plant's condition—stunted or excessive growth, yellowing of the leaves, or wilting
- Make note of these and any other deviations from the norm for the ornamental species you are surveying
- Specific Procedures
  - Locate the infested ornamental plants or trees. Look for evidence of an infestation.
  - JAPANESE BEETLES
    - Look for plants that may be completely defoliated
    - Leaves will have a skeletonized appearance
  - BAGWORMS
    - Look for silken cases or bags around tree tips and on facilities
  - FALL WEBWORMS
    - First thing to look for are large webs over ends of branches on trees and shrubs
    - Trees may be fully defoliated in years of high caterpillar population
  - EASTERN TENT CATERPILLAR
    - Look for webbing in the forks of tree
    - Look for live pests.
    - Adults can be seen during flight on leaves and branches
    - Larva will be seen on or around the plant
    - Once you have positively identified the ornamental pest species, determine control measures

### **Slide 5.1 – Control Measures, Ornamental Pests Intro**

### **Slide 5.2 – Control Measures, Ornamental Pest**

- Ornamental Pest Control Measures
  - Once you have completed your surveillance and identification, it is now time to determine the means in which to manage these pests
  - It is important to realize that not all defoliators are managed with the same techniques
  - As a pest manager, you are the one who is responsible for choosing the course of action to alleviate or eliminate the pest problem
- Elm Leaf Beetle Management
  - Leaf beetles are easily managed with several insecticidal sprays or dusts
  - Repeated applications may be necessary

- Follow product label directions and/or consult with your major command (MAJCOM) pest management consultant for specific recommendations during large-scale elm leaf beetle operations
- Leaf & Needle Miner Management
  - Leaf and needle miners are difficult to control because they are concealed between the layers of the leaf
  - Insecticidal sprays can be effective if coverage is thorough and repeat treatments are made when necessary
  - You can control light infestations by hand-picking needles or twigs from the tree
- General Defoliator Management
  - Control general defoliators with insecticidal sprays, provided they are applied when the pests are vulnerable
  - Polyhedral virus (biological insecticide) sprays readily control some species
  - For gypsy moths, pheromone traps combined with insecticides or insect growth regulators and barriers of tacky materials placed on tree trunks can be effective for individual tree protection but are not practical for large-area management
  - Focus your fall cankerworm controls on trapping the wingless females and/or spraying the active larvae once they start feeding on foliage
  - Insecticidal suspensions containing a sticker/spreader are highly effective at controlling general defoliators
- Webbing, Leafy, Leaf Rolling, Defoliator, and Bagworm Management
  - Insects in webbed tents and in rolled or tied leaves usually can be managed by conventional insecticidal sprays as well as biological pesticides, such as *Bacillus Thuringiensis Israelis* (Bti)
  - Cultural and mechanical methods also are useful when infestations are confined to single limbs or branches on individual trees
  - Not planting wild cherry trees, a preferred host of the eastern tent caterpillar, helps reduce this pest's population
  - You can control these caterpillars together with leaftiers and leafrollers by removing twigs and other plant debris in the fall
  - Prune off and destroy caterpillar tents on trees or burn them in place
  - Remove and destroy rolled and tied leaves to effectively manage light infestations on individual ornamental and shade trees or burn them in place
  - Another option is for you to use pheromone traps to capture adult Tortricid moths
  - Manage small populations of bagworms by hand-picking bags from affected hosts
  - If this is not feasible, use pesticidal sprays but only in the spring and early summer months when vulnerable larvae are feeding and exposed without bags
  - Bti sprays are also effective against bagworms, tent caterpillars, and other caterpillars, which become diseased as they feed
  - Cutworm management involves the use of simple preventive techniques and some chemical controls

- Preventive measures include rotating the soil and/or removing excess debris from the base of ornamental plantings—weeds and plant leaf litter to starve developing larvae
- For small infestations, handpick caterpillars after dark
- Handpick following a good rain or after thoroughly watering
- Biological controls include the use of beneficial nematodes
- Use Trichogramma wasps to parasitize cutworm eggs/larvae
- Diatomaceous earth sprinkled around the base of ornamental plants is also very effective
- Focus your cutworm pesticidal control operations to late afternoon or evening treatments when the cutworms are actively feeding

### **Slide 6.1 – Course Completion**

Congratulations, you have completed the identify, survey & control measure lesson. Please click complete lesson to receive credit.