Intro to Ecosystems

• Managing turf areas from a Best Management Practices perspective.
• Important that it be placed in the context of functioning as part of the ecosystem.
• Land use BMPs which are part of the design, engineering and construction of the area.
Intro to Ecosystems

- **Turf management strategies - source prevention**

*BMPs* and Integrated Pest Management (IPM) are areas which are new to many turf professionals.
**Intro to Ecosystems**

- **Environmental monitoring** is becoming more of an important issue in protecting natural resources. A valuable management tool. It allows for detecting changes within the ecosystem allowing adjustments to be made to management programs. *Monitoring ensures that the land use BMPs and source prevention control BMPs and IPM programs are functioning as intended.*
Ecosystems

- Turf Areas as Ecosystems
- Ecology is the study of the relationship of organisms or groups of organisms to their environment.
- The hierarchical structure of organisms within ecology is individuals ⊆ species ⊆ populations ⊆ communities ⊆ ecosystem.
Ecosystem Structure

- The **species** is the most basic level of organization and is defined as a group of the same organism.

- A **population** is any group of individuals of the same species that occupies a given area at the same time. For example, the turf on a putting green may be creeping bentgrass (*Agrostis stolonifera*). This turf is all the same species and it is located on the green.
Populations

- Populations are often analyzed and characterized by their:
  - density (how many),
  - biomass (how much),
  - birth and death rates (sustainability and growth),
  - age distribution,
**Populations**

- Populations are often analyzed and characterized by their:
  - **carrying capacity** (how many can the environment support),
  - **regulation of size** (density dependent and density independent),
  - **type of energy flow** and
  - **interactions** (competition, mutualism, parasitism, etc.).
Communities

• **Communities** are composed of an assemblage of populations living in the same area (e.g., bermudagrass, mole crickets, *Rhizoctonia* fungi.)

• In order to characterize a community, information is gathered on **diversity of species** (how many different types of species are present), **dominance** (is one species dominant or are species evenly distributed over time, space and number).
Communities

- what are patterns of dispersal of species (clumped, random) and are
- ecotones (edge effects) well developed.
- An ecosystem is composed of these biological communities and the abiotic (non-living) environment.
The ecosystem is the basic functional unit in ecology, because it includes both the living (organisms, biotic communities) and nonliving (abiotic) environment, each influencing the properties of the other and both necessary for maintenance of life as we have it on earth.
**Ecosystems**

- When designing or maintaining a turf area, the primary aim of an ecosystem management approach is to take advantage of what happens naturally - or - to mimic as closely as possible all the functions that naturally occur.

- Basically, ecosystems capture and process energy and energy is used for growth. Continued growth is dependent on the availability of water, the necessary cycling of minerals, and the processing of natural wastes.
Water. Water is fundamental to the maintenance of turf areas, as well as natural ecosystems.

The key issues regarding water are

- availability,
- quality,
- conservation,
- waste disposal, and
- potential ecological and legal liabilities associated with pollution.
Energy. Without an outside energy supply, ecosystems would not exist. Nutrients and materials are cycled within an ecosystem, but, energy flows through and is not recycled. Energy from sunlight is captured by plants and is passed on to animals who feed on plants, which are in turn consumed by predators as part of the ecosystem food webs. Energy leaves the ecosystem through metabolic activity of organisms.
Biogeochemical cycles. Biogeochemical cycling refers to the movement of inorganic substances through the ecosystem. The living or ‘bio’ component refers to the producers (e.g., plants), consumers (e.g., animals) and decomposers (e.g., bacteria, fungi) within the system.
Biogeochemical cycling

- The **abiotic or ‘geo’** component is composed of the atmosphere, lithosphere (earth) and hydrosphere (water).
- Under turf management situations, cycling of inorganic components within the ecosystem is an important process.
Biogeochemical cycling

• Within a turf area biogeochemical cycling of nitrogen and phosphorus is important from an ecological perspective because these elements can create environmental concerns if excessive quantities find their way into lakes or ponds.

• Phosphorus cycling naturally occurs in every ecosystem. (Figure 1).
Figure 1. Phosphorus cycle.
In aquatic ecosystems, phosphorus levels in water are normally low. In freshwater, phosphorus is often the limiting nutrient for biological production. When phosphorus levels in ponds or lakes increase biological production can also increase. A common response being algal blooms.
Phosphorus cycling

Algal blooms can produce many different results including:

- physically clogging irrigation intakes,
- blocking sunlight penetration which limits the extent of submerged aquatic vegetation, or
- in the event of a sudden die-back of the algae, oxygen depletion can occur which may affect aquatic organisms such as fish, amphibians, reptiles and macroinvertebrates. In the most severe cases, death of large numbers of aquatic organisms can occur.
Nitrogen cycling

• Nitrogen cycles within the ecosystem as does phosphorus (Figure 2). However, it is much more easily lost from the system in the form of inorganic ions, either as nitrite (NO$_2^-$), nitrate (NO$_3^-$) or ammonium (NH$_4^+$) and can become of concern in surface water and groundwater.
Figure 10. The Nitrogen Cycle as represented by the more important biologically mediated conversions of nitrogen into different oxidation states occurring within most aquatic and terrestrial ecosystems.
Figure 2. Nitrogen cycle

Aerobic conditions:
- Nitrate
- Nitrite

Anaerobic conditions:
- Nitrite

Fixation
- Organic-ammonia
- Ammonia
- N₂O, N₂
Nitrogen cycling

• One concern is for maintaining drinking water supplies where the world-wide health standard for nitrates in drinking water supplies is 10 ppm.

• Another concern in aquatic ecosystems is maintaining concentrations so that biological production does not significantly increase. Nitrogen tends to be a limiting nutrient to production in estuarine or marine system more often than phosphorus.
From an ecological perspective, nitrate concentrations should be lower than the drinking water standard to avoid excessive production. At levels above 0.2 to 0.4 ppm, nitrogen in combination with phosphorus can bring about prolific plant and algal growth completely dominating the ecosystem and creating “bloom” conditions which are a very undesirable situation.
Interrelationships

- Because any turf area is an integral part of an ecosystem, functions of animals and plants are related to each other, and to abiotic factors (Figure 3).
Figure 3. Interrelationships at the ecosystem level
Interactions

• These interactions occur on both a micro- and a macro-scale.

• At the microscale, it may be as simple as plant uptake of nutrients or bacterial decomposition.

• At the macroscale, it is also important to look at some of the “larger” relationships. An example might be foraging of songbirds, or waterfowl migration.
A watershed is a land area that drains to a common point.

However, with any given area of land, there may be many basins within the watershed which ultimately drain to the same common point based on topography (Figure 4). At the most simple level, every land form is part of a watershed.
Watersheds
Sub-basins in the watershed are based on topography

Figure 4a. Watershed basins.
Watersheds
Sub-basins in the watershed are based on topography

Figure 4b. Watershed basins.
Watersheds
Sub-basins in the watershed are defined by topography.

Figure 4c. Watershed basins.
Watersheds

• Protection of the watershed drainage areas which are susceptible to influence from both point and nonpoint sources of pollution is critical so that water resources are not degraded.

• This is especially apparent when land forms drain directly to a protected water supply (e.g., drinking water source). It is critical that water quality be protected as the water moves from the land through streams to ponds or lakes or reservoirs.
Watersheds

• Use of Best Management Practices can help protect water quality.
• The watershed also provides the management unit for the ecosystem.
• This is determined by the component drainage basins.
Water Quality Management

- Water is often the dynamic link between natural resources and the landscape or golf course.
- It is used for irrigation, aesthetics and wildlife habitat.
- Successful water quality management requires an understanding of water dynamics, water quality requirements for given uses, and management strategies for protection of those waters.
Water Quality Management

• Potential water quality problems involve nutrient and sediment loading which impair water quality by causing algal blooms, overgrowth of aquatic vegetation, low dissolved oxygen content, changes in aquatic macroinvertebrates and even fish kills.

• In a water body, there are several characteristics that are important to its overall health and stability, and thus important to good water quality management.
Water Quality Implications

Because of the chemical composition and solids content, this *bottom water* can also be *inappropriate* for turfgrass irrigation. To ensure the best quality water possible for irrigation, a *floating intake structure* for the irrigation system should be installed. The intake structure should be about 2 feet below the water’s surface, and should move up or down with changing water elevations. This intake structure will usually provide the best possible water quality for the turf.
Nutrients

- Nitrogen and phosphorus are macro-nutrients that are most often of interest in water resource management.
- Ecological interest in nitrogen and phosphorus stems from its major role in biological metabolism.
- In dealing with nutrient enrichment of aquatic systems, lakes can be classified based on the nutrient content.
<table>
<thead>
<tr>
<th>Ecological Classification</th>
<th>Common Term</th>
<th>Total Nitrogen mg/l</th>
<th>Total Phosphorus mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oligotrophic</td>
<td>Clean water</td>
<td>0.5</td>
<td>0.01</td>
</tr>
<tr>
<td>Mesotrophic</td>
<td>Moderately enriched</td>
<td>0.8</td>
<td>0.03</td>
</tr>
<tr>
<td>Eutrophic</td>
<td>Highly enriched</td>
<td>1.25</td>
<td>0.08</td>
</tr>
<tr>
<td>Hyper-eutrophic</td>
<td>Very highly enriched</td>
<td>1.8</td>
<td>0.10</td>
</tr>
</tbody>
</table>
At some point a healthy aquatic plant population may actually become an aquatic weed situation detrimental to the lake or pond’s ecosystem balance.
The physical environment of lakes coupled with water quality will determine the response of the aquatic ecosystem and influence whether or not aquatic plants will become weed problems. The primary factors involved are the following:

- **light**
- **nutrients**
- **gases**
- **temperature**
Lake Management

• Aquatic plants are of four main types including algae, floating weeds, emergent weeds, and submersgent weeds. There are a number of distinct strategies for aquatic weed control. Table 2.

• Methods include prevention, physical removal, mechanical removal, environmental controls and biological controls. A combination of strategies will produce the best results for managing a healthy pond ecosystem.
### Table 2a. Standard aquatic nuisance plant control methods.

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevention</td>
<td>Eliminate nutrient loading. Install aerators to increase water movement and oxygen.</td>
</tr>
<tr>
<td>Physical Removal</td>
<td>Hand harvest aquatic vegetation by pulling, rolling, cutting, or digging</td>
</tr>
<tr>
<td>Mechanical Removal</td>
<td>Use specialized mechanical equipment to cut and harvest aquatic weeds</td>
</tr>
</tbody>
</table>
### Table 2b. Standard aquatic nuisance plant control methods.

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Controls</td>
<td></td>
</tr>
<tr>
<td>Bottom barriers</td>
<td>Made of plastic, rubber, or fiberglass, these can be used to inhibit or prevent rooted growth in selected areas</td>
</tr>
<tr>
<td>Shading</td>
<td>Use of black plastic, soluble dyes, or artificial structures will inhibit or shade out aquatic plant growth. Trees can be used to permanently shade certain areas</td>
</tr>
<tr>
<td>Drawdown</td>
<td>Periodic lowering of water levels will expose bottom sediments; can control some weeds by desiccating or freezing</td>
</tr>
<tr>
<td>Dredging</td>
<td>Remove existing rooted plants and nutrient rich sediments to reduce nutrient accumulations and create greater water depth to control aquatic growth</td>
</tr>
</tbody>
</table>
Table 2c. Standard aquatic nuisance plant control methods.

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Biological Controls</strong></td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td>Grass carp or white Amur can be introduced in certain areas to eat plant material</td>
</tr>
<tr>
<td>Insects</td>
<td>Adults and/or larvae of certain moths and weevils have been introduced to selectively eat plant populations. This method has worked for water hyacinth and alligator weed</td>
</tr>
<tr>
<td>Plant Diseases</td>
<td>Introduction of pathogens such as bacteria, viruses, fungi, and other micro-organisms is a new approach that is working on many courses</td>
</tr>
</tbody>
</table>
Table 2c. Standard aquatic nuisance plant control methods.

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Controls</td>
<td>The use of chemicals is the most common and versatile management strategy for controlling nuisance aquatic plant populations. However, chemical management often treats the symptom and not causes of weed and algae populations. Chemical controls should be used in conjunction with strategies to control the problem</td>
</tr>
</tbody>
</table>
Adjacent ecosystems form complex and diverse mosaics on the landscape. Forests, wetlands, bottom land hardwoods, agricultural fields, streams, rivers, and lakes, taken in combination, form biologically diverse and ecologically complex watersheds.
**Integrated Landscape**

- **Turf management** is closely integrated with the local natural landscape. Some of today’s turf areas are carved out of the ecosystem, rather than being blended into them.
- In these situations, use of **Best Management Practices** to maintain environmental integrity is critical.
Environmentally sensitive areas are those natural resources that are susceptible to change which can alter the ecosystem structure. Areas such as natural or constructed lake and stream systems, wetlands and riparian corridors, groundwater, and native habitat should be protected as sensitive resources.
Ecologically Sensitive Areas

- Each turf area will have distinct ecologically sensitive areas, and they should be identified. Once identified, strategies can be implemented to protect these areas.
Ecologically Sensitive Areas

- This is accomplished by implementation of **Best Management Practices**, careful selection of pesticides and fertilizers, **restrictions** on the use of certain materials in sensitive areas (e.g., no spray zones), and proper construction to minimize point and non-point source pollutant input to sensitive sites within these areas.
Ecosystem Protection

• An important concept in managing turf areas as ecosystems is **not to over-ride or alter natural processes**, but to maintain naturally occurring processes.

• **Natural ecosystems function because of their complexity**, which builds stability.
Ecosystem Protection

- **Chemicals** are an important part of the ecosystem. Ecosystems use energy to assimilate chemicals into new biological structures, decompose dead materials, and recycle mineral nutrients.
Ecosystem Protection

- **Introduction of chemicals** into the system (e.g., pesticides) **need not** upset the natural balance. However, turf management must be careful not to override the natural cycling processes nor to introduce **toxic** materials where they can harm organisms or ecologically sensitive areas.
Ecosystem Protection

- **Excessive** use of chemicals can **result** in **ecosystem changes**. These may be subtle, undetected for years to decades, and the resultant changes may be subtle an imperceptible they can have a myriad of consequences (**Figure 6**).
Pollutant Input

→ Bioaccumulation to effect Threshold

→ Behavior response

→ Biochemical response

→ Physiological

→ Morphological

→ Altered Performance

→ Population Impact

→ Ecological Interactions

→ Community and Ecosystem Structure and Dynamics (extinction, dominance, diversity, similarity, stability)

→ Ecosystem Function
Pollutant Input

Immediate to days

Bioaccumulation to effect Threshold

Behavior response

Days to months

Physiological

Altered Performance

Months to years

Biochemical response

Morphological

Population Impact

Ecological Interactions

Community and Ecosystem Structure and Dynamics
(extinction, dominance, diversity, similarity, stability)

Months to decades

Ecosystem Function
The best approach is to avoid or minimize problems by using Best Management Practices. This may include the sensible use of biocides emphasizing localized applications of highly specialized toxins that act quickly, effectively, and decay naturally and quickly without any impact on the natural system.
The principles of sustainability within any ecosystem dictate that natural resources neither be degraded nor consumed.

Within turf management then, sustainable resource management could be defined as a pattern of human activity that can be supported indefinitely. In order for this to occur, it means becoming less dependent on nonrenewable resources, and carefully protecting those resources which must be recycled.
Nature never breaks her own laws.

- Leonardo da Vinci, inventor and painter
Science does not permit exceptions.

- Claude Bernard, French scientist
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