UNIT LESSON PLAN

RX-310, INTRODUCTION TO FIRE EFFECTS

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LESSON: Fire Effects and Resource Management: Flora

UNIT: Unit 3A

OBJECTIVES:

Upon completion of this lesson, participants will be able to:

1. **Describe basic physiological plant characteristics and processes.**

2. **Identify plant adaptations to fire regimes influencing plant community composition and structure.**

3. **Discuss appropriate management practices for modifying first order fire effects on flora.**

4. **Identify key vegetative attributes to evaluate the first order fire effects on flora.**

NARRATIVE:

I. INTRODUCTION

A. Welcome, Introduce Myself
B. Learning Goals for the Unit: understanding what plant species survive fires, which plants die, and the reasons why.
C. Outline of the Unit

II. Plant Physiology & Adaptations to Fire Regimes

A. First Order fire Effects cause immediate damage or mortality of plants as a result of the fire.
   1. Examples of FOFE on plants?
   2. Variables that determine how damaging fire is?

B. Fire Damage to Plants
   1. Adult Trees
      a. May survive surface fires with little or no damage, or be killed by more intense fires, depending on heat vs. bark thickness
      b. Heat kills cambium just beneath the bark - tissue in the stem that generates new wood to conduct water (xylem) and vascular tissue to conduct photosynthate (phloem)
      c. Fire Scars on survivors - on side where fire was most intense

d. Species with roots near the soil surface are more susceptible than species with deeper roots.
e. Killed outright (First Order Fire Effects) or
f. Die over several years (Second order?)
g. Gap formation = Increase in light to the understory
h. Snag formation = habitat and resources for many types of creatures
i. Increase in Coarse Woody Debris from killed trees (increases fuels - Second order)

2. Saplings and Seedlings
   a. Almost always top-killed by fire
   b. Some species with well-established root systems can resprout, but not all species can do this.
   c. Repeated fires (especially spring burns) can deplete energy stored in roots and kill the trees.

3. Buried Seeds
   a. Protected from low intensity fire even a few inches down
   b. Killed by ground fire or by repeated surface fires

C. Plant Adaptations to Fire

1. Fire Resistance - Live through the fire
   a. Thick insulating bark - examples: pitch pine, chestnut oak. (Bark becomes thicker with age on most tree species.)
   b. Deep root system: ericaceous shrubs, oaks (Shallow roots can be heat-killed.)
   c. Ability to regrow needles and branches (epicormic sprouting): pitch pine
   d. Ability to effectively seal off wounds to prevent subsequent rot: oaks, pines

2. Resprouting Ability
   a. Dormant buds at the root collar or on roots: oaks, chestnuts, red maple (to some extent), ericaceous shrubs
   b. Sprouting from rhizomes (underground stems; ferns, clubmosses, canada mayflower, trillium) or bulbs (ramps, orchids)
   c. Storage of starch and nutrients in roots to fuel resprouting and regrowth
   d. Resprouting ability declines as trees age
   e. Periodic fires may increase productivity of sprouting shrubs (blueberries, huckleberries)

3. Seed Bank
   a. Buried dormant seeds in the soil and duff. Some species' seeds can be viable for only a couple of years, whereas a few species have adapted to have very long dormancy periods. Example: Pin cherry (Prunus pensylvanica) can survive up to 50+ years in the soil and germinate after a disturbance in response to increased light.
   b. Aerial seed bank: Certain pines (e.g., pitch) can retain seeds in sealed serotinous cones for years, until the heat from a fire melts the resins holding the cone scales closed. Seeds released after fires, for immediate recolonization.

4. High Reproduction & Dispersal

a. Some plants cannot survive fire at all, and must recolonize and reestablish.
b. Reproductively-oriented, shade-intolerant, early-successional species are well adapted to quickly colonized disturbed areas.
c. Annuals, biennials, and short-lived perennials are likely to be in this category. (Long-lived perennials in fire-prone areas must be able to survive fires.)
d. Wind dispersal: examples?
e. Bird dispersal: examples?
f. Mammal dispersal: examples?

D. Common Appalachian Plant Species: Fire-Adapted?

For each plant species below, rank degree of fire-adaptation. What characteristics does the species have that would help it deal well with fire (or not)? What strategies does it employ?

1. Oaks (Quercus alba, Q. rubra, Q. prinus, etc.)
2. Ericaceous Shrubs (Vaccinium, Gaylussacia, Kalmia, etc.)
3. Pitch Pine (Pinus rigida)
4. Red Maple (Acer rubrum)
5. American Beech (Fagus grandifolia)
6. Eastern Hemlock (Tsuga canadensis)
7. Raspberries (Rubus spp.)
8. Black Cherry (Prunus serotina)
9. Hickories (Carya ovata, C. glabra, etc.)
10. Sedges and Grasses (graminoids)

III. Key Vegetative Attributes for Evaluating First Order Fire Effects

A. Understanding the interactions between fire characteristics and forest type will help managers design and implement more effective controlled burns, as well as monitor and assess their effectiveness.

B. Fire Effects on Non-Resprouters (most conifers in our area except pitch pine)

1. Stem (cambium) damage restricts movement of water from the roots to the leaves and photosynthate from the leaves to the roots.
   a. Damage all the way around girdles and kills the tree.
   b. Damage to one side leaves a fire scar.
   c. Damage can be from scorch or smoldering of leaves and coarse woody debris at the base of trees (fire scars on uphill side).
   d. Wounds can lead to further insect damage and fungal infection if not sealed off with pitch or secondary plant compounds (pines & oaks, respectively)

2. Crown damage reduces photosynthesis and vigor of the tree, including its ability to withstand other stresses.
   a. Scorch and consumption of needles and leaves
   b. Position of crown changes effects:
   c. High crowns get less heat
   d. Open stands get less heat from crown to crown
   e. Self-pruning species tend to produce higher, more open crowns naturally

3. Root damage affects water and nutrient uptake (support less so).

   a. Small feeder roots near the surface are sensitive to fire
   b. Structural roots are deeper, less sensitive to fire
   c. Heat damage results from smoldering and consumption of duff and CWD at the ground surface - as many small roots are in the duff layer.

C. Fire Effects on Resprouters (pitch pines and many hardwoods)
1. All of the above, plus:
2. Effects depend on level of severity / intensity
   a. Damage produces hormones that turns on dormant buds
   b. Top-kill eliminates apical dominance, releasing lateral buds from suppression
   c. Gap formation increases light at soil surface
3. High severity fires can kill the parts of plants where buds reside.
   a. Burns the duff layer down to the soil surface, or heats it to the point where cambial death occurs: Shallow roots, rhizomes, and root collars
   b. CWD & Soil wood consumed
   c. Much exposed mineral soil
   d. Recolonization from seed will be necessary in these situations.
4. Low fire severity indicators:
   a. Soil wood intact
   b. Little exposed mineral soil
   c. Resprouters will likely do well following the fire, and have a competitive advantage over plants colonizing from seed.

D. Other Factors that affect response to fire disturbance
1. Phenology - timing of growth, development, and reproduction during the growing season
   a. Plants more susceptible to damage in spring, when they have just invested in new growth, or during periods of flowering
   b. Susceptibility to damage decreases as the plant moves into dormancy for the winter.
   c. Single burn probably will not kill off resprouters
   d. Repeated spring burns have the ability to kill off resprouters after 2-3 fires

2. Plant Health
   a. Plants that are already under stress from other factors are more susceptible to damage from fire.
   b. Insect damage
   c. Fungal infection and disease
   d. Competition with shady neighbors
   e. Drought stress
   f. Old age & senescence

3. Weather context
   a. High humidity and recent rainfall reduce intensity
   b. Dry air and drought conditions increase intensity
   c. Wind increases intensity and spread of fire
   d. Microclimates due to topography modify intensity
   e. Sandy soils lead to drier stand conditions

4. Long term fire exclusion in fire-adapted habitats
   a. Increase in fuel load could lead to more intense fires, OR

b. Increase in spongy leaf litter, green leaves in the understory, coolness and higher humidity in the understory with succession - can fireproof formerly fire adapted sites (process of mesophication)

5. Climate Change
   a. Hotter and wetter conditions expected as CO_2 levels double by 2100
   b. More photosynthesis = higher fuel loads
   c. More extreme weather events = more coarse woody debris (fuel loads) and drought events
   d. Northern species at the southern end of their range will experience more stress, more susceptible to insects & disease = higher fuel loads
   e. Southern species at the northern end of their range could be expected to do better in future climates
   f. Specific effects for specific areas hard to predict, though climate models mostly agree on the regional scale.

IV. Management Practices for Modifying First Order Fire Effects

A. Examples of management using fire: Oaks and Pines.

- Due to 20th century fire suppression, most forests in the state have not seen fire in a long time, even though they may still contain fire-adapted species.
- Reintroducing fire can be an effective management tool for accomplishing specific goals, but the process is much more complicated than simply setting a fire and keeping it from getting out of control. In your group, brainstorm factors and considerations that need to be taken into account:

1. Which tree species do you want to favor?
2. Which species do you want to eliminate or reduce?
3. What adaptations and weaknesses do they have that will affect their response to different kinds and intensities of fire? Consider different life stages (seedling, sapling, adult).
4. What characteristics of fire might work best for accomplishing the objectives?
5. When should the fire be timed during the year?
6. How often should fire be returned to the site?
7. What other questions do you have, or what else do you need to know that you don’t? (probably lots, as there is much to learn!)

B. Group 1: Enhance oak regeneration and reduce red maples on a productive site. Silvicultural objectives are primary, though game animals and biodiversity are still important as secondary objectives.

1. Favor oaks for lumber and wildlife.
2. Reduce red maple (fight mesophication!)
3. Oak adaptations
   a. Adults - thick bark and deep roots to survive surface fire.
   b. Saplings - will probably be top-killed if < 4 inches dbh, but can resprout. If fire scarred, can wall off wounds.
   c. Seedlings - will be top-killed but invest heavily in roots. If the taproot is thicker than your finger, it has been there for years storing up energy, and will vigorously resprout.

d. Weaknesses: without fire, seedlings will eventually succumb to shade. Also a favorite deer food.

4. Maple adaptations
   a. Adults - If large enough, can survive. But fire scarring causes rot.
   b. Saplings - susceptible to fire, but can resprout.
   c. Seedlings - killed by fire, do not sprout as vigorously as oaks
   d. Weaknesses: not as thick bark as oak, can't seal off wounds as well. Shallow roots. Strength: more shade tolerant than oaks.
5. Fire or other disturbance without strong oak advanced regeneration (seedlings with well developed root systems) in the understory will be unsuccessful at regenerating oaks.
   a. Precommercial thinning several years prior to the burn may increase light in the understory enough to give the oak seedlings a competitive edge, but without regenerating other species to a greater extent.
   b. Surface fire will top kill seedlings and saplings of all species. Non-resprouters eliminated. Damage maximized if burn in the spring. May damage some canopy trees of susceptible species, creating gaps.
   c. Red maples may regenerate somewhat, but oaks with their well developed root systems will sprout more vigorously. Oaks will grow taller than maples in gaps.
   d. Can burn again 3-5 years later to enhance the gaps and kill residual red maples, but don't want to wait until you are killing oak saplings that are on their way to becoming trees.
   e. The above can be combined with a shelterwood treatment to yield oak lumber while helping to regenerate oak in the understory.
   f. Much good info in Brose et al. 2014: The Fire-Oak Literature of Eastern North America: Synthesis and Guidelines

C. Group 2: Enhance pitch pine and scrub oak regeneration where pitch pines are growing older and not reproducing successfully (sandy, nutrient-poor site). This site is a habitat restoration effort to enhance habitat for rare and endangered species that need the habitat.

   1. Favor pitch pine and scrub oak
   2. Reduce other competing hardwoods
   3. Pitch Pine adaptations:
      a. Thick bark
      b. Epicormic sprouting and stump-sprouting
      c. Serotinous Cones (in some areas)
      d. Weaknesses: shade, require bare mineral soil to regenerate from seed
   4. Fire Characteristics
      a. Intense fire will regenerate the stand, killing most adults. Pitch pine is well adapted for seeding in after a fire like this, but an intense burn may not be easily controllable in this kind of habitat. Thick overmature scrub oak or laurel and high fuel load complicate use of fire (stop its spread altogether or enhance it and transmit fire to the canopy)
      b. Surface fires can be used if the habitat is open enough. Mechanical treatments can be used to create buffers and thin the stand before applying fire, to make it more controllable.

c. Once open enough, surface fires can burn through the stand without catching the tree canopy on fire.
d. Burn hot enough or often enough to eliminate some leaf litter and duff, allowing for pine regeneration.

5. Timing:
   a. Weather must be humid/wet enough to control the burn
   b. Spring burn will knock back the hardwood competition most significantly
6. Frequency:
   a. 5-25 years, depending on management objectives for the stand (how open it will be).

D. Summary:
1. Fire regime must be designed to enhance target species and discourage other species.
2. Too hot or not hot enough will not accomplish objectives effectively.
3. Degree of damage to a tree by a fire depends on many factors, including:
   a. Species life history characteristics (adaptations and weaknesses)
   b. Season of the burn (dormant vs. growing season burn)
   c. Extent of the plant affected (stem, canopy, roots)
   d. Weather before and during the burn (humidity, temp, wind)
   e. Weather after the burn (e.g., drought stress on the trees)
   f. Degree of fuel accumulation or mesophication prior to the burn
   g. Mechanical thinnings or other treatments done before the fire
   h. Any others you can think of?

d. Fire is one tool in a forest manager’s toolkit and it can be used in combination with silvicultural treatments.