CHAPTER IX

ECOLOGICAL EFFECTS

OBJECTIVES

1) Identify fire's primary impacts on basic ecosystem components (soils, water, flora and fauna).
2) Demonstrate a basic understanding of how fire impacts ecosystems.

INTRODUCTION

No natural force is so misunderstood or such a ready catalyst for heated debate as fire. A student of its literature finds much contradiction, many anecdotal offerings and results of poorly designed research projects. Few long term studies have been conducted to weigh and document fire's ecological effects and in this culturally altered landscape of ours it is often difficult to sort out ecological consequences in systems that human disturbances have made unnatural.

Fire is a global phenomenon, not something confined to Florida, though we can claim to be the lightning capitol of our continent. Florida possesses many systems which require frequent fire to maintain their appearance, function, and diversity. Although it is now a much changed landscape, the systems recognized in Florida today have existed for at least 20,000 years (except for the Everglades which is less than 10,000 years old). Lightning has been a primary force in maintenance of biodiversity and we, the human animal have never been adverse to setting landscapes ablaze to achieve a variety of objectives.

Wood Smoke in our Environment The most evident, yet shortest lived component of a fire is the smoke of combustion. Wildland fire produces mostly carbon dioxide and water vapor (up to 90%). The balance includes particulates, carbon monoxide and trace amounts of other gases. Particulates and carbon monoxide are the major pollutants produced by wildland fire. Airborne particulates can be considered a pollutant in terms of human health but they are very short –lived in the atmosphere. They are also important because they may serve as nuclei for the formation of clouds, condensation, and precipitation. Residual smoke and fog are likewise serious safety and smoke management issues but their long term ecological impacts are minimal. Carbon monoxide is also a pollutant and when concentrated and confined it can be fatal. On wildland fires personnel must exercise caution when working in heavy smoke for extended periods or in areas where smoke is concentrated. However, in open areas it oxidizes readily and poses little threat to people, plants or animals.

As resource managers we are charged with meeting a wide array of management needs. This discussion of ecological effects is designed to provide fire managers with an understanding of basic ecological principles and how they may be incorporated into each fire management program.

Fire ecology is the study of the effect of fire on living organisms and their environment, or how fire affects the surroundings of living things. This discussion will focus on how fire may affect soils, water, wildlife (Fauna) and vegetation (Flora), (APPENDIX H: Ecological Effects Glossary). These four components of the environment and interactions between them account for the majority of fire's ecological impacts. Certain things occur as a result of every fire regardless of origin or time of year.

HYDROLOGY

Fire affects hydrology in Florida's systems through a variety of both short and long term processes. Some short term effects are:

Infiltration and percolation rates can be slowed, especially in dry, sandy soils that have good grass cover.

Surface evaporation rates can be hastened due to higher post-fire soil temperatures. This is usually minor since plant transpiration rates are usually decreased due to loss of plant biomass.

Surface runoff can be accelerated when fires remove most of the fuels and plants that capture water and impede flow. In Florida a relatively flat landscape minimizes runoff. In areas with a pronounced slope, erosion may occur but plants with well developed and undamaged root systems will continue to bind and protect soils.

There are also more lasting effects of fire on hydrology:

Fire in wetlands may prevent organic buildup, impede succession, and enhance water storage.

Heavy removal of organic soils (especially when their drying has been anthropogenically influenced) can re-create wetlands. Under natural conditions these peat or 'muck' fires were far less frequent than today because wetlands were not drained by canals and other human activities.

SOILS

Effects on soil vary depending on the intensity of the fire, fuel types, soils, topography, and residence time. The most observable or measurable effects to soils are:

The rate of oxidation and decay is accelerated. Leaf and other organic litter decompose and oxidize more rapidly. Nutrients and minerals released by this process enhance plant growth.

Concentration and mobility of potassium, calcium and magnesium are increased; short term transfer of phosphorous, potassium, calcium, magnesium, and nitrogen occurs from litter to soil.

Increased soil temperatures after fires enhance nitrification of remaining organics (however, fire also volatizes nitrogen).

Soil bacteria and insect populations decline immediately after a fire but can increase 3 – 10 times within a month. Bacteria act to break down organics making nutrients available to plants.

The above factors when combined with soil moisture will greatly enhance soil fertility and plant growth.

Slight elevations in PH may occur for up to two years after some burns. This may influence the types of plants that will grow in the area.

FLORA

Fire has some immediate, sometimes lethal, effects on living plant tissues. These affects will vary based on the temperature and amount of time it takes for the fire to pass over an area (Residence Time). For instance, seed germination is frequently enhanced by fire. Other immediate effects include:

For most plants, mortality of plant cells will occur if temperatures from 122-131 °F are sustained for 10 minutes.

The time and temperature required to kill a plant varies, depending on moisture content of the tissue. Heating of swollen cells bursts cell walls.

Senescent grasses (older growth), especially wire grass, are highly susceptible to fires that move very slowly over an area

Pine trees have bark that does not conduct heat well. Studies have shown that though temperatures may reach 1500 °F on the bark surface, the temperature at the cambium is but 180 °F. (This can still be a lethal temperature for plant tissue when sustained long enough).

The highest temperatures are experienced on the leeward side of the tree where it can be twice as hot as the windward side.

Needle consumption of pine trees (except pond pine) generally leads to death.

Needle scorch in longleaf and south Florida slash is **not** an indicator that the affected trees will die. However, total scorch of north Florida slash, loblolly, shortleaf and sand pine usually results in death of the trees. Also, 100% needle scorch can be lethal to all pine species in late fall. Pine trees are evergreens and they depend on energy from photosynthesis during the winter dormant period. Needles lost in the fall are not replaced until spring and without winter photosynthesis no energy is produced.

Many different environmental conditions and various plant characteristics will influence the impact that fire will have on vegetation. There is usually a good correlation between fire behavior and its effect on trees, but much less correlation between fire behavior and its impact on understory vegetation (shrubs, grasses and forbs).

Plants have different abilities to recover after a fire. If you understand the basic principles that determine how plants are affected by fire and the factors that control plant response after a fire you can understand why various studies often present apparently different results even on the same plant species. You can also realize why there is so much variation after different fires or even in different locations of the same fire.

Once you grasp the causes of variation in fire effects, then, given a certain plant community and a certain set of burning conditions, you can better predict what post fire effects are likely to occur. You should also be able to explain departures from what you predicted. This process must also take into consideration the conditions that existed prior to and following the burn.

With the exception of some communities that naturally burn catastrophically (scrub and scrubby flatwoods), most "killing fires" are a result of abnormal fuel loads created by infrequent fires resulting from an interruption of the natural fire cycle.

FAUNA

In considering effects of fire on animal life, the most often overlooked issues revolve around the impacts associated with fire exclusion and reduced fire frequencies. Florida wildlife evolved and thrived in an environment shaped and maintained by frequent fires across much of the landscape. It is not surprising that under most circumstances direct mortality of wildlife is rarely a problem even when heavy fuel loads are burned during wildfire events. The ecological effects of the lack of fire are often long term. Some consequences are:

> Without fire, communities become mono-cultural, grasses grow senescent, trees are crowded, excessive fuels build up, and new tree and shrub species invade the site. This 'new' habitat supports fewer individuals of once abundant species and some species disappear.
>
> Forest communities often experience a decline in both the abundance and diversity of birds. While the actual faunal components may vary by plant community, the decline in abundance and diversity is a predictable consequence of fire exclusion.

Burns conducted for ecological purposes should incorporate the entire faunal component of the region, vegetation types, stages of succession, weather patterns and intensity of burns. Often, a mosaic of successional stages of vegetation created by a series of fires, over time, is the preferred habitat for the optimal diversity and abundance of wildlife.

Animals can also influence the probability of fire. For instance, heavy grazing reduces ground fuels and the likelihood of fire, while heavy insect damage which kills trees may increase the potential for severe burns.

The principle way that fire affects fauna is by altering habitat. Direct wildlife mortality is rare but depending on the type and frequency of fire the altered habitats may support higher or lower densities of a particular wildlife species. Ecological prescribed fires in Florida should be designed to maintain or restore wildlife densities to levels consistent with historical pyrogenic (fire maintained) conditions.

Wildland fires can kill wildlife but mortality is usually limited to a few individuals representing a small fraction of the population. With careful planning the prescribed burner can further minimize the risk of direct mortality. In Florida this can be especially important when dealing with species that are threatened, endangered, or of special interest on a particular site. Red cockaded woodpecker, panther, bald eagle, gopher tortoise, scrub jay, and black bear are examples of species that receive special attention. Positive and negative impacts on fauna include:

Pathogens (disease causing organisms) may be killed or controlled by fire (e. g. brown spot which is detrimental to longleaf pine).

Insect populations may be reduced dramatically but these species may rebound quickly.

Small mammals often evade a fire by using burrows or moving to unburned areas or wetlands. Fast moving fires burning across heavy continuous fuels may cause significant mortality but short reproductive cycles can quickly compensate for these losses.

Alterations in food quality and abundance as well as cover, nesting and denning sites are more important factors that ultimately determine small mammal populations.

Primary indirect effects may cover an animal's lifetime and include changes in cover/habitat, microclimate changes, and changes in food sources and nutritional levels.

Large and/or severe fires in concentrated nesting or reproductive sites may cause significant mortality or recruitment failure.

INTERACTIONS

Plant Characteristics That Influence Fire Impacts

Many plants have specific adapted resistances to heat but may be more resistant when dormant and when tissue moisture is very low. During the growing season many green plants will have high moisture content and may not burn at all. Accumulations of dead fuels and other factors may generate fire intensities or severities that negate these adaptations.

In wooded areas the stand characteristics can alter the impact of a fire. These include factors such as the distance between crowns, the shape of the crown, the ratio of live to dead trees, and the amount of litter accumulation beneath the trees. Under some conditions special prescription precautions must be taken to prevent intense or severe fires.

When leaf litter, pine needles and other types of duff accumulate at the base of trees, fires may burn into the roots or lower trunk, causing stress or mortality. This is especially prevalent in old-growth pines that have experienced fire exclusion.

A high percentage of understory plants are usually top-killed by fire. Those without fire adaptation qualities may be killed by a single fire or eventually eliminated by subsequent fires that follow at close intervals. Those which are fire adapted recover quickly. They usually have specially adapted parts that resprout and grow vigorously after a burn (rhizomes, stolons, bulbs or corms, dormant buds, root crowns, etc).

Fuel and moisture characteristics affect the amount of heat generated in a grass fire. Factors determining temperature are stem coarseness, fine vegetative culms, bunchgrass diameter, amount of surface litter, fuel moisture content, soil moisture and wind speed.

Slow, hot burns can weaken grasses, especially those approaching senescence. Delayed sprouting or heavy mortality can occur but mortality can be managed by appropriate prescriptions.

Varying the Effects of Fire

There are numerous variables which govern temperature and the heat effects of a fire:

Air temperature, exposure to sunlight and wind determine pre-burn surface temperature.

Relative humidity and soil moisture do not seem to affect soil surface temperature in grassland fires. Wind is the biggest factor.

In grasses, surface temperatures can vary widely depending on fuel loads, degree of compacted fuels, and residence time. Temperatures may range from 200-1100 °F.

Soil surface temperatures higher than 150 °F generally last one to five minutes, indicating that the seeds of most plants can survive grass fires. Residence time is the key. Grass seeds can tolerate temperatures of 240°F and some shrub seeds tolerate 300°F for up to five minutes. Moderate exposure enhances germination for some plants.

Headfires are generally hotter than backing fires. However, backfires are hotter at ground level, may have a longer residence time and may cause more damage.

Slow moving fires of all types are hotter at soil surfaces.

Headfires are consistently hotter above the soil surface (above 4”) than backing fires and may do more damage to shrubs and trees.

Below the soil surface there is seldom a significant temperature increase. In grasses and light fuels, temperature increases are restricted to the upper ¼” layer of soil and in shrub lands and heavy fuels, temperature increases may be expected in the upper 1” layer of soil.

If it is desirable to affect re-sprouting of trees and shrubs, fire’s effects on sprouting can be managed by:

1. Knowing the location of dormant buds from which new shoots can originate.
2. Knowing the distribution of reproductive structures in organic layers of the soil.
3. By prescribing a fire that will cause the desired amount of mortality of these reproductive sites.
4. By minimizing leaf and meristem mortality.
5. By burning under appropriate fuel and soil moisture parameters.

Fire and Seed Production

Reproduction by seeding can be influenced and managed with fire by:

1. Knowing the seed ecology of the target species;
2. Selecting burn sites where optimal seed production will occur;
3. Sizing the burn to promote dispersal;
4. Timing the burn to take advantage of seasonal responses;
5. Designing a prescription which will favor seed production.

It is also important to consider the variation in germination and seedling establishment requirements for different species. For instance:

The naked seeds of pines and awned seeds (such as wiregrass) are favored by access to bare mineral soil.

Both post-fire and pre-fire soil moisture conditions can have a major impact on germination.

“Seed banking” from previous seasons can be a major seed source once fire sets the stage for germination.

Though some plants produce seeds annually they may also produce hormones which may inhibit their seeds from germinating (rosemary, for example). Fire may also remove the parent plant and promote seedling establishment.

Some plants (longleaf pine) do not produce a good seed crop every year and many plants (especially trees) cannot produce seed until a certain minimum age is reached. If it is desirable to encourage areas dominated by this type of species, then timing of burns is vital to seed production, release, germination and survival.

Seeds may become established in burned areas in several different ways:

1. Some types of seed may be carried by wind, animals, or other means from adjacent or distant sites.
2. Seeds may fall from the tree canopy on site.
3. Seeds may be stored in litter, duff, and soil (seed banking).
4. Seeds can be stored in closed cones or fruits which open after the fire.

Fire enhances seedling response of some species when they are burned at the appropriate time of year. This is especially true of grasses but many woody shrubs also produce a major post-fire crop of seeds or fruit.

Some plants also have a double adaptation to fire by both sprouting and producing or releasing seed.

Plant Response after a Fire

The major factors which affect post fire plant recovery and growth are:

1. The seasonal cycle of carbohydrate reserves: woody species fare better when burned during their dormant season and worst when they are burned at the time when their carbohydrate reserves are lowest.

2. Post fire plant competition: faster growing plants and those that thrive under the specific moisture and temperature conditions existing after a fire compete better for light, space, and nutrients. Also, plants with carbohydrate reserves exhibit growth prior to other species. Saw palmetto is an excellent example. With highest carbohydrate reserves in February and March, palmetto experiences rapid re-growth after repeated winter season burns allowing it to expand and replace other plants.

3. Post fire weather can also be a major recovery aid or hindrance. In wetlands, flooding immediately after a fire may eliminate some emergent species such as sawgrass. These newly created open areas may be relatively permanent if subsequent water levels remain high. Less pronounced plant responses are governed by the duration and degree of soil saturation/inundation.

Plant Productivity

Fire alters plant composition and productivity in a variety of ways. The overall number of plants may increase or decrease; some species may increase while others decrease; and the density of plant growth (amount of cover) may be altered. These factors interact and determine the species composition of the burn unit (ratio of various types of plants and total plant biomass).

Fire stimulates plant growth and increases nutrient levels. Animals benefit from improved forage quality and from increased seed and fruit production as re-growth occurs.

PREDICTING THE EFFECT OF FIRE

Post-fire plant productivity is dependent on post fire weather but prescriptions can be tailored to achieve specific objectives based on expected post fire productivity and long range weather forecasts. Key elements to consider when predicting fire effects on plants are:

1. Characteristics of the plant species of interest: ability to survive heat, recover after fire and reproduce by seed; seasonal growth cycle and age of plant.
2. Fuel characteristics of plants and vegetation type.
3. Site Productivity.
4. Amount of time since last burn.
5. Range of fire intensity and burn severity possible on the site.
6. How different intensities and severities will interact with the survival and reproductive characteristics of the plants on the site.
7. What kind of fire is necessary to meet the stated objectives?
8. The effect that post-fire conditions may have on vegetation response.

Before completing your prescription do a literature search, ask researchers, extension agents and other prescribed burners about suggested techniques. Observe and learn from every prescribed burn. The effects of fire are not a mystery, nor are they random responses. There are specific reasons for the variation observed in plant communities after different fire treatments. They include:

The heat regime that affects vegetation is created by the interaction of ignition technique weather,
fuel conditions, and site moisture.

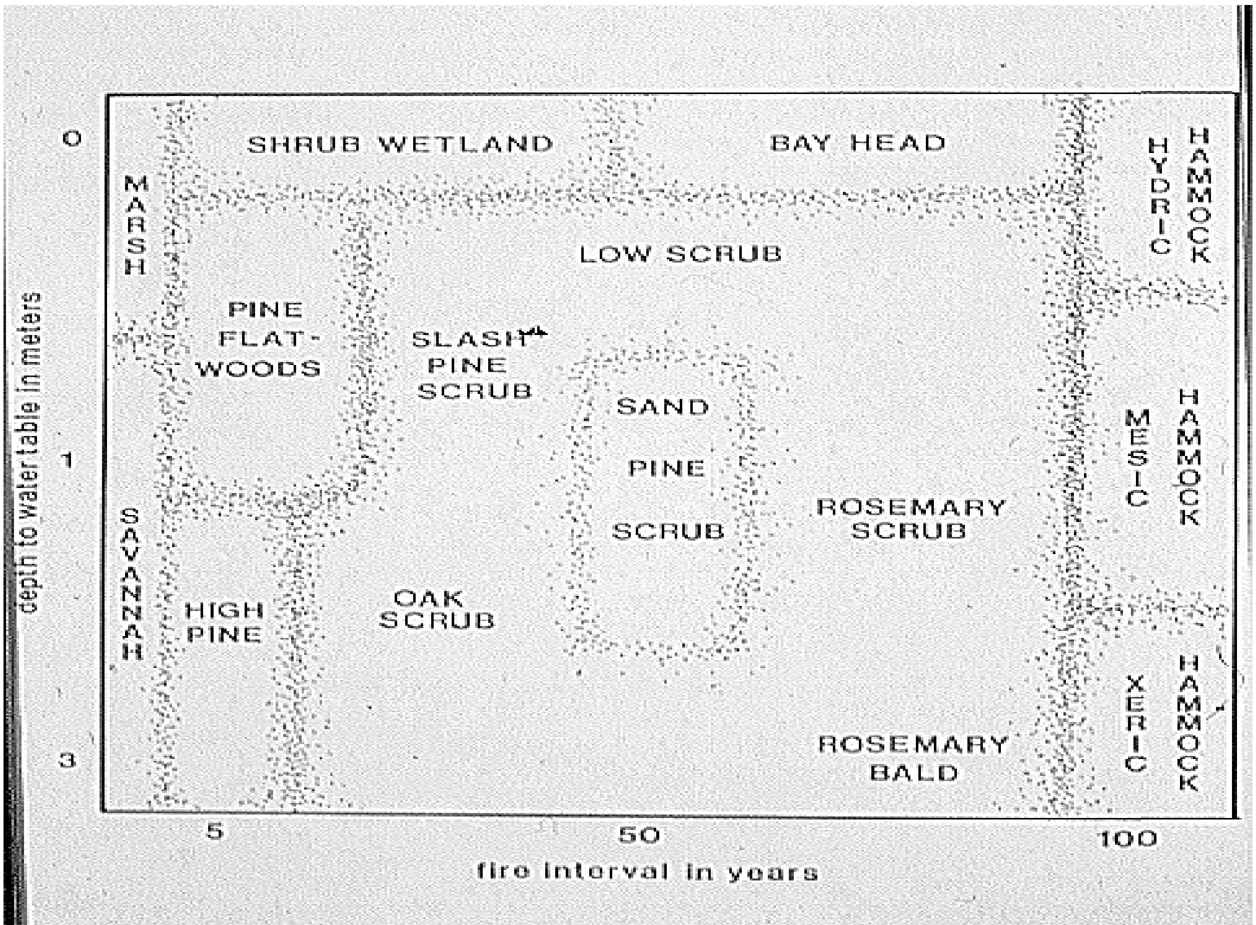
Plants have different levels and adaptations to fire. Within a species, individual plants may respond differently. These differences allow some plants to respond well to one type of fire while other species may thrive when subjected to other types of fire.

Post-fire conditions can have a significant effect on plant recovery and productivity.

Understanding and evaluating fire effects depends upon documentation of burning conditions and post burn observations designed to record plant community responses and status.

SUMMARY

Most of Florida's diverse flora and fauna have evolved within a fire environment. Today, ecological fires occur in a fragmented, dramatically altered landscape. Land managers must plan and execute prescribed burns that meet their specific goals but that also provide sustained floral and faunal values for the benefit of all Floridians.



"Conservation is a state harmony between men and the land"
Aldo Leopold