Chapter 5.1: Fire and Heat [1]

Introduction

Returning to the section on physiology, man is a tropical animal. Below 70ºF and the body needs an external source of heat or more insulation. Above 70ºF and the body needs to be cooled or protected from the heat source. One of the ways to gain heat is from an external source. Fire is one of the primary sources of heat. Fire is also needed in cooking.

This chapter begins with the principles of creating a fire. Strike a match and a flame results instantly. Turn on the gas stove and an electric spark ignites the flame. In a lighter, spin the wheel against the flint and a spark ignites the lighter fluid. There are many ways to create fire in a modern society. It is easy to take them for granted. In time of emergency, many of easy ways to create a fire may not be available. The electricity to ignite the gas burner on the stove may not be available. If matches are available, it is still easy to ignite the gas stove. Understanding the principles helps in creating and nurturing a fire in time of emergency when modern conveniences may not be available.

Next, the chapter integrates "primitive technologies" along with other emergency methods used to create fire. In primitive technologies, the term "primitive" is a misnomer because the techniques and technology required to use these methods to start a fire can be quite sophisticated. They are only primitive only in the sense that they use natural materials or materials that are readily available in nature. Because they can be quite sophisticated, it is wise to practice them prior to an emergency situation. They are included here because they are novel and because creating fire without modern conveniences is not always a simple task.

The next section focuses on improvising within an emergency situation. It focuses on alternative heating sources that can be used when centralized heat is no longer available. The last section focuses on alternative cooking sources.

Principles

Fire is really part of the oxidation process. It is linked with the fire triangle and the pyrolysis process. Understanding these processes provides a conceptual foundation which is useful when building a fire. Without the use of petrochemicals such as lighter fluid or kerosene, a fire is built and nurtured. Again, building a fire illustrates the underlying principles of building a fire.

<b>**Fire Triangle** (Figure 5.1) – Three components are necessary and sufficient for fire to occur. These are fuel, oxygen and sufficient heat. Necessary and sufficient are code words for causal. Necessary means that if the component is missing, fire will not occur. Extinguishing a fire usually involves removing one or more of the components. A CO_2 extinguisher both lowers the temperature of the fire and

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smothers the fire with carbon dioxide which is non-flammable and denies the fire oxygen. Sufficient means that if all three elements are present, a fire will occur. If all three elements are present, a fire will occur.

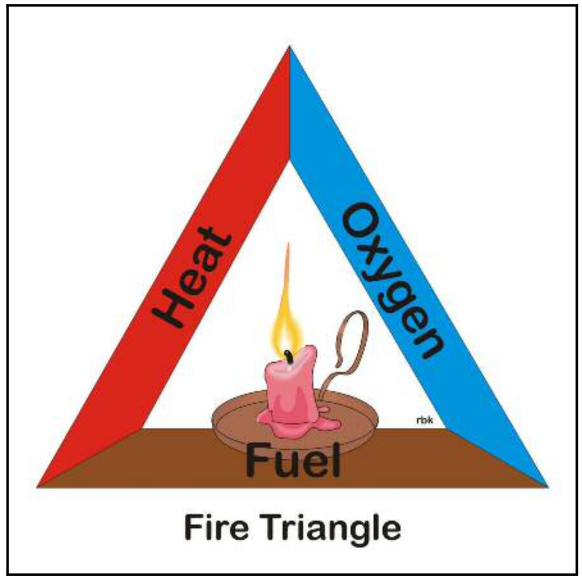

Figure 5.1: Fire Triangle – In order to create a fire, it needs fuel, oxygen, and sufficient heat. Conversely, eliminate one of the elements and the fire will go out. Source: author – [file:\FR-FireTriangle.cdr]

<b>**<u>Pyrolysis Process</u>** (Figure 5.1) – A burning candle is illustrative of pyrolysis process and how a fire actually burns. The wax or paraffin is the fuel. Careful inspection of a burning candle reveals that the wax is present as a solid, liquid and gas. It is the gas that burns. The solid (i.e. wax) must be converted into a gas where it combines with oxygen from the surrounding environment. The burning candle has sufficient heat to maintain the fire. In addition, the heat of the burning candle melts the wax converting it into a liquid. The candle's wick transports or "wicks" the liquid wax into the flame where it is converted to a gas by the flame and then it burns. It is the gas that burns, not the solid or the liquid.

The traditional candle snuffer is a small cone-shaped device with a handle on it that is placed over the burning candle. As the candle burns, the combustion process creates carbon dioxide (CO_2). When the snuffer is placed over a burning candle, the carbon dioxide fills the cone of the candle snuffer denying the burning candle the oxygen it needs. Without oxygen, one of the three necessary components is eliminated and the flame is extinguished. Careful inspection of the extinguished flame reveals the end of the wick is usually still glowing. It is smoldering. There is insufficient heat remaining to maintain the flame and to melt the wax. Hence, the flame is denied fuel. It quickly goes out. Without the flame, it has insufficient heat to maintain the flame.

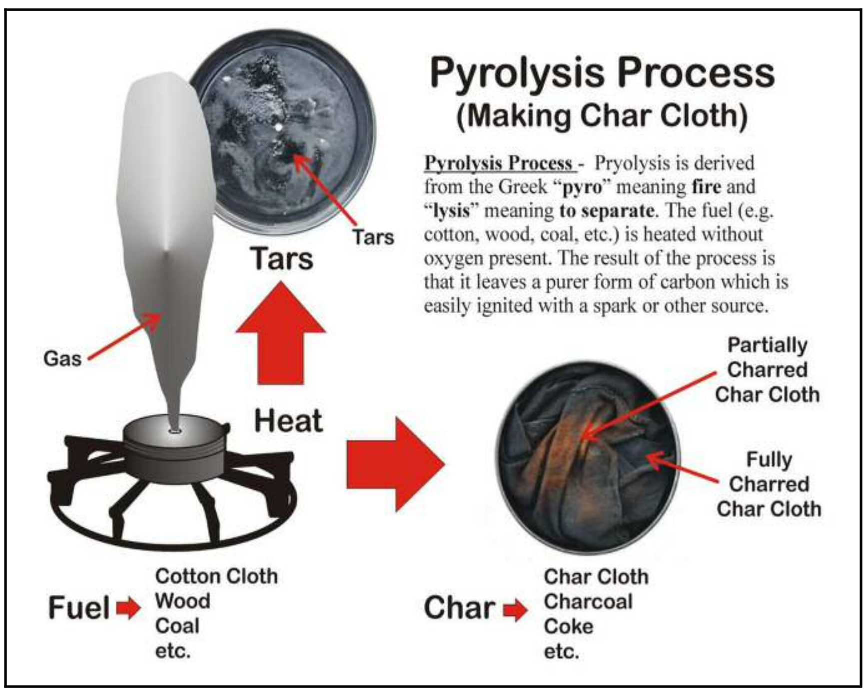

Figure 5.2:Pyrolysis Process – "Pyro" is Greek for fire and "lysis" is to separate. The pyrolysis process results in the fuel becoming a purer form of carbon. Source: author – [file:\FR-Pyrolysis.cdr].

<b>**<u>Building a Fire</u>** – A fire is built carefully. It is not thrown together. Conceptually, it is fairly simple. The objective is to raise the temperature of the fuel to a temperature where the pyrolysis process can

sustain itself. In practice, it is not so simple unless a blow torch or petroleum products are used. For discussion purposes, there are three phases. The first is the initial source of heat. Essentially, it is the spark or initial friction as discussed. The second phase is igniting the tinder. The third phase is creating a fire that is self-sustainable. All that needs to be done in this phase is add fuel to the fire.

<c>***Initial Source of Heat*** – There is an initial source of heat. Usually, it is the result of friction and chemical action. The flint striking against the steel creates a spark of burning metal. Lighting a match creates friction with powdered glass embedded in the head against the striker that ignites the sulfur in the match head. The electric energy from a battery heats the steel in steel wool to the point where the steel begins to burn.

The initial source of heat can be divided into four phases (Figure 5.3). The first phase is the initial source of heat as previously noted. The second phase is the smouldering phase. There is sufficient heat for the fuel to burn, but there is no flame and it is not sustainable. When using a bow-drill, this phase occurs when the sawdust is heated to become a smouldering coal. There is plenty of smoke produced but there is no flame. When a match passes over the striker, this phase occurs fairly quickly as the match ignites. The third phase is when the gas ignites. Blowing on the glowing coil produced by the bow-drill creates a glowing coil that may easily transform into a small flame that is used to light the tinder. The match lights and its flame lights the tinder. In the four phase, the fire becomes self-sustainable. As long as fuel is added, the fire has sufficient heat to maintain itself.

Figure 5.3: The Pyrolysis Process and the Four Phases of Starting a Fire

Phases:	Characteristics:	Notes:
1st Phase – Initial Source of Heat	Can be friction generated, a chemical reaction, or both	1) Bow drill is an example of a friction only device. The spark from flint and steel is the result of friction.
2nd Phase – Smoldering	The fuel is burning but no flame is present	1) Fuel is burning but no flame is present (i.e. smoldering) 2) Fire is not sustainable
3rd Phase – Gas Ignites	The fuel is burning and a flame is present	1) There is sufficient heat present to convert the solid or liquid into a gas, and the gas begins to burn. 2) Often increasing the oxygen (e.g. blowing on the ember) is sufficient to create a flame. 3) Lighting a match combines the first three phases within one act.
4th Phase – Self-sustaining	There is sufficient heat to maintain the flame as long as fuel is added to the fire.	1) With the addition of more fuel, the fire has sufficient heat and oxygen to maintain itself. 2) Add more fuel and if adding wood, gradually add larger pieces.

Phases can be bypassed. Using a butane lighter bypasses the smoldering phase. The spark directly ignites the vapor. It might even be argued that lighting a match bypasses the smoldering phase. However, occasionally, a lighted match smolders and doesn't ignite into a flame.

<c>***Tinder*** – When building a fire consider the following three principles. The first is to start small and get bigger. Twigs, give way to larger twigs and eventually to logs. This is self-evident but in practice, it is easier said then done. Second is the concept of sustainability. This means that there is sufficient heat present to maintain pyrolysis. The burning candle illustrates this concept. The candle's flame creates sufficient heat to melt the wax and transport it up the wick to burn. The heat of the candle's flame is sufficient melt the wax, transport it, and maintain the flame at a constant level. The candle continues to burn. It is sustainable. Third is a minor point but worthy of consideration. Different fuels burn at different temperatures. Be sure not to decrease the energy value of the fuel. The classic example is burning leaves which burn at a lower temperature than the twigs and branches used to burn the leaves.

<c>***Self-sustainable*** – The key element is that the fire has sufficient heat to maintain itself as long as sufficient fuel is supplied. The burning candle that continues to burn exemplifies self-sustainablity. Without a constant soft blowing on the glowing coil produced by the bow-drill, the glowing coil is not sustainable and will quickly go out. Usually, burning tinder is sustainable as long as additional fuel is added. But then that is the definition of self-sustainable.

<c>***Double the Fuel*** – Tinder burns quickly. Small twigs burn quickly. As a rule, double the twigs and fuel perceived to be needed to build a fire. This is an experience thing. It is easy to under estimate how quickly the tinder can burn. It is a common mistake.

Sources of the Initial Source of Heat

The initial source of heat can be generated one of several ways. Usually, friction is involved in some way in generating the initial source of heat. In a match, usually powder glass or a similar abrasive creates sufficient friction to ignite the chemicals. In the bow drill, the friction of the twirling spindle raises the sawdust created to its ignition temperature. The flint in flint and steel strikes the steel. The small flake of steel is ignited by the friction of the striking action.

<b>**Flint and Steel** (Figure 5.4) – Flint striking against steel produces a spark of burning steel in the range of 2,498ºF. Although it can ignite small tinder, this author prefers directing the spark onto char cloth or steel wool. The striker is made from high carbon steel.

The striker is held in one hand, The flint is struck downward against the steel striker. The flint peals off a small flake of steel. The friction ignites the small flake of steel. It is rapid oxidation. Care needs to be taken when striking the striker with the flint. The flint is sharp and it can easily cut the hand holding the striker. With a little practice, the use of flint and steel to start a fire can easily be mastered.

Figure 5.4:Flint and Steel – Striking the flint against the steel can send a spark which is burning steel with a temperature of 2,498ºF. Source: author – [file:\FR-Flint&Steel05.jpg].

<b>**Bow-drill** (Figure 5.5) – The bow-drill is a sophisticated fire starting device. The literature suggests that a person can construct a fire drill using a pocket knife, and vines found in the woods. This author won't deny the possibility, but it is a hard device to use even under the best of circumstances. If a prepper thinks he or she is going to go into the woods and start a fire without prior experience, good luck.

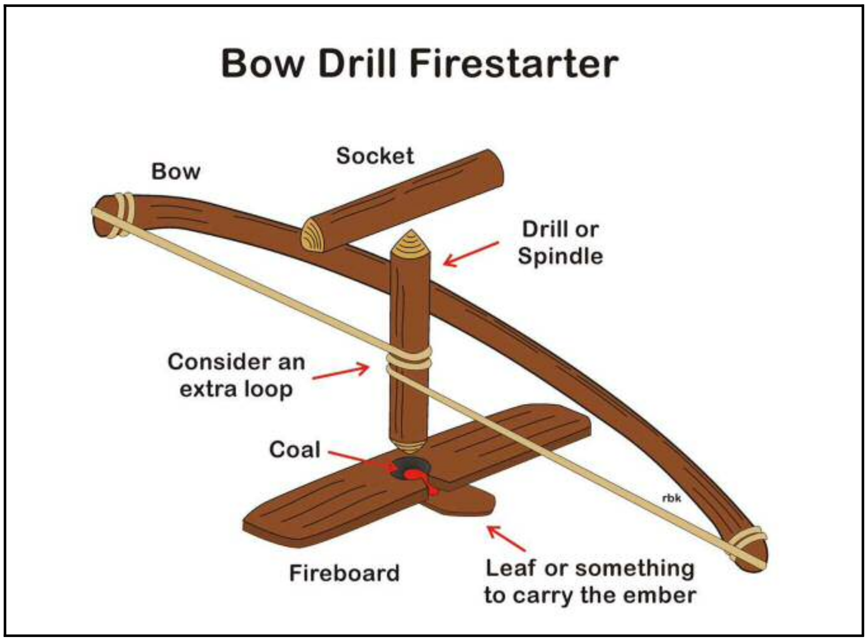

Figure 5.5: Bow-drill – Using a fire drill is not easy and requires considerable experience. Source: author – [file:\FR-BowDrill.cdr].

The bow-drill is a friction device. Conceptually, it is fairly simple to understand. The spindle is rotated by the bow creating friction between the spindle and fireboard. The friction creates sawdust which is heated to kindling temperature. The heated sawdust is collected in the cut "V" and begins to smoulder. Gently blow on the ember and transport it to the tinder. This can be a bird's nest or other small twigs. is

The color and texture of the sawdust is an indicator of the effectiveness of the bow-drill. A sawdust that is dark brown/black with a fuzzy consistency is an indicator that the system is working properly, It indicates that sufficient pressure is being applied on the spindle. A light brown thick sawdust is an indicator of inadequate pressure on the spindle and that it not rotating fast enough. A dark brown sawdust (i.e. not blackened) is an indicator of adequate pressure on the spindle but not adequate rotating speed.

Normally, the spindle and fireboard are constructed from the same type of wood. The wood should be non-resinous with a low kindling temperature. Yucca is considered the ideal wood because it is non-resinous and has a low kindling temperature (i.e. 200ºF). Other choices include aspen, buckeye, basswood, and white cedar can be used.

<b>**Ferrocerium Rod Fire Starters** (Figure 5.6) – Ferrocerium fire starters are found in the commonly found flints used in lighters and ferrocerium rods. "Ferro" is the chemical term for iron and "Cerium" is an element that ignites at the low temperature between 300ºF to 350ºF. When combined the mixture gives off burning

Figure 5.6: Ferrocerium Rod Fire Starter – The rod is composed of Ferro (iron) and the element, cerium. When scraped with a hard metal, the ferrocerium rod gives off hot sparks that can be used to start a fire. Source: author – [file:\FR-FerroceriumStick04.jpg].

sparks when scraped with a hard metal surface, particularly a high carbon steel.

<b>**Magnesium Fire Starters** – Magnesium fire starters are ferrocerium fire starters using magnesium rather than iron as the material combined with the cerium. Magnesium burns at 3,000 °F . Also, it burns longer than the iron in a ferrocerium rod.

Figure 5.7: Battery and Steel Wool – The battery provides an electric current that shorts out and ignites the steel wool. Source: author – [file:\FR-Battery&SteelWool07.jpg].

<b>**Battery and Steel Wool** (Figure 5.7) – The battery provides electric current. The steel wool provides a short circuit with some resistance. Steel wool comes in several different sizes. It is rated similar to the gauge system used rate the diameter of electric wire or shotgun pellets. Four ought (i.e. O_4) is the finest steel wool and is the grade with which this author has played. Thicker grades should work equally well.

Surprisingly, even small batteries can deliver sufficient current to ignite the steel wool. Small nine volt batteries work as do the one and one-half volt C or D cell batteries. The steel wool shorts out the battery and usually begins glowing near the terminals. The steel burns at a hot 2,498ºF which is sufficient to ignite tinder. A word of caution. Once a section of steel wool burns it leaves a cinder which won't ignite again if current is applied to it.

<b>**Matches** (Figure 5.8) – Matches come in basically two varieties, either safety matches or strike anywhere matches. In safety matches the red phosphorus in the striking surface converts into white phosphorus vapor that spontaneously ignites. The friction for powdered glass or a similar material in the head rubbing across the striking surface is used to create friction and generate the initial heat. In turn, the potassium chlorate in the head of the match decomposes and liberates oxygen which ignites the sulfur in the head. The match head burns, In turn, it ignites the wood or paper match stick. In a strike anywhere match, the phosphorus is contained in the head of the match along with the potassium chlorate and sulfur.

Figure 5.8: Matches – Waterproof, strike anywhere matches (lower left), waterproof matches (upper left), common kitchen matches (upper right), and wind proof matches (lower right). Source: author – [file:\FR-Matches03.jpg].

For preppers, keeping matches dry is important. They can absorb moisture which will render them useless. Storing them in a watertight

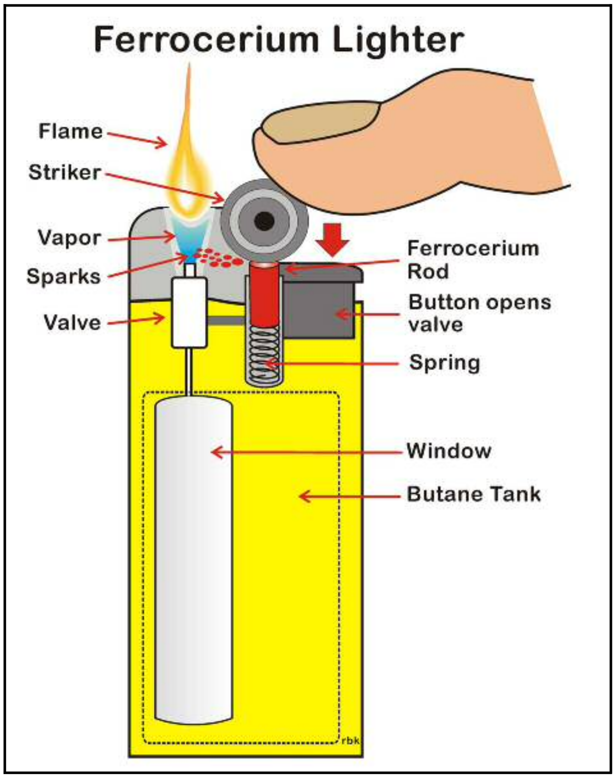

Figure 5.9: Ferrocerium Ignited Lighter – This is the traditional lighter where a striker wheel strikes the ferrocerium stick creating sparks that ignite the vapor. Source: author – [file:\FR-LighterFerrocerium.cdr].

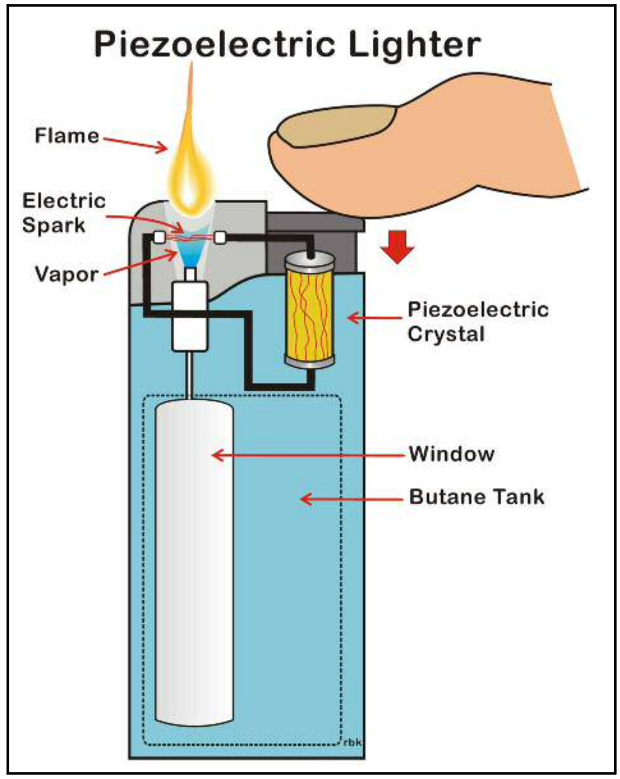

Figure 5.10: Piezoelectric Ignited Lighter – Pressing the button down puts pressure on the piezoelectric crystal which creates an electric charge and spark that ignites the butane vapor. Source: author – [file:\FR-PiezolectricLighter.cdr].

container is prudent. Also, matches can be waterproofed. If the match is waterproofed, both ends of the match need to be waterproofed. Moisture can be absorbed through the stick end of the match. Common waterproofing materials include dipping the match in paraffin, nail polish or lacquer.

<b>**Lighters** (Figure 5.9 and Figure 5.10) – Lighters have two major components the fuel and the igniter. Lighter fluid or butane are commonly used fuels. Lighter fluid requires a wick and conceptually, works similarly to a candle wick. In contrast, butane released under pressure vaporizes quickly and can be ignited directly.

There are two commonly used ignitor systems. The first is the traditional flint striker. It consists of ferrocerium which is a man-made flint like substance that ignites when rubbed against a rough metal surface (Figure 5.9). The second approach uses a piezoelectric crystal for its ignition system. When placed under pressure, the piezoelectric crystal creates an electrical current that ignites the gaseous vapor, usually butane (see Figure 5.10). The use of piezoelectric crystals have found their way into numerous appliances including butane lighters and ignition systems including outdoor grills.

<b>**Propane Tank** – Most home owners have a propane tank and flint starter used to solder copper pipes. It may be overkill when starting a fire, but that should not discount its use. It is mentioned here because it is easily overlooked as a fire starting source. Don't overlook the steps used in starting a fire. Small tinder may be bypassed, but be sure there are ample quantities of larger tinder to grow the fire. Add larger pieces of wood as would occur with building any fire.

Tinder

Tinder is a readily combustible material. When building a fire, it is the first level of combustible material. The original source of heat is delivered to the tinder. Several of the more readily available materials that can be used as tinder are presented. When building a fire without many of the modern petrochemical products, tinder becomes an important component in building a fire. When using these petrochemical products such as charcoal starter or gel strips, the tinder phase is often bypassed. Not all sources of tinder are covered here.

Figure 5.11: Char Cloth – Using the pyrolysis process, the cotton cloth is heated without oxygen. The lighter colored fabric is not yet fully processed. Source: author – [file:\FR-CharCloth03.jpg].

<c>***Char Cloth*** (see Figure 5.11 and see Figure 5.2) – Char cloth is made using the same process used to make charcoal from wood or coke from coal. It is the pyrolysis process. "Pyro" is Greek for *fire* and "lysis" means *to separate*. Place cotton cloth or a similar material in a small canister. Drill a hole in the lid of the canister. This allows the gases to escape during the pyrolysis or charring process. The cotton cloth or a similar material is heated to high temperatures without oxygen. Denied oxygen, the material can't burn. The high-heat without oxygen separates and drives out the tars and gases leaving char cloth. Char cloth is a purer form of carbon than the original cotton cloth.

Figure 5.12: Bird's Nest – Most bird nests are constructed from densely interwoven twigs that makes them an excellent fire starter. Source: author – [file:\FR-Bird's Nest.jpg].

Char cloth works well with flint and steel. For this author it works better than hemp and other materials. In Figure xx0502, the canister is being heated on a stove. In the frontier days, the canister was placed in the campfire and retrieved after the process was completed.

<c>***Bird's Nest*** (Figure 5.12) – Most birds construct their nests using small twigs and grass. A birds nest provides an excellent source of concentrated twigs and makes an excellent fire starter. In a very real sense, they have done all the work gathering all the twigs.

<c>***Birch Bark*** (Figure 5.13) – Birch bark contains an oil which burns hot. When it burns, the burning oil in the bark gives off a black sooty smoke. The bark can easily be harvested from dead birch trees. The oil in the bark acts as a preservative and the bark is waterproof. Because the bark is waterproof, the tree literally rots out inside the bark. In the woods, the bark of the trunk can be found supporting a rotting interior where without the bark the tree would fall to the ground. When harvesting the bark from live

trees, cut the outer layer of the bark. This doesn't kill the tree and leaves the inner bark intact. The bark can be stored in ziplock bag or since it is water resistant, by itself.

There are several species of birch trees. The most common is the white birch which is naturally found in the northern states with their cooler climates. It is identified by its bright white bark. Other birch trees include the river and yellow birch trees. The bark from any of the birch trees can be used as a fire starter. Since birch trees are popular ornamental trees used in landscaping, they are readily available in time of emergency. The fire starter may be growing on the front lawn.

Figure 5.13: Birch Bark – Birch bark contains an oil which burns with a hot and black sooty smoke. It makes an excellent fire starter. Source: author – [file:\FR-BirchBark.jpg].

<c>***Pine Knots*** (Figure 5.14)– The resin in dead pine trees drains toward the trunk of the tree where it collects. The resin preserves the knot and the rest of the tree rots away around it leaving the resin rich knot intact. In theory the resin rich knot is supposed to burn like a fire starter with intense heat. The pine knots are also called fatwood. This author has had little success with using pine knots.

Figure 5.14: Pine Knots – Pine knots are resin rich which in theory makes them good fire starter. This author hasn't had great success with their use. Source: internet – [file:\FR-PineKnots.jpg].

Summary

This section focuses on starting a fire using primarily primitive technologies. The section covers several of the more common methods. The take-away is that if anyone is planning to utilize some of the primitive technologies like flint and steel or a bow drill, practice with them prior to being immersed into an emergency situation when one has to rely on using that technology to create a fire.

If there is any doubt, buy several boxes of matches and store them in airtight containers. This author has several boxes of unused waterproof wooden matches that are over ten years old. They work as well today as they did ten or fifteen years ago. That is good insurance and reassuring. In addition, this author likes the butane lighter with a piezoelectric crystal igniter. It is simple and effective. This author still hasn't mastered the bow drill. There has been lots of smoke, but no ember.