Throughout the 20th Century, the impact of industry and mankind�s needs have lead to the destruction of many ecosystems. These effects on the environment are serious, due to the fact that their effects are tied together. For example, the burning of rainforests in Brazil and other tropical nations in pursuit of more lands for agriculture, not only damage the ecosystems of Brazil, but also it contributes to global warming. Due to the fact that global warming raises temperatures of the earth, and effects worldwide climates, it is an excellent example of how a single event in one part of the world can affect us all. My research project is related to these problems. The question that I ask is what impact does the process of making paper have on the environment, and what resources are available to substitute the use of trees for the creation of paper.

The importance of paper to society is essential. Paper allows the expression of ideas and thoughts, as it also facilitates communication. Therefore, forms of primitive paper existed prior to the invention of paper in the middle ages. The first type of written communication that used a substance like paper were clay tablets used by the Sumerians around 4000 B.C.[1](http://docs.google.com/biblography.htm) However, this method was difficult to use and was difficult to transport. The first type of paper that used plant materials was tree bark. Many cultures, like those in the Americas, Himalayas, and the Pacific used tree bark as a form of paper. Often, the bark was moistened and then beaten, after which the bark paper could be written upon.[1](http://docs.google.com/biblography.htm) Another primitive form of paper was the use of leaves, like palm or bai-lan. For example, civilizations in India and Southeast Asia would flatten, beat, and smooth these leaves, which would, then scratched upon, forming writing. Other primitive forms of paper were more advanced and are more like the paper that is used today.[1](http://docs.google.com/biblography.htm) One such example was the use of the *Fatsiapapyrifera* plant, in which the inner pith of the plant was cut spirally away from the plant, which could then be used as a form of paper. This form of paper existed Asian cultures, and was often used as the paper for Chinese paintings. [1](http://docs.google.com/biblography.htm)

The origin of the word, paper, comes from Greek and Latin roots for papyrus. This plant was used to create a form of paper that would be used extensively in Egypt and the Mediterranean. Papyrus was created by first harvesting and peeling the triangular stalks of the plant. Then the pith was sliced away and pounded together, forming strips. Next a second layer of pith was applied perpendicular to the first and pounded together, forming the paper.[1](http://docs.google.com/biblography.htm) While Papyrus acted as major type of paper in Europe and the Middle East for several hundred years, paper was first invented in 105 AD in China. This process used the waste materials from hemp, a form of cloth, to create the paper. The hemp was washed and beaten to a form of pulp, which was then dried to create the paper. This process is the basic form of paper, as it is still used today in the modern papermaking process. As the process spread across Asia, from China to Korea to Japan, the types of plant materials that were used in the process were varied. Among the different materials used were bark, hemp, bamboo, rattan, mulberry, rice straw, and seaweed. Ultimately, the process of making paper spread to Europe. [5](http://docs.google.com/biblography.htm)

*On the left is a bark book created by the Batak, and on the right is a bark cloth from Tonga.*

The process of papermaking was initially adopted around 10th and 11th Centuries, however, the process did not spread throughout Europe until the 12th Century. The Europeans used cotton and linen rags as the form of pulp for the paper. The rags would first be cleaned and treated in a hot alkali solution. Next, the rags would be washed and mashed into a pulp, and then bleached to remove any stains from the mixture. A wire mesh in a frame for the shape of the paper would remove some of the pulp, which would then be pressed and dried.[1](http://docs.google.com/biblography.htm) One problem with this method was that a ready source of rags was needed in order to produce the paper. With the introduction of the process of using wood fibers from trees, rags were no longer used in the process of making paper, since the wood could be more easily obtained. In order of the tree and then grind the wood into a pulp, which could then be dried to form paper.[5](http://docs.google.com/biblography.htm)  This process continues to be used in today�s modern paper mill.

*A modern day paper mill, with the drying rollers seen above.*

*A logging operation in Montana*

In a modern paper making process, the process of making paper is long and complex. At first, wood in the forms of trees, are stripped of their bark and then chipped into small pieces. These pieces are then feed into a digester, in which sodium hydroxide and sodium sulfate remove the lignin from the cellulose fibers in the wood. The cellulose fibers are removed and then bleached to form a whitish pulp. These fibers are then pressed and heated to aid in the process of holding the fibers together in the paper. The pulp is then passed down a moving mesh in which allows water to leave the pulp and then the paper is pressed to remove additional water. A series of heated drums then dry the paper, which is later sorted and cut according to the type of the paper.[3](http://docs.google.com/biblography.htm) This efficient process of paper has aided in the increase in use of paper throughout our society. The great demand paper leads to a large impact on our environment.

Algae may be an intriguing alternative source of paper, due to the fact that fact that algae can grow at fast rates in ideal circumstances. If it is a possibility that algae can be used in the paper making process, then its fast growth could allow for a cheaper, environmentally safe product. In any case, the chance that a form of algal paper can be made is high, since some species are very similar to the plant material that leads to the production of paper. In the normal use of a hardwood for the manufacture of paper, it is the vascular bundles that form the paper. Those vascular bundles are very similar to some types of algae, such as Spirogyra.  Spirogyra is a member of the division of Chlorophyta, often referred to the green algae due to its green color, due to the chlorophyll present. Spirogyra is a likely candidate in the use of a type of algae for the production of paper, since its shape is much like vascular tissue in plants. The organism forms long chains of cells that are cylindrical in shape. Paper is created by the tangling of plant fibers, and Spirogyra could provide a similar mat of tangled fibers. Therefore, in my research I will look at the possibility of the use of Spirogyra in as an alternative form of paper.

                                There are Four different types of Spirogyra:

The first consists of band form chloroplasts

The second consists of beaded chloroplasts

The third consists of straight chloroplasts

The fourth consists of folded structure

*A sheet of Papyrus detailing Egyptian hieroglyphics.*

The fact that paper is now created through the use of trees means that large numbers of trees must be felled in order to check the demand for paper. In fact, each person in the United States consumes about 675 pounds of paper a year.[1](http://docs.google.com/biblography.htm) Such a use of paper is similar throughout all the major industrial countries. For example, each person in England consumes about 193.6 kilograms of paper per year.[2](http://docs.google.com/biblography.htm) As a result of this consumption of paper, logging can have a large impact on the success of a natural forest, even with techniques that reduce the environmental impacts of logging. One possible alternative to logging is the growth of tree farms, in which fast growing trees, such as eucalypts trees, are grown for logging purposes.[4](http://docs.google.com/biblography.htm) Nevertheless, this process requires adequate land and nutrients for success. In addition, this process is more likely to face environmental difficulties, as the area is populated by a single tree, which leads to a lack of diversity in the ecosystem of the tree plantation. A single disease could kill many individual trees, due to the lack of diversity in the population. Yet, alternative sources could be effective means of reducing the impact of papermaking. While some alternative paper sources have been discovered to be less efficient or cause more pollution, it is important to continue research in alternative paper sources, as demand for paper will only increase in the future. In fact, the International Institute for Environment and Development recently proposed in report concerning the use of paper that research should continue to provide greater flexibility in the type of fibers available for the production of paper.[4](http://docs.google.com/biblography.htm) With my research project, I plan to look at the possibility of using algae as an alternative paper source.

*The first automatic papermill, a "fourdrinier" machine, named after its inventors, Henry and Sealy Fourdrinier.*