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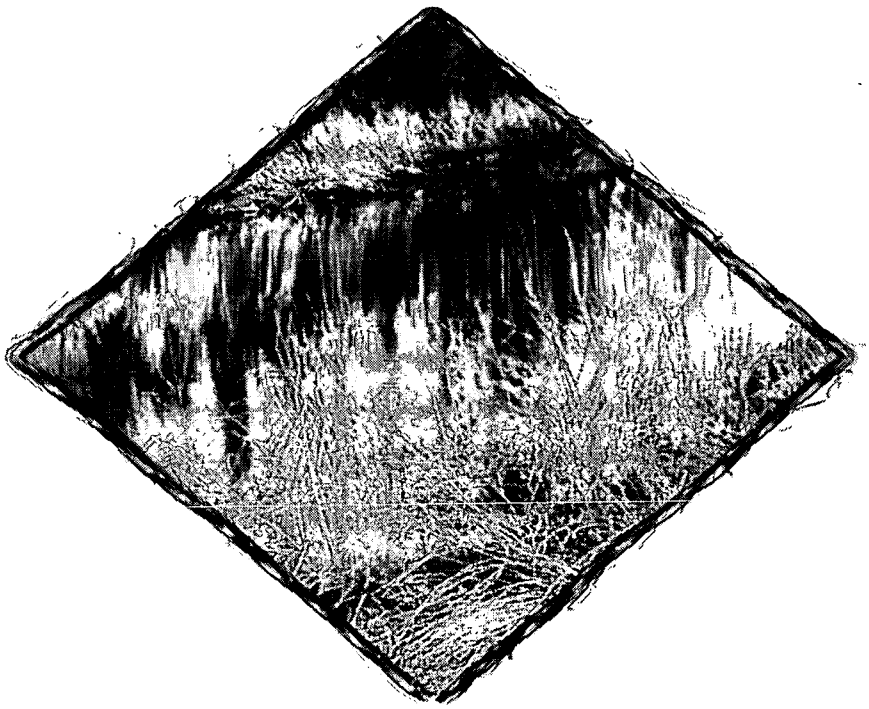
ABSTRACT

In addition to a historic overview of papermaking, this book explains the painstaking process of papermaking and details the results of actually making paper from samples of grass gathered from Arizona to Minnesota, and Maine to California, including 11 states and climates. The book describes how to teach papermaking and offers a list of equipment suppliers as resources for help getting started. A study of the effects of rainfall and altitude on the grasses used in making paper was conducted. The handmade paper shown in this book is only an example of what can be accomplished. Since there are so many different varieties of grass, this project has only scratched the surface of the potential for decorative paper made from grasses. The book is divided into the following sections: (1) "The Beginning of Papermaking"; (2) "Renaissance of Hand Papermaking"; (3) "Chemistry of Hand Papermaking"; (4) "A Little Bit about Grasses"; (5) "Papermaking from Grasses"; (6) "Papermaking Results"; and (7) "Teaching Hand Papermaking." (Contains 25 resources and 13 relevant Web sites.) (BT)

Papermaking:
Then and Now



Kathrine D. Vickerman

Papermaking:

Then and Now

A history of hand papermaking from
its beginning, plus a process for
using natural fibers to make paper.

Kathrine D. Vickerman, MA

Photographs by
Lyssa O'Riley

Papermaking: Then and Now

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Acknowledgments

Yes, this book is about making paper by hand but it also covers a lot more. It reflects institutional support of employees and the cooperation of departments working together. I believe this book reflects the cooperation of family and friends. It projects a variety of interests of many people. And, hopefully, it will become a resource for papermakers in the future.

Basically, projects like this cannot happen without help from many sources. In this case, I owe a great amount of gratitude to the Idaho State University Professional Development Committee for selecting my proposal. I also owe a large amount of gratitude to the Director of Academic Outreach, Karen Skinner, for supporting my professional leave. And my co-worker, Susan Williams, for taking up the slack in my absence.

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The wonderful photographs were taken by Lyssa O'Riley. This book would not be nearly as exciting without her work, time, and energy. When she agreed to be the photographer, I realized this project would really be a success.

Thank you to all,
Kathrine Vickerman

Introduction

In addition to an historic overview of papermaking, this book explains the painstaking process of papermaking and details the results of actually making paper from samples of grass gathered from Arizona to Minnesota and Maine to California - 11 different states and climates. The book goes on to describe how to teach papermaking and offers a list of equipment suppliers to help the novice papermaker get started.

Through a Professional Leave funded by Idaho State University, a study of the effects of rainfall and altitude on the grasses used in making paper was conducted. By traveling throughout the United States and by coercing friends and relatives to bring samples of grass, 30 different samples were taken. Each sample was 1 - 2 pounds of raw fiber (grass) to be processed as described in pages 31-70 to end up as sheets of paper.

The handmade paper shown in the book is only an example what can be accomplished. Since there are so many different varieties of grass, this project has only scratched the surface of the potential for decorative paper made from grasses.

The Beginning of Papermaking

Paper, according to the Webster's Dictionary definition, is "a substance made in the form of thin sheets or leaves from rags, straw, bark, wood, or other fibrous materials for various uses." Dard Hunter (1925) qualified that description by stating that true paper

> must be made from fiber that has been macerated until each individual filament is a separate unit with the fibers intermixed with water, and by the use of a sieve-like screen, the fibers lifted from the water in the form of a type of stratum, the water draining through small openings of the screen leaving a sheet of matted fiber upon the screen's surface. This thin layer of intertwined fiber is paper.

Although Hunter's description of handmade paper is lengthy, it describes the process which still remains much the same today.

Any attempt at understanding making paper by hand in today's world and the influences of nature on the fibers used, will be augmented by researching papermaking from the beginning. So, what do we think of in connection with paper? Material used for writing or printing, of course. In other words, a means for conveying ideas and thoughts. Was paper the first medium for doing this? No! Oral transmission was the earliest method of handing down information from generation to generation. This was, however, not a very satisfactory method of keeping the story straight.

In general, writing developed in three stages: pictographic writing, ideographic or hieroglyphic writing, and phonetic writing—first with syllabic signs and then with alphabetic characters. Although no exact date can be given for the development of writing, it can be traced through Egyptian and Babylonian artifacts to at least 4000 B.C.

The first records of writing have been found on stone, clay, metal, wood, wax tablets, ivory, leaves, bark, papyrus, and parchment. Engravings on stone have revealed information about the early Chinese civilization and the Ten Commandments were said to

be engraved on stone. Hieroglyphics stamped on clay tablets have produced most of the history of Chaldea, Babylonia, and Assyria. The Greeks used metal plates for their engravings but the Romans favored ivory. Other early writing materials included scraped leather and parchment made from skins of sheep and goats. The papyrus plant produced the closest approach to paper. Many papyri have been found in an excellent state of preservation in the ancient Egyptian tombs. The *Pisse* is said to have been written about 2500 B.C.

Those who write about the history of papermaking agree that it was invented about 105

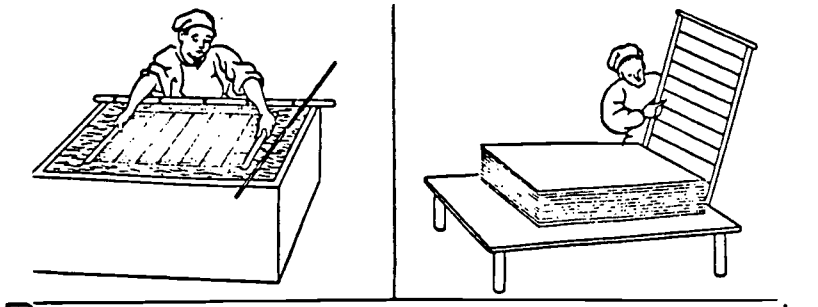
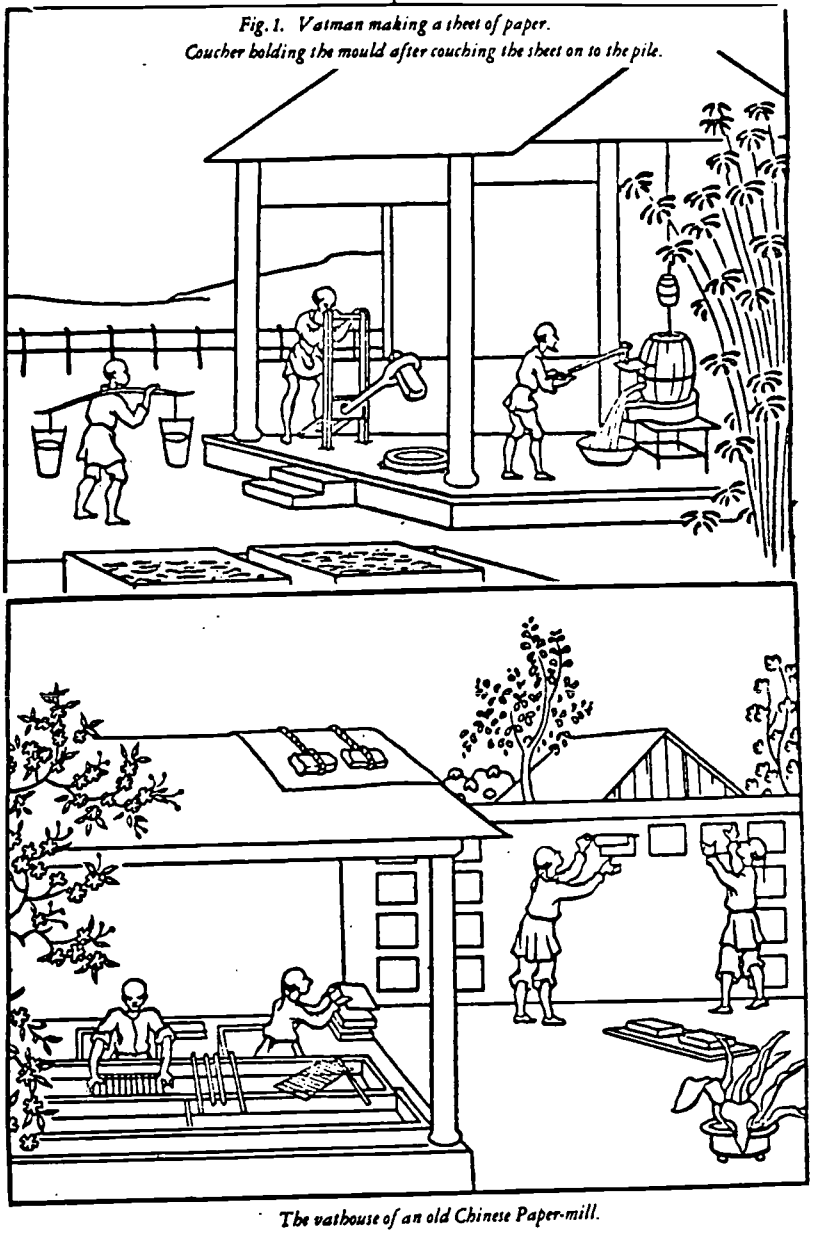


Fig. 1. Vatman making a sheet of paper.
Coucher holding the mould after couching the sheet on to the pile.



The vathouse of an old Chinese Paper-mill.

A.D. in China. The credit is generally given to Ts'ai Lun, a eunuch of the Imperial Court. Lun's method of papermaking was based much the same as that of wasps. Wasps chew plants to make their nests, producing a material much resembling paper. Lun suggested the use of old silk garments, pulped and made into sheets to be written on with ink in place of the bamboo tablets and stylus then in use. Whether he actually invented papermaking or just reported it to the Emperor, Lun is honored in history for his role in developing a material that revolutionized his country. Eventually Ts'ai-Lun was given the honorary title, Marquis of Long-Ting, and the government gave him as salary, the land tax and the crops of three hundred villages. Alas, fame and a place of stature was, even then, hard to hold onto in China. As the story goes, Ts'ai-Lun got himself crosswise with the next Emperor and poisoned himself.

Early Chinese paper appears to have been made from a suspension of hemp waste in water; then washed, soaked, and beaten to a pulp with a wooden mallet. A paper mould, probably a sieve of coarsely woven silk stretched in a four-sided bamboo frame, was used to dip up the fiber slurry from the vat and hold it for drying. The sheets were dried in an oven. Later a smooth material (probably finer woven silk) was used to cover the mold which allowed the papermakers to free the newly formed sheet to dry on a flat surface, usually the walls of their houses. This not only increased production of paper but produced a much finer paper. The Chinese called their folded sheets a *pan* and the flat sheets a *fan*. One hundred sheets of paper made a *tao*, five hundred sheets a *ta-tao*. Eventually, tree bark, bamboo, and other plant fibers were used in addition to hemp.

Documents found by Sir Aurel Stein at the Lop-Nor site in Turkestan show that the Chinese quickly brought the art of papermaking to a high degree of perfection but after the middle of the 8th century the quality of their paper rapidly deteriorated. The oldest paper, about 151 A.D. was very thin, transparent, and of a very white color. In the 5th century the papers were all thick and of a dull buff color, while those of the latter half

of the 6th and the 7th centuries were golden yellow and once again thin. Towards the end of the 7th century the papers became more brittle and hard; the fibers were not so long and the paper was more easily torn. By the beginning of the 8th century the paper was thick, flabby, and of dull buff color with an uneven texture that gave a poor resistance to ink. This deter- ioration in paper quality would indicate that good raw material became harder and harder to find.

Although papermaking was a closely guarded secret in China for 500 years, thr process migrated to Korea sometime around the 6th century A.D. Paper pulp in Korea was prepared from fibers of hemp, rattan, mulberry, bamboo, rice straw, and seaweed. Eventually a Buddhist monk, Dokyo, from Korea introduced papermaking to the Japanese. Dokyo was chief physician and adviser to the Japanese Empress Shotoku. To Shotoku's zeal for Buddhism the world owes its first certain and clearly attested record of printing upon paper with wooden blocks. The Empress ordered the printing of a million charms to be placed in a million tiny wooden pagodas in about 770 A.D.

As papermaking moved to Japan, three plants were discovered that produced thin translucent papers of exceptional quality. The first and most common paper was made from the inner bark of the mulberry tree—called kozo. Later, gampi and mitsumata were produced from the inner fibers of small shrublike plants—Witzstroemia canescens and Edgeworthia

An old Japanese Paper-mill showing all the processes in operation.

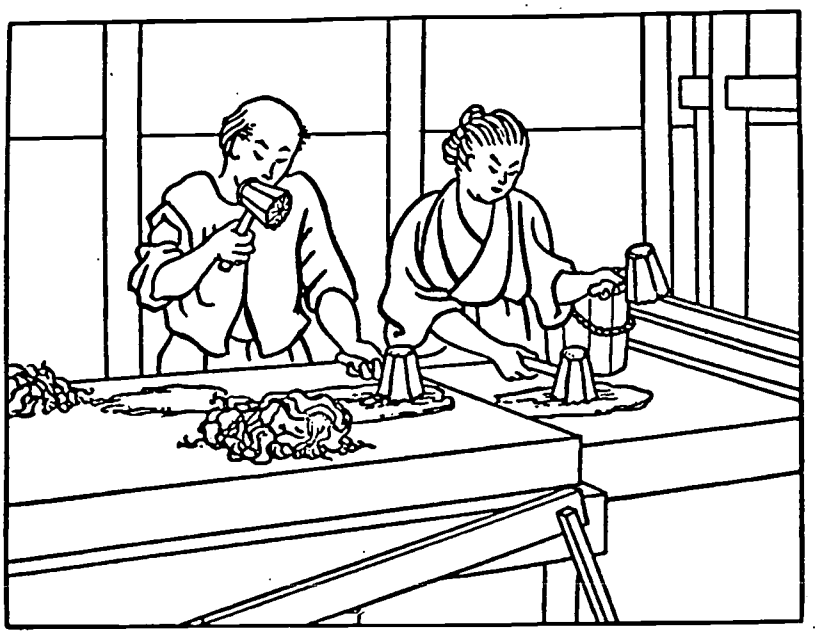
papyrifera. At first the Japanese used paper only for official records and documentation.

Washi is the Japanese word for paper. It does not stand for rice paper only, as has been observed in Western thinking. Actually, rice had almost no place in Japanese papermaking until the 17th century. Washi, to the Japanese, was a material and a medium of expression, yet it was also an expression in itself—it occupied a place where man's inner world and his external statements meet. Washi was more than experiencing a special beauty. It was viewed as warm, tender, human, quiet. The Japanese added a spirituality to hand papermaking, often using it for clothing and accessories. They

The vatman making a sheet of paper on the mould.

believed paper lived harmoniously with nature; their homes were never built without it.

The recorded Japanese attitude toward paper and papermaking support what Toale writes in his book, The Art of Papermaking (1983). According to Toale, "the Japanese believe that the beauty of paper lies in the suppleness, transparency, surface qualities, and strength of the sheet." To achieve this quality of paper, the process was laborious and time consuming. Traditionally, the plants were cultivated during the spring and summer, then papermaking became a fall and winter activity after plants were harvested.



Beating kozo pulp with wooden hammers or mallets.

In 751 A.D. the papermaking skill spread via a war to Samarkand. Samarkand was in possession of the Turks, but two Turkish chiefs quarreled. The Turks of Ferghana appealed to the Chinese for help against the Turks of Tashkand and between them they subdued Tashkand. The neighboring Arabs did not approve of this and the Arab governor of Khorasan made war against the Turks of Ferghana and defeated them, pursuing them as far as the frontiers of China. In this pursuit they captured Chinese prisoners, some of whom were papermakers. The prisoners were forced to divulge their trade secrets and teach their craft to the Arabs.

The Arabs called paper *Kaghadh*, a corruption of the Chinese name of *Kak-dz.* Later they adopted the Persian word *Kaghad* for paper—a curious word also used by the Indians— modified to *Kaghdi*, which was derived from the word *Kagh* meaning noise. This, perhaps, alluded to either the rustling sound made by paper or the noise of the stampers or hammers of the paper mill.

The Arabs or Samarkandis made their paper from linen rags. Linen, which is woven from flax and has fibers approximately one inch long, was the strongest Arabs until the 17th century when cotton was introduced and mixed with it. No paper from around the 10th and 11th century had any trace of cotton. It was made entirely of hemp and flax, woven first into linen and used only after it had outlived any other purpose.

From Samarkand, papermaking spread to Bagdad in the 8th century and into Damascus, Egypt, and Morocco by the 10th century. In Egypt, the seat of the papermaking industry was Cairo. In 1437 there is mention of a paper market in Damascus, where paper, pens, and ink were sold. Besides Damascus, the paper industry flourished at Tiberias, Tripoli, Hama, and also Hieropolis.

According to official documents of Kashmire, papermaking was introduced into the country by King Zanulabin (1420-1470). The King himself brought papermakers from Samarkand and gave them facilities in Kashmir. Records show that he made a special journey to Samarkand to get the papermakers, giving them lands in suitable places in which to settle. Kashmir paper was for many years highly prized in India, being largely used in the court of Moghul Emperors. Four qualities of paper were usually made:

1. *Famashi*, made from pulp containing two parts of hemp to every seventeen parts of rag (linen). This paper was very fine, with a high glaze.
2. *Dabmuchti*, made from pulp containing three parts of hemp fiber to 117 parts of rag.

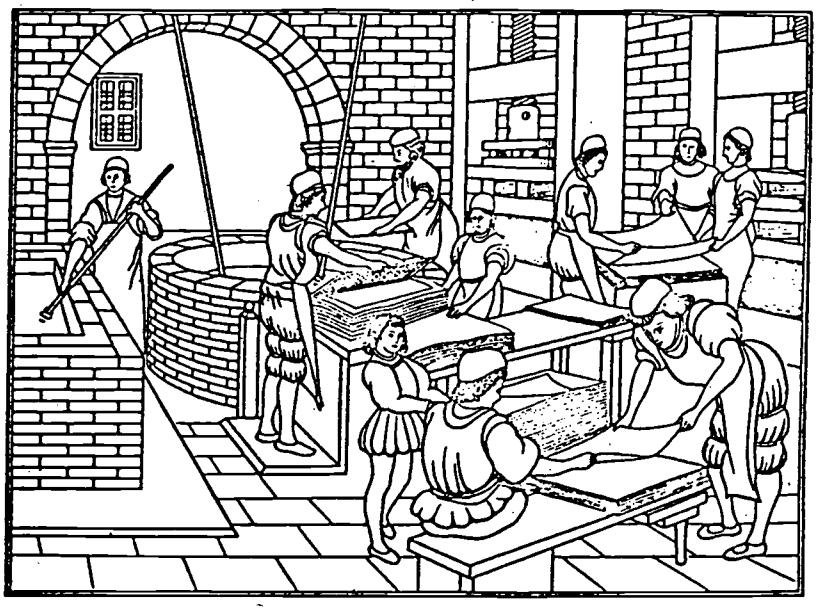
3. *Kalamdani*, the paper in general use, contained no hemp and was usually sold in the bazaars.
4. *Rangamez*, a colored, rough paper used for packing purposes.

India followed the example of most other countries in failing to hand down any records of the early history of papermaking. Although very little is known of the early history of papermaking in India, it is certain that many thousands of people were employed in mills in various parts of the country. Their raw materials appear to have consisted mainly of jute, hemp ropes, and rags. Most of the paper made in India was used for account books by merchants and moneylenders. Records show that the Indians never quite approached the Chinese or Japanese in skill as papermakers.

One account of the process used in India describes the paper made as very inferior, made by very simple procedures. A shallow well eight feet in diameter and four feet deep was dug; a block of hard wood inserted into the middle. A heavy hammer or wooden beater was placed on the side of the well poised so that a man standing on its center could move it up and down by lifting either leg, causing its head to fall on the wooden block, beating into a pulp the materials used for papermaking. A second man stood in the well to keep the materials to be beaten in the proper place. Apparently, the Indians used anything they could get for paper, such as old cloths, old tents, and any other available material. When rags were not available they used the bark of shrubs. After the pulp was sufficiently beaten, it was mixed with a little quantity of water in reservoirs. The workmen dipped their moulds (made of thin shreds of bamboo) into the vats, removed the sheet of paper, and hung it up to dry.

For nearly 60 years, Great Britain put such restrictions on the making of paper in India that it nearly died out. In 1882, John Lockwood Kipling, father of Rudyard Kipling, protested the use of imported paper and the fact that the British required local paper be sold at a much higher price, but to no avail. After World War II, however, all

restrictions on papermaking were lifted starting a revival of the traditional crafts which Mahatma Gandhi had launched in 1930.



The vatroom of a paper-mill at Fabriano in the middle of the 15th century. All the processes are shown in detail; the sheet being made on the mould; a sheet being couched on to the felt; boys parting the sheets from the felts; men parting the sheets from each other; and the great presses.

The fact that it took nearly 500 years for papermaking to reach Europe is not too surprising. Early paper was disfavored by the Christian world as a manifestation of Moslem culture; a 1221 decree from the Pope declared all official documents written on paper were invalid. It does appear that papermaking was introduced in Spain by the Moors who had mills at Zativa, Valencia, and Toledo about the middle of the 12th century. Spain was probably the first European country to manufacture handmade paper. The town of Zativa was an important center of paper manufacturing around 1144. According to Clapperton (1980) "paper there was prepared as nowhere else in the civilized universe, and was sent both East and West." However, on the fall of the Moorish power, the industry passed into the hands of the less skillful Christians, who made inferior papers.

Italy was probably the second European country in which papermaking was practiced. The earliest evidence of papermaking shows that paper of excellent quality was being made, and a large number of mills were firmly established for a good many

years at Fabriano by 1270. According to dated documents, a paper mill there was given to the monks of the monastery of Montefano by a certain Temperanze d'Albatuccio in 1278. In 1980 on this same site, one could see the enormous paper mills of the Cartiere Pietro Miliani, one of the largest concerns in the world engaged in the manufacture of handmade and machine made paper of every description.

Many of the Italian papermakers started to emigrate because of the great demand for paper in foreign countries. The departure of so many of the craftsmen became such a serious problem toward the end of the 14th century that several decrees were passed prohibiting this emigration. Too late! Papermaking was on the move.

A very romantic story of the introduction of papermaking into France is as follows: Jean de Montgolfier went to the Crusades and was unfortunate enough to be taken prisoner, and to be kept confined for some years in the city of Damascus. In this civilized and busy city he had ample opportunity for observing the Saracen arts and crafts, and he became interested in their method of making paper. When he was released from captivity he returned home to France, bringing with him a knowledge of the art of papermaking and, thus, established the paper industry in France.

Old records show that in 1190, Raymond, bishop of Lodeve, gave permission for one or more paper mills to be constructed in the Herault region, on condition that an annual quitrent of three measures of barley be paid to him.

Once the papermaking industry became established in France, trouble arose over the difficulty of obtaining rags, the only raw material then in use. This trouble created constant anxiety for papermakers and retarded papermaking in every country, almost as soon as the art was started. Even in the early days in France, papermaking came under government control. In 1398 the French papermakers at Troyes were diminishing the size of their molds so the paper was reduced in size "about one good finger in width and breadth," and were also counterfeiting the signs of one another. In order to control the

thievery, authorities ordered that all papers should be of definite dimensions, that none should make better paper than the others, and that each should have a different sign with which to sign his paper.

An old German paper mill, from a 16th Century woodcut.
Courtesy of Dard Hunter Paper Museum of M.I.T.

In 1799, the Frenchman, Nicolas-Louis Robert invented a machine in which the pulp was delivered to an endless traveling wire cloth by a sort of revolving fan, passed between small squeeze rolls, and wound up in the wet condition in a roll. This was then removed, the paper unwound, passed through press rolls, and hung up to dry. The rights to all the

machines were later acquired by Henry and Sealy Fourdrinier, who had financed and promoted the machines. Thus, the new invention became known as Fourdrinier Machines.

There is a great deal of conflicting information regarding the actual establishment of the papermaking industry in Germany and the different dates given vary by as much as 70 years. Some writers claim that Cologne and Mayence had the earliest mills (about 1320). Others declare that Augsburg was the original place. The diary of the papermaker who built and equipped the mill in Nuremberg shows definitely, however, that paper was made during the 14th century there. This mill was established by Ullman Stromer, probably a merchant, who in the course of his trading journeys to Northern Italy had seen paper mills in operation.

Although paper seems to have made its first appearance in Holland during the early part of the 14th century, it was imported from Italy and France. The first attempts to manufacture paper in Holland were made towards the end of the 15th century, when imported paper had deteriorated in quality and became difficult to obtain as a result of the violent conflicts taking place in the Republic of the United Provinces. Also, this inferior quality paper became very expensive.

The apparent founder of the papermaking industry in Holland in 1613 was a Frenchman, Martin Orges. An inscription on his tomb says that he was 'the earliest maker of paper in Guelderland.' However, the famous white papers of Holland which made such a reputation for the Dutch papermakers of the 17th and 18th centuries were made in the Northern districts. Holland's biggest mark in the papermaking industry though, came with the creation of the Hollander Beater. This was the greatest advance in papermaking that had taken place since the invention of the craft in China about 1500 years earlier. Up until this time, papermaking material had always been pulped by means of stampers, a slow and costly procedure. The Hollander Beater revolutionized

papermaking and was the first step toward the mass production of paper which was soon to follow.

Papermaking came to England relatively late and was one of the results of the Edict of Nates, published in France at the end of the 16th century, permitting the toleration of Protestants. When the Edict was revoked, Protestants (many of them Huguenot papermakers) fled for their lives from France to England.

Some records say the first English papermaker was John Tate, who established a paper mill near Hertford about 1490. Paper made by Tate was used for a *Bull of Pope Alexander VI* in 1494 and also for the supplement to it in 1495. Tate's paper was used for an edition of Chaucer in 1498, and for de Word's edition of the *Golden Legend.* Tate's venture into papermaking, however, did not succeed.

Papermaking had to undergo a change that converted it from an Eastern writing material to a Western material able to take the water-based writing inks made with ox gall and lampblack. These substances had a somewhat acidic nature which permitted the use of a quill pen without scratching up the surface of the paper. Thus, the English chose macerated cotton or linen rags rather than raw vegetable fiber sized with glue to make paper. Through sorting, cleaning, and processing, the rags were macerated into a pulp. The pulp was then dipped to form sheets of paper. The sheets were stacked between woolen cloths and squeezed to remove excess water and then dried. Many papermaking ventures in England were not a success due to the scarcity of rags. Also, the English papermakers failed to produce paper of sufficiently high quality to compete in the current market.

Even though the English did not make superior paper and were not as successful as some other countries, the following poem illustrates that they did have great

admiration for the craft and recognized its worthiness. The following example is taken from a lengthy Old English poem of around 20 stanzas written by Thomas Churchyard in 1588.

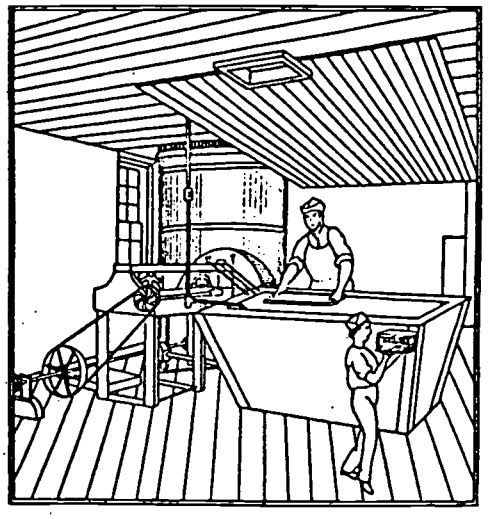
A DESCRIPTION and playne Discourse of PAPER, and the
whole benefites that Paper brings, with rehearsall and
setting foorth in Verse a Paper Myll built nere
Darthford, by an High Germaine, called
MASTER SPILMAN, Jeweller to the
QUEENES MAJESTIE.

When sence of man sought out what Science was,
And found each Art, through wit and study great,
Before long proofe could bring great thinges to passe,
In judging head did many a hammer beat:
But triall had, experience prooved good,
For practise skill, on certaine surety stoode:
Then ignorance blinde gave learned knowledge place,
So studious mine gaynde glory, wealth and grace.

I prayse the man that first did paper make,
The onely thing that sets all vertues forth:
It shoes newe bookes, and keepes old workes awake,
Much more of price than all this world is worth:
It witnesse beares of frendship, time and troth,
And is the tromp of vice and vertue both,
Without whose helpe, no hap nor wealth is won,
And by whose ayde great workes and deedes are done.[1]

1. Reprinted from a unique quarto pamphlet housed in the Bodeian Library, Oxford.

The migration of papermaking to America resulted from the immigration in 1690 of a Dutch papermaker, William Rittenhouse, his son, Klaus, and William Bradford. Bradford later became New York's first printer and published the first newspaper in the colonies. Rittenhouse established the first paper mill in America on the banks of



Interior of an early American paper-mill.

Wissahickon Creek in Germantown, Pennsylvania. Rittenhouse's mill had a very small capacity and a day's work for three men might be 4.5 reams of newspaper, 20 x 30 inches. Thus, the mill might produce annually from 1200 to 1500 reams of paper of all sorts. Although this seems like a very small number, it should be remembered that newspapers were started only after 1700, and there was little correspondence and very few books creating very little need for paper. This mill remained the only one in America until around 1710. It should be noted that all paper was made by hand very much in the manner employed by the ancient Chinese, except for minor improvements. The pulp was placed in a dipping vat to which it was conveyed by buckets. The mould was dipped almost vertically into the pulp, turned to a horizontal position and raised evenly, allowing the pulp to collect on the bottom of the mould and the water to drain through. The excess pulp was allowed to flow over the back portion of the mould, which was surrounded by a removable edge or 'deckle,' which acted like a fence to retain the pulp on the mould. Inverting the mould onto papermaker's felt where the sheet would stay allowed paper to be made much faster than drying on the mould.

Because Great Britain objected to the establishment of any business which would interfere with her exports, the Stamp Act of 1765 was enacted. This was an attempt by Great Britain to control papermaking in the colonies and keep colonists under British

rule. The Stamp Act is said to have been a major contributing factor to the discontent of the colonists and may have precipitated the Revolutionary War.

By 1810, however, there were at least 185 paper mills in the United States. Mills began to spread throughout Pennsylvania and into the other colonies via fledgling papermakers who trained at the first established mills. One mill supplied Benjamin Franklin with large quantities of paper for his printing and publishing activities. Throughout the first 150 years of papermaking in America, the crying need of the papermakers everywhere was for rags, which were very hard to come by in sufficient quantities to keep the mills going. The shortage was more acute in America than in England. Judging by the appeals, resolutions of councils, advertisements in the press, and proclamations, the papermakers did everything possible to encourage the saving and collecting of linen rags. Apprehension about the supply of rags was evident in the creativity of advertising. Apparently, it was thought that poetry might convince the ladies to save, save, save.

Sweet ladies, pray be not offended,
Nor mind the jest of sneering wags;
No harm, believe us, is intended,
When humbly we request your rags.

The scraps, which you reject, unfit
To clothe the tenant of a hovel,
May shine in sentiment and wit,
And help to make a charming novel.

The cap exalted thoughts will raise,
The ruffle in description flourish;
whilst on the glowing work we gaze,
The thought will love excite and nourish.

Each beau in study will engage,
His fancy doubtless will be warmer,
When writing on the milk-white page,
Which once, perhaps, adorn'd his charmer.

Though foreigners may sneer and vapour,
We no longer forc'd their books to buy,
Our gentle Belles will furnish paper,
Our sighing Beau will wit supply.
A History of Lewis County in the State of New York (1860), p. 181—FB Hough

Despite the creative advertising, colonial papermakers faced a persistent shortage of raw material. Paper at that time was made from cotton, linen, and hemp; the primary source for these fibers was clothing. The frugal colonists, however, mended their clothes and wore them for very long periods of time. They were not in the habit of discarding their clothes for collection. The entreaties became official appeals by the colonial government once it was realized the shortage was critical. Alas, neither money nor patriotism could produce what was in short supply. Not only were rags scarce, they were generally in poor condition. Added to the poor condition of the rags was unfiltered water in the stamper, often laden with a variety of foreign matter. The resulting paper made by American papermakers was brown or dark in color, displaying a rage of impurities.

The first machine to make a continuous roll of paper was invented by the Frenchman Nicholas-Louis Robert and when it was imported to America commercial papermaking exploded. In 1809, amid great secrecy, Thomas Gilpin built the first cylinder machine in America at Brandywine Creek, Pennsylvania. It produced a sheet 30 feet wide at a rate of 60 feet per minute. The first Fourdrinier machine in the United States was imported from England in 1829 and erected in Saugerties, New York. The second was built in Connecticut by a mechanic, George Spafford, and his friend, James Phelps.

Because of the scarcity of rags, American papermakers began experimenting with alternative raw materials as early as the 1790's. Fibers tested included tree bark, bagasse, straw, cornstalks and finally woodpulp. It was not until 1844 that the groundwood

process came into being when Charles Fenerty of Halifax, Nova Scotia, created a sheet of paper to prove that wood could be reduced by a chafing machine and manufactured into paper. That same year in Germany, Keller patented a woodpulp grinding machine which he sold to Henry Voelter, who improved it by 1847. The Pagenstecher brothers imported two Voelter grinders and set up for business in Curtisville (now Interlaken), Massachusetts in 1867. This was the first commercial groundwood mill in the United States. Their first sale of pulp was to the Smith Paper Company of Lee, Massachusetts, at 8 cents per pound.

Although the Pagenstecher brothers did not establish the first commercial groundwood mill until 1867, experimentation on processes began much earlier. There were three chemical processes for reducing wood to pulp. The first was the soda process, developed in 1851 by Hugh Burgess and Charles Watt who secured an American patent in 1854. The first mill to use this process was built on the Schuylkill River near Philadelphia in 1855.

The second chemical method for pulp making was the sulfite process invented by Benjamin C. Tilghman. An improvement of this process was used by the Richmond Paper Company, built in 1882 at East Providence, Rhode Island.

The third chemical process for the preparation of fibers from wood was developed by Dahl in Germany in 1883. Other processes have been developed but these three processes account for the bulk of papermaking fibers in commercial production.

The 19th century saw more changes and progress in the paper industry than took place during all preceding time since the inception of the art in China. The foremost changes of this era were the development of the paperpulp machine and the use of wood and other fibrous materials as substitutes for rags. The modern paper mill is a highly complex industrial facility. Although the principles of papermaking have not fundamentally changed for many years, a papermaker from Imperial China or pre-

industrial Europe would be hard pressed to recognize his craft among all the equipment of a modern mill. The increased use of paper products required commercial production. Thus, handmade papermaking began a steady decline and nearly died out completely in the late 19th and early 20th century.

Renaissance of Hand Papermaking

The world of hand papermaking may never have surfaced again except for the dedication of one man. Dard Hunter, foremost authority on the history of papermaking, devoted his life to researching, collecting, writing, and publishing the world's history of hand papermaking and printing. In his book, Pioneer Papermaking in America (1952), Hunter states;

> When the paper-machine came into use in this country, the hand moulds, both plain and watermarked, were eventually cast aside as having served their purpose. The discarded moulds were soon adapted by the nearby farmers for use in sifting grain and many of the moulds were worn out and destroyed in this commonplace service.

To counteract the decline of hand papermaking, Hunter spent his life researching historical methods, wrote two books, and established his own hand papermaking mill on the Salmon Fells Kill, Lime Rock, Connecticut. By the time of his death in 1966, he was credited with a renaissance in hand papermaking that has since seen continual growth.

Both traditionally and historically paper has been used for practical purposes, first to record current events and then as a way to disburse information. The renaissance of handmade paper was advanced even more during the 1950's and 1960's when it began to be used as an art medium. Douglass Morse Howell is credited as the major source of the growth in awareness of paper's sculptural potential. Howell's original contribution was to focus attention on the nature of handmade paper in terms of the structure of its making.

He concentrated on processing linen and flax for paper without adding chemicals, using only water and the action of the Hollander beater. Howell was immersed in varieties of ways of forming materials which led to an exploration of papermaking unrelated to specific use. In other words, he simply wanted to see what would happen.

Most artwork in handmade paper is based to some degree on the premise that an idea can be found or amplified by examining a material and discovering how it behaves. The range of visual and tactile qualities possible through making paper by hand is dramatic. There are three approaches to papermaking: manipulation, pulp making, and metaphors in the procedures. Most emphasis is on manipulation of the paper pulp. There is an array of techniques for patterning and coloring pulp, spraying, stenciling, pouring, as well as adding embedments or layers of color, making embossments or casting freehand.

Pulpmaking has been accorded less attention as a way of controlling the final appearance of the work of art but once the pulp is made, alternatives proliferate. Casting is one example of an alternative use of papermaking pulp. Most cast paper is made by pressing prepared pulp, or by laminating small pieces of lightly pressed paper, into a plaster or latex mould which then functions on its own as a bas-relief. Paper pulp can be hand moulded or cast to assume almost any shape and size.

Many artists take inspiration from the pace and structure of papermaking procedures. They say the transformation of the raw fibers through beating, the wave of the pulp washing across the surface of the mould, the layering of sheets during couching, and the rhythmic, cyclic nature of the whole enterprise are perceived as metaphors.

Contemporary artists are interested in using plant fibers for their work because the fibers have unique properties like lustre, transparency, and great strength in very thin paper. Artists have gone beyond the paper surface to manipulate the pulp into aesthetic statements. This has resulted in the need for a broader spectrum of pulp qualities than

offered by the use of rag pulps and a greater variety than is offered by wood pulp. It is also important to note that plant fibers are more available than rag pulp and easier to process than wood.

Truly, the Chinese method of making and finishing paper is the same as that which is in use at the present time with only minor improvements in equipment. During the long journey of the art from the Celestial empire to Europe, through Persia, Arabia, Egypt, Morocco, and finally to America, the quality of the paper deteriorated badly. Most of the Arabic paper and all the European paper of the middle ages was much poorer in color, texture, surface, and general writing quality than was made in China one thousand years earlier. It is no wonder the art of hand papermaking gave way to industrialization.

However, a renewal of the attitude of ancient papermakers, to establish a rapport with the pulp which brings to the paper a harmony and texture that is unobtainable in machine paper, has become evident in the many papers used in sculptures and bookmaking. Lee S. McDonald wrote that he had witnessed an evolution "beginning with the revival of hand papermaking (almost a lost art) to papermaking concerns expanding to embrace the ecosystem." In the making of paper by hand, no one sheet must be like another, for the objective in the artistry of papermaking is not to make the same paper time and again. Folding and bending of paper and the shaping of prints has led artists to explore new fields with the side, front, and even the back of the paper becoming important to the viewing of the work.

The methods and materials emphasized in the process of hand papermaking possess the advantage of simplicity of equipment. They restore to the artist-craftsman a wholeness of control and involvement in the process of papermaking, beginning with the selection of raw plant materials, through appropriate methods of cooking and beating, to casting and sheet formation. The visual and tactile qualities of papers made from plant fibers are rich, diverse, and very distinctive. Variations of surface quality, sheet density,

and subtle coloration add substantially to the palette of the papermaker. Hand papermaking allows the artist-craftsman to use plant materials readily available in the area of residence and work.

The revival of hand papermaking in this country has been paralleled by an increased emphasis placed upon the book as a means of artistic expression. The renaissance of papermaking over the last two decades with artists and writers printing books on their own private presses has been phenomenal. Interest in small limited editions has been contributed to the revival of many of the traditional crafts associated with fine book production such as typesetting, bookbinding, and the handmade paper used for books. The handmade paper book has become a particular creative challenge to artists attracted by the intimate nature and direct involvement allowed by the papermaking process. A limited-edition book, utilizing handmade paper in its construction, is a book with its own character. For many artists the book presents an opportunity for sculptural expression and handmade paper itself becomes the subject matter.

In most countries of the Western world until the late 1950's, papermaking survived only in museums as a thing of the past. In India, China, Burma, and Thailand it was still alive, but barely. At present, only in Japan where a papermaker is deemed a "Living Treasure" does he get the respect deserved. Today, thanks to the devotion of Dard Hunter and others, hand papermaking has taken an upturn and there are several small mills/studios located across the United States. They not only offer handmade paper in many sizes and colors, but in addition, they sell supplies from raw fibers and prepared pulp to papermaking equipment. In addition, most mills offer papermaking workshops to increase their visibility. Thus, the art and craft of hand papermaking continues to experience a growth in interest and production.

Chemistry of Papermaking

What an astonishing chemical factory is the living plant! Utilizing the energy of the sun, it transforms inorganic materials—oxygen and carbon dioxide from the air, minerals in the soil, and water— into carbohydrates and also into chemically distinct materials such as the oils of the olive and the flaxseed. Through its roots the living plant absorbs water from the soil. Through microscopic pores in its leaves it takes in carbon dioxide gas from the atmosphere. With the aid of chlorophyll, the green matter found in all plants, and using the energy of the sun, water and carbon dioxide unite to form carbohydrate units and oxygen.

Careful study of a mature flowering plant will show that it is made up of structural elements of two kinds: fibers and cells which some say function much like bricks and mortar. The fibers and cells are aggregated together into compound tissues. The strength of paper made from plants is due to the strength and cohesion of the fibers, which may be natural fibers or fractions thereof.

There are two distinct categories of fibers: raw unprocessed fibers and partly processed fibers which can include ready-to-use pulps. Raw fibers are usually in the form of long, loose strands and are classified according to their location in the plant. These fibers require some kind of treatment, usually cooking in an alkaline solution to remove non-cellulose impurities as well as beating to render them suitable for papermaking. Bast or inner bark fibers, such as flax, hemp, and kozo, contain some of the longest fibers. Leaf stem fibers, such as abaca, sisal and yucca, offer a comparatively shorter range of fiber but still produce a strong, crisp paper. Kapok and cotton are examples of "seed-hair" fibers (covering around the seeds).

Processed fibers are cooked and partially beaten fibers (half-stuff) that are sold in dry, compressed sheet form and as woven rags. Cotton and linen fabric scraps, or rags from the textile industry, are good examples. Ready-to-use pulps are pre-beaten to

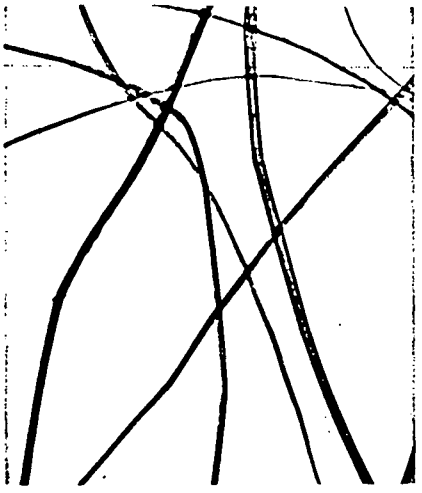
customer specification.

Raw fibers that may be obtained from various plants fall into these categories:

1. fruit fibers like cotton seed hairs
2. wood fibers like those from deciduous and coniferous trees
3. bast fibers
4. leaf fibers
5. grass fibers

The last three—bast, leaf, and grass—are most used by hand papermakers.

Bast fibers are those collected from the inner bark or phloem, the transportation tissue of the plant through which water is supplied to the plant and food produced in the leaves is carried to be stored in the roots. Bast fibers are long, slender, and strong. Examples are: mulberry tree, okra,



Hemp fiber, unbeaten.

Hemp fiber beaten for the production of very thin papers. Note the very complete longitudinal splitting of fibers.

Sulfate fiber from pine, unbeaten.

Sulfate fiber from pine, beaten extremely hard. Note that the fibers split much less than hemp, but tend to mash off.

milk weed, flax, hollyhock, and thistle.

Leaf fibers are shorter and more opaque than bast fibers and generally produce a paper with a rougher texture—used in the box industry and for heavy weight card stock. Examples are: sisal, pineapple, yucca, and raffia.

Grass fibers produce the shortest and most brittle papermaking fibers. The yield per volume of dry grass fiber is low but more available. Examples are: corn stocks, bamboo, bulrushes, beach grass, sugar cane, wheat, and rice straw.

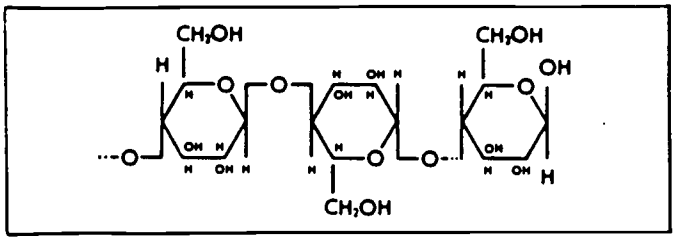
Another factor affecting paper is the season that plants are harvested which affects the fiber length and paper color. Soil also affects the plant's growth. Geographic location, differences in soil types, site quality, availability of moisture, and age of plant, shrub, or tree are influences on fibers. Whitney (1978) declared that paper is a sheet material made by bonding together many very small discrete elements called fibers. He says that a material is fibrous if its elements are slender, threadlike, and filamentous; that is, one dimension is very much greater than the other two. Fibers may be composed of animal, vegetable, mineral, or synthetic materials. Vegetable fibers are called natural fibers because they grow in nature. Information on plant fibers is scattered, sketchy, and only rarely specific with respect to fiber preparation for papermaking.

Webster's Dictionary describes cellulose as "an inert substance constituting the chief part (cell walls) of ordinary wood, linen, paper, rayon, etc. It is a carbohydrate...of the same percentage as starch, and is wholly convertible into glucose by hydrolysis. It is tasteless, white, odorless, nonvolatile, and is insoluble in water. It is part of a class of substances call polymers."

Cellulose, being the predominating constituent of plant tissues, can be described as the structural basis of the vegetable world. It never occurs in the plant in the free state but always in admixture or combination with other groups: members of the fatty series; the aromatic series; the pectic group or more or less oxidized, and acid, derivatives of the

carbohydrates. All paper made from plant fibers is made of cellulose in one form or another and in different degrees of purity. Cellulose is a carbohydrate having the empirical formula C6H10O5, from which its composition may be calculated to be: carbon 44.4%; hydrogen 6.2%; and oxygen 49.4%. While treating various kinds of woods with all sorts of different chemicals, the Frenchman Anselme Payeu was the first to recognize cellulose as a definite substance in 1839. Eighteen years later the German Fritz Schultze separated cellulose from lignin and identified them both.

Cellulose is a polymer composed of a great many glucose radicals linked with one another to form chains. The number of glucose radicals which combine to form one cellulose molecule can range from a few to many thousands. This figure is called the degree of polymerization (DP). Generally, the higher the DP value, the greater the strength of the fiber. For instance, the DP of cotton is said to range from 3,500 to 10,000; the DP of wood cellulose is 1,500 to 2,000. The glucose radicals are arranged parallel as seen in the illustration. It is somewhat important for the papermaker to determine the amount of cellulose in the fiber, the nature of the cellulose, plus the ease with which it can be obtained from the fiber.



Cellulose is the basis of all natural fibers. Chemically speaking, cellulose is a polymer of glucose, which is a common sugar. Cellulose and glucose are carbohydrates, which means that they are composed of carbon, hydrogen, and oxygen. Cellulose has a great affinity for water and cellulose molecules also have a great affinity for each other,

especially when they are wet. The portion of a plant in which papermakers are interested is the cellulose fiber. Papermaking fibers are hollow tubes of cellulose. The extent to which the inside of this tube is fractured determines the flexibility of the fiber. A more flexible fiber will intertwine more completely and will be compacted more easily during sheet forming and pressing.

In order to be made suitable for papermaking, the cellulose portion of the plant must first be separated from substances that are not cellulose: for example, lignin, pith, woody shive, cors, and fats. Higher cellulose content and less lignin is considered more desirable for hand papermaking. Lignin and other non-cellulosic substances are dissolved out of the fibers by alkaline cooking. Some papermakers prefer soda ash over stronger alkali such as lye, because the former provides a more gentle cook. Rinsing very well is extremely important to flush out the non-cellulosic substances that have been removed from the fiber and to get rid of the alkali used in the cooking.

In the papermaking processes, the aim is the absorption of water and the promotion of bonding, both of which make a stronger sheet of paper. However, as water goes through its cycles it picks up impurities which reflect the composition of the atmosphere and the earth's crust. Rainwater can dissolve gases such as oxygen, carbon dioxide, sulphur, and nitrogen dioxide as well as absorb soluble and insoluble matter. It may also contain organic matter caused by industrial contamination of the atmosphere as well as that evolved from vegetation and even contain concentrated deposits of limestone, magnesite, iron ore, gypsum, copper ore, sulphur, and other compounds. Thus, water can change the finished product in handmade paper.

A simplified description of the process of papermaking includes the following steps:

1. select and gather plant fibers
2. soak plant fibers in water
3. boil the fibers in alkali

4. beat fibers
5. add coagulant to a vat of water
6. add plant fiber to the vat of water and mix gently with hands
7. gather fibers onto a mould
8. tilt gently to distribute the fibres evenly on the mould screen
9. remove deckle and couch fiber onto felt or pellon
10. press excess water from fibers
11. dry paper either in drying box or by brushing onto a flat surface

A Little Bit About Grasses

When most people think about grasses, they think of the green grass that they have to keep watered and mowed all summer long. Actually, grasses are herbs with round or flattened (never 3-angled) usually hollow stems solid at the joints, and 2-ranked, alternate, parallel-veined leaves, composed of two parts—the sheath, which surrounds the stem like a tube split down one side and the blade, which is usually strap-shaped flat, folded, or with rolled margins. The grass plants may be annual or perennial. The root, stem, and leaves are the vegetative part of the plant and the flowers are the perpetuating of the species part. In grasses the vegetative parts are more uniform and characteristic than in most other families.

Of all the world's flowering plants, the grasses are probably the most important to man. They contribute tremendously to the earth's green mantle of vegetation; they are the source of the principal foods of man and his domestic animals; they hold the hills, plains and mountains against the destructive erosive forces of wind and water. Since man's existence depends directly or indirectly almost entirely on the grasses, it should make this part of the vegetable kingdom the most interesting. Aside from their usefulness, the beauty and graceful forms of grasses are unsurpassed by any other plants.

There are over five thousand kinds or species of grasses in the world and fourteen hundred of these are found in the United States alone. Probably there is not a county in the United States where less than 50 to 100 species of grasses are to be found. Some will be very common and conspicuous, but others will be rare and hard to find.

Harrington (1977) points out that the great civilizations of mankind have almost invariably developed in the midst of extensive grasslands. This is because the most important food producers are almost exclusively to be found in the grass family; for example, wheat and oats. The entire grazing industry is likely to be based primarily on grasses.

Grasses are easy to collect and prepare so it is important to take good specimens. This makes working with the pulp much easier. For the purpose of hand papermaking, it is not necessary to disturb the roots which allows the grasses to grow again, thus guarding against extinction. By cutting only the top portion of grasses, hand papermakers can produce paper in a variety of styles without worrying about the ecological consequences. Grass may be collected green or dry. However, green grass must be allowed to dry at least 30 days before processing. Whether a grass sample is collected green or dry may affect the final color of the paper.

Grasses are, however, considered to be relatively hard to identify. Grasses and grasslike plants constitute a large group with many of the genera containing large numbers of species. Identification has been done on as many as possible of the grasses used for this project. It should be noted that this project is not about identifying grasses as much as using them in papermaking. A documentation of the process and the resulting paper made from each type of grass gathered has been done. Photos of the grasses and the area where they were collected have also been included.

Papermaking From Grasses

General Information

Want to make paper but don't have many resources? Think about grass as a raw, natural fiber. It is possible for teachers who are on limited budgets to offer students an opportunity to experience hand papermaking for very little investment and inventory.

Grasses produce the shortest and most brittle papermaking fibers and the yield per volume of dry fiber is low but the geographic distribution is so broad and availability so great that grasses make an excellent choice.

Grasses can make paper in a variety of colors and textures. Some grasses are hollow stemmed and buoyant in water, which makes them difficult to cook. Some grasses are so tender they turn to mush when cooked. But with a little patience and some trial and error, any grass can become a beautiful sheet of paper.

Making paper wih natural fibers is the most fun when done in the Eastern method but the Western method can be used. Japanese or Eastern deckle and su are very expensive. The Japanese mould is worth the money but if one cannot be afforded, then use a more economical Western method mould. To press the paper, it must be couched between pieces of felt or pellon. Felts are more expensive but absorb more water. Both felt and pellon can be purchased anywhere that material or sewing supplies are sold.

The fiber pulp should be added to a tub containing water and a "coagulant." After each sheet of paper is "formed" in the mould, it is "couched" onto a felt/pellon. When several sheets have been couched they form a "stack" of paper that must be pressed so the excess water will drain off. The pressed sheets are then put into a dryer box or "brushed" onto a hard surface. The hard surface can be glass, plexiglass, or walls.

This book lists the results of papermaking using 30 different collections of grass. Approximately the same amount of grass was collected from different locations throughout the United States.

Grass Collection

Grass can be collected green or already dry. Green grass will require enough more raw material to allow for natural shrinkage that occurs while drying. If the paper-maker does not have a pre-designed amount of paper expected as a finished product, then shrinkage will not be a concern.

A grass with bigger and longer stems will make less pulp than grass that is softer. The amount of stem in a grass is determined by several factors; type of grass, altitude, rainfall, heat.

Grass Preparation

Generally, soaking grass for 24 hours is enough. Longer soaks may result in very smelly pulp and the resulting paper will be a drab trey color. If the grass has grown very long, the papermaker may want to cut it up before cooking. Smaller pieces fit into a large cooking pot easier and will be easier to handle throughout the process.

Most grasses can be sufficiently cooked in one hour. Two to three tablespoons of alkali added to two gallons of water (enough to cover the grass) will soften the mass. After cooking, the pulp must be rinsed very well to remove the extraneous material, sugars, starch, wax, and lignin which are brought out by the caustic—rinse at least 15 minutes.

Then the fun begins. Each batch of pulp must be beaten to further soften and break up the fibers. Place the damp fibers on a hard surface and beat them with a wooden or rubber mallet or club. Oak boards specifically made for beating pulp can be purchased through papermaking equipment suppliers. Beating time will vary much as cooking time but most grasses can be pulped in 20 minutes. To test if the fibers have separated, place a small amount of pulp in a glass of water and shake thoroughly. Hold this up to a light and examine the suspension. It should appear as small, fine, individual fibers. If the grass pulp still contains alot of harsh stems, they can be removed throughout the beating process.

Papermaking

Prepare the pulp and add it to water that contains coagulant. Dip the mould into the pulp, shake gently, and allow the excess water to drain off. Couch the pulp onto felts or pellon. After a stack has been couched, it needs to be pressed. This can be accomplished by the use of C-clamps if you don't have a hydraulic press. Place the stack onto a 3/4 inch plywood board, cover with another 3/4 inch plywood board and clamp together slowly. Increase the pressure each time the water stops dripping until the handle won't turn anymore. Remove the clamps, and the top board. The stack of paper should be fairly firm.

If a drying box is available, remove the sheets of paper from the felts and set them in the dryer between blotters. If a drying box is not available, take each sheet from the felts and brush them onto a flat surface. Once the paper is dry, it should be pressed overnight so it will remain flat. A dry stack of paper can be pressed (ironed) by placing a heavy object such as a stack of books on it.

Conclusion

The purpose of this project was to determine if the amount of rainfall or the altitude of an area would affect the finished product of handmade paper. Not all of the samples of grass collected are the same, although all are from the grass family.

On the following pages a description of each sample shows that grasses collected in higher altitudes produced fewer sheets per pound of fiber. The reason appears to be because grasses growing at higher elevations have much stockier stems which must be removed before paper can be formed. Removing the stems leaves less pulp. The same is true of the lowest altitudes if the area experiences heavy rainfall.

Grass collected from extremely dry areas was not as full of stems but the pulp did not form well. The resulting paper was hard to remove from the felts and didn't brush onto the hard surface as easily. Grasses collected from 2000 to 6500 feet with rainfall between 10 to 25 inches seemed to work the best.

Grass Type Unidentified
Location Ogunquit, Maine
Date Gathered June 20
Altitude 20 feet
Average Annual Rainfall 46 inches

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallet	**Beating Time**	15 minutes
Forming Method	Western	**Formation Aid**	poly(acrylanich) (PNS) coagulant

Paper Results

Number of sheets	16	**Size of sheets**	8 x 10 inches

Forming and Parting Characteristics The first sheets came out thick with small fine stem pieces throughout. The final sheets came out tissue thin. This pulp couched, pressed and brushed very easy.

Paper Strength Strong

Appearance A very light tan with dark brown flecks. The thick sheets are very stiff, almost like cardboard. The tissue thin sheets are very flexible and lovely.

Grass Type Foxtail Barley
Location Cedar City, Utah
Date Gathered June 5
Altitude 6450 feet
Average Annual Rainfall 17.3 inches

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	13	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics Even though the stems were long, they were flexible so the pulp was soft. Sheets formed and pressed very easily. Sheets came out full size with very few holes.

Paper Strength Very strong — crisp

Appearance Light tan color with occasional yellow and green stems throughout. Also, many small brown seeds. Very interesting. It did wrinkle (shrink) more than others.

Grass Type Clasping Leaf Pepper and Cheat
Location Dinosaur, Colorado
Date Gathered June 10
Altitude 4767 feet
Average Annual Rainfall 8.4 inches

Process

Amount Gathered	1 1/2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	One month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous running clear water		
Beating Method	rubber mallet	**Beating Time**	25 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

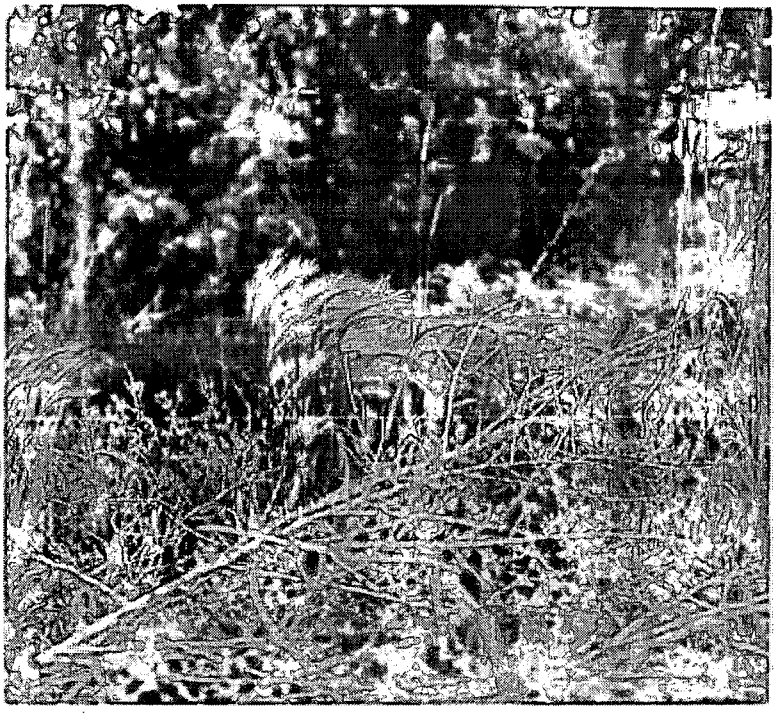
Number of Sheets	9	**Size of Sheets**	8 x 10 inches

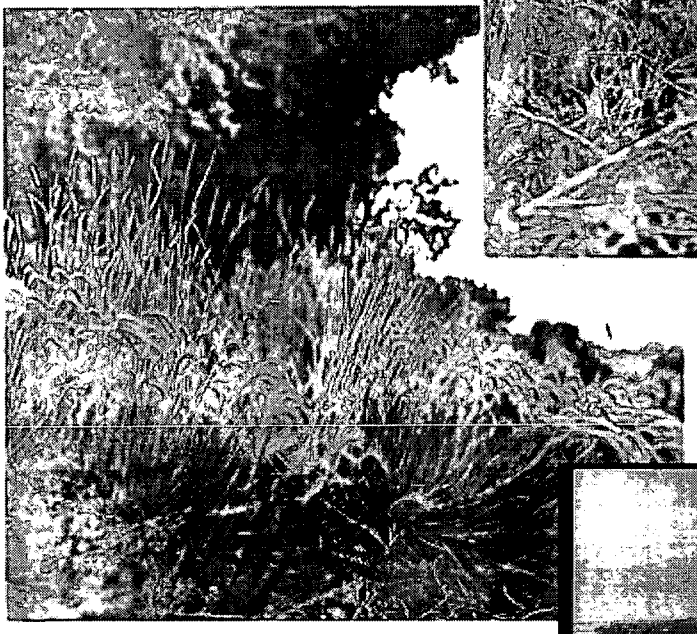
Forming and Parting Characteristics Even with extra beating time, there was no pulp—only stems and seeds. The seeds are very large and very sticky. The pulp stuck to the pellon. The only way to achieve a sheet of paper was to add kozo to the batch and remove as many stems as possible.

Paper Strength Without kozo-very weak and full of holes. With kozo-quite strong

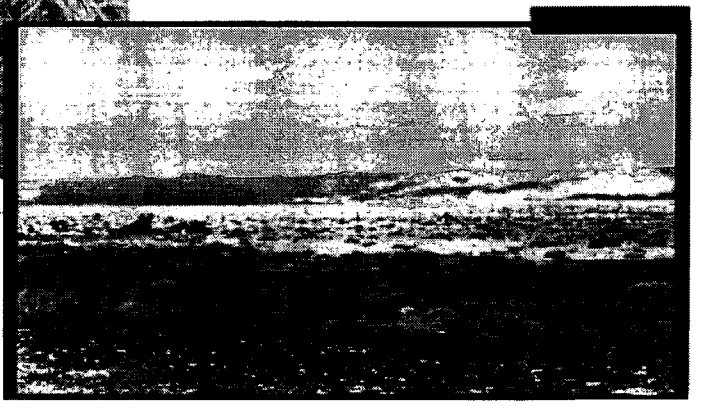
Appearance Very disappointing. The grass was a beautiful purple but what little pulp there was turned out grey. The final paper with kozo added was a nice cream color with large red seeds but the sheets were thick.

The foxtail barley in the fields by Cedar City, Utah was so beautiful and graceful in June. Cedar City is located near Zion and Bryce Canyon National Parks.





On the other side of Utah, the area around Moab is much more arid. Grass was hard to find.



Grass Type Cheat
Location Near North Rim Grand Canyon, Arizona
Date Gathered June 5
Altitude 6500 feet
Average Annual Rainfall 15.5 inches

Process

Amount Gathered	1 pound	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	1 tablespoon
Rinsing Time	15 minutes continuous running clear water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets 8 **Size of Sheets** 8 x 10 inches

Forming and Parting Characteristics Although this grass was similar to the grass found in Dinosaur, Colorado, it had quite a lot more pulp and the seeds were smaller. Couching and brushing were very difficult. The wet pulp was very easily torn.

Paper Strength Final paper is quite strong but has uneven edges and some holes.

Appearance This was also disappointing. The grass had such a lovely purple color that didn't hold through the processing. Final sheets are dingy grey with lots of purple seeds.

Grass Type Brome
Location Northeastern Nebraska
Date Gathered July 1
Altitude 1788 feet
Average Annual Rainfall 26.5 inches

Process

Amount Gathered	3 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous running clear water		
Beating Method	rubber mallot	**Beating Time**	25 minutes
Forming Method	Western	**Formation Aid**	PNS

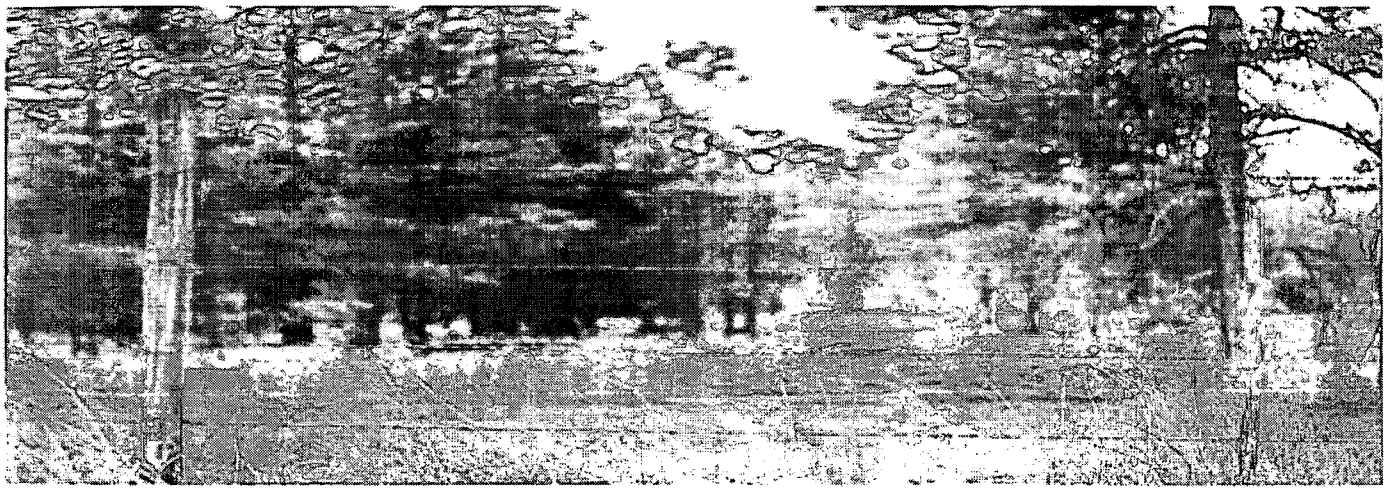
Paper Results

Number of Sheets	7	**Size of Sheets**	8 x 10 inches

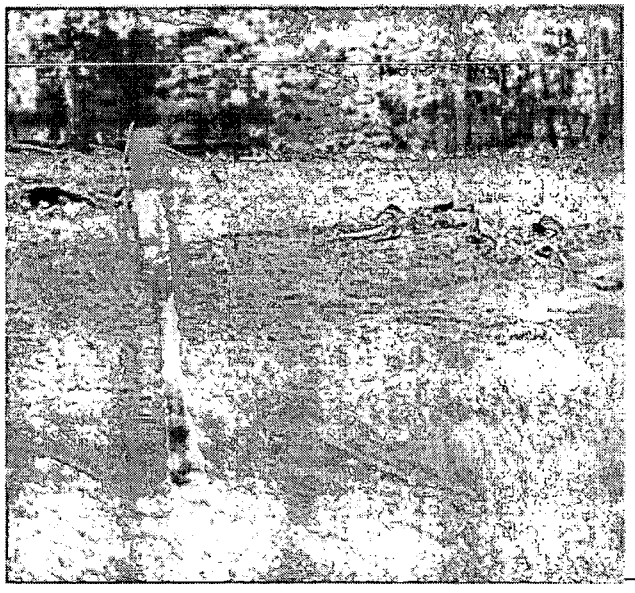
Forming and Parting Characteristics Even though more grass was gathered, there were so many large stems that would not beat into pulp, so there were less final sheets. Once the stems were removed, the pulp tended to stick to the pellon. This pulp was very difficult.

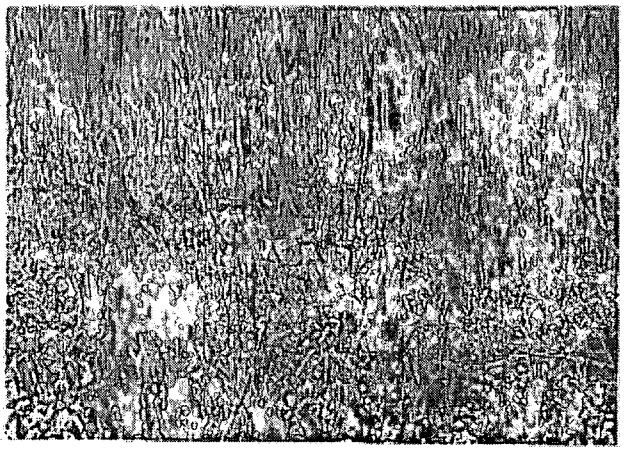
Paper Strength Tissue thin sheets that have lots of flexibility

Appearance Final sheets have a pale celery green color. A very fine pulp with small stemmy pieces and a few large dark seeds throughout. The finished paper smells like dry hay.



The area near Grand Canyon National Park has a variety of grass types. The Cheat grass at this elevation is a beautiful deep purple





Grass Type Prairie Wedge
Location Marble Canyon, Arizona
Date Gathered June 5
Altitude 3200 feet
Average Annual Rainfall 5.9 inches

Process

Amount Gathered	1 1/2 pounds	**Gathered Green**	✓✓ **Gathered Dry**
Drying Time	none	**Precook Preparation**	24 hour soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous running clear water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	6	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics A very fine pulp that couched, pressed and brushed very easy. Raw material did not result in as much pulp.

Paper Strength Tissue thin sheets, very flexible.

Appearance Light yellow pulp with small stem material throughout.

Grass Type Threeawn
Location Apache Reservation, Arizona
Date Gathered June 7
Altitude 2000 feet
Average Annual Rainfall 15 inches

Process

Amount Gathered	2 pounds	**Gathered Green**	✓✓ **GatheredDry**
Drying Time	none	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous running clear water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

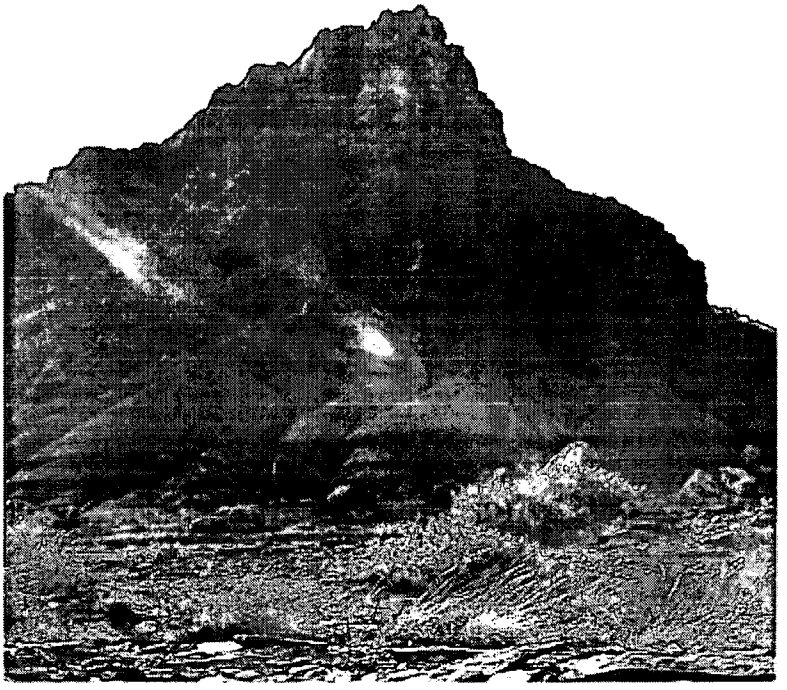
Number of Sheets	12	**Size of Sheets**	8 x 10 inches

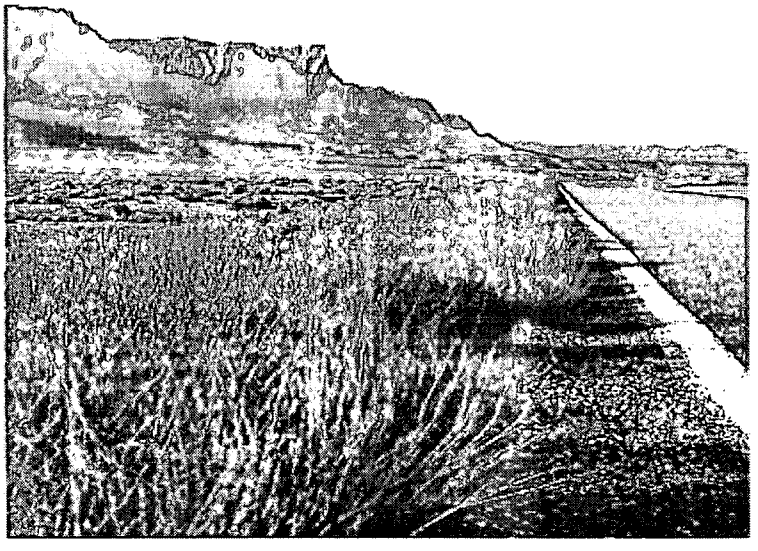
Forming and Parting Characteristics A very fine pulp that was easily couched, pressed, and brushed onto plexiglass. This pulp formed nice full sheets without any holes.

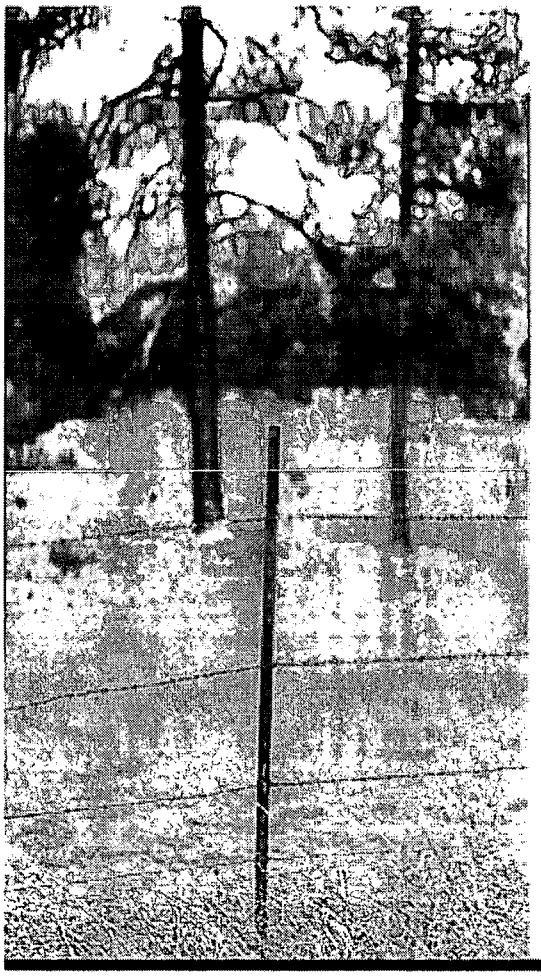
Paper Strength Fairly thin to medium thick sheets.

Appearance Light tan with some small stem material throughout which gave a light texture to the surface. This was one of the nicest batches of paper made from the grasses.

The highway through Marble Canyon near Show Low, Arizona offers magnificent views of huge mesas and rock outcroppings. Grass is scarce but the drive through the desert is a wonderful experience.







The desert west of Phoenix, Arizona provides multiple vegetation.

Further on into the Apache Reservation the mountains change the view and grass is more plentiful.

Grass Type Not really a grass—small shrub
Location Marble Canyon, Arizona
Date Gathered June 5
Altitude 3200 feet
Average Annual Rainfall 5.9 inches

Process

Amount Gathered	1 1/2 pounds	✓✓	**Gathered Green**		**Gathered Dry**
Drying Time	one month		**Precook Preparation**		24 hours soak in warm water
Cooking Time	1 hour boiling		**Alkali**		2 tablespoons
Rinsing Time	15 minutes continuous running clear water				
Beating Method	rubber mallot		**Beating Time**		20 minutes
Forming Method	Western		**Formation Aid**		PNS

Paper Results

Number of Sheets	10	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics At first there were so many stems that sheets would not form. After removal of large stiff stems, the pulp was very fine and made tissue thin paper but full of holes. Tended to stick to the pellon.

Paper Strength First sheets were not paper. Final sheets were tissue thin - crisp.

Appearance Pale yellow-green with light colored stems throughout. This grass had a very strong odor when it was gathered and the smell carried through the processing and into the finished paper. Not at all satisfactory.

Grass Type Bluegrass
Location Flaming Gorge, Wyoming
Date Gathered June 10
Altitude 6269 feet
Average Annual Rainfall 12.5 inches

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm watr
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

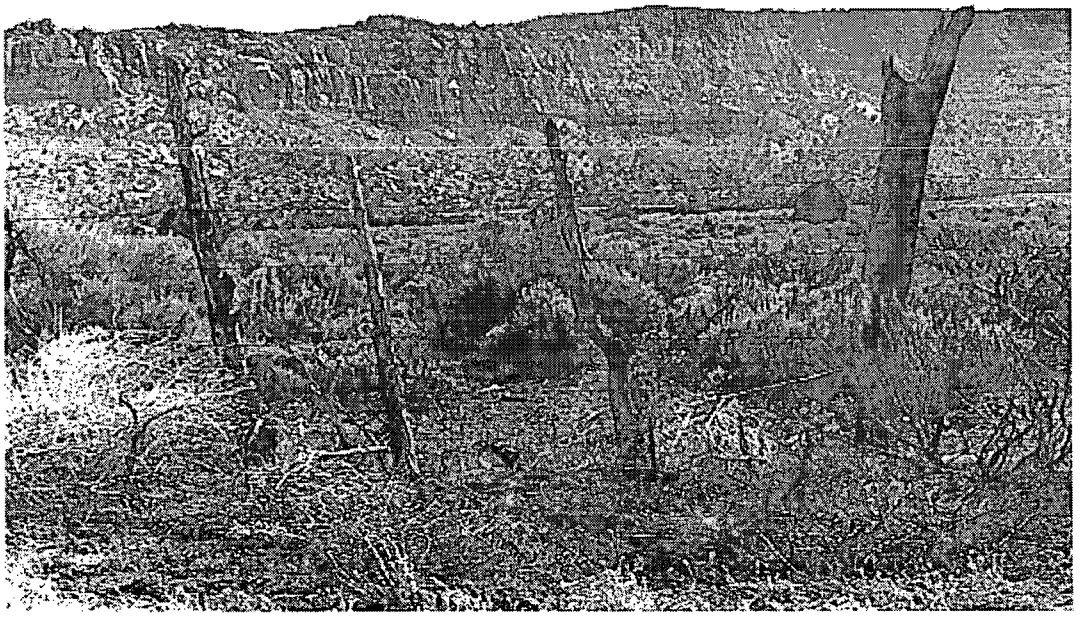
Number of Sheets	17	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics Heavy stems were removed leaving a fine pulp that couched, pressed, and brushed very easy.

Paper Strength Thin and flexible but very strong.

Appearance A very light yellow thin sheet of paper with thread-like particles throughout. This was one of the best papers made.

Highway 139 in northern Colorado flows through a ranching valley over Douglas Pass. It is not a superhighway but it was a wonderful drive. The clasping leaf pepper and cheat grass was gathered in Dinosaur, the last town in Colorado on highway 40.



The Flaming Gorge area in southern Wyoming is spectacular.
The grass gathered along this route made some of the best paper.

Scouring rush and horsetail along the Animas River in Colorado.

Grass Type Scouring Rush and Horsetail
Location Animas River, Colorado
Date Gathered June 8
Altitude 4416 feet
Average Annual Rainfall 11 inches

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	25 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	14	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics The reed did not pulp out—just broke up into small pieces so an equal amount of kozo was added. This combination allowed easy couching, pressing, and brushing.

Paper Strength Exceptionally strong - some sheets were too thick but some were quite thin and flexible.

Appearance A very interesting pattern created by the short pieces of reed that remain dark against a light tan background.

Grass Type Unidentified
Location Cedar City, Utah
Date Gathered June 5
Altitude 6450 feet
Average Annual Rainfall 17.3 inches

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

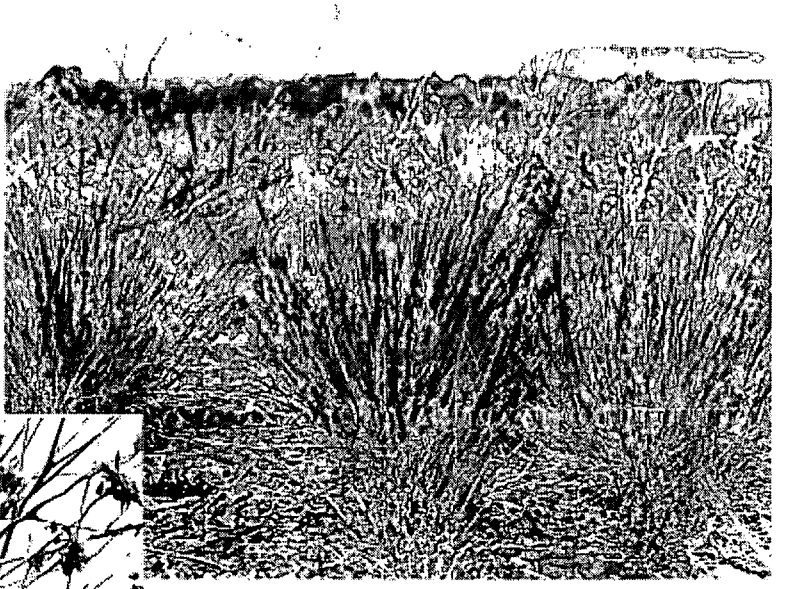
Paper Results

Number of Sheets	10	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics Required removal of heavy stems. Very seedy. Seeds stuck to the pellon so some sheets tore apart before they could be brushed onto the plexiglass.

Paper Strength Most sheets had holes and some lost part of the edges.

Appearance Light golden background with small brownish stems and large dark seeds. If it had formed better sheets, it would have been lovely paper with an interesting texture.



The drive through Arizona from Flagstaff to Phoenix through Sedona presents a large variety of plant life and a major change in elevation from over 7000 down to 2000 feet.

Grass Type Reed Grass
Location Sierra Nevada Mountains
Date Gathered July 18
Altitude 7000
Average Annual Rainfall 40 inches

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	17	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics There were some large stems that had to be removed. Resulting pulp was easily formed into sheets—couched, pressed, and brushed. The first sheets were a little thick but final sheets were like tissue paper.

Paper Strength Strong-thick sheets very stiff; thin sheets quite flexible.

Appearance A fine tan pulp with some yellow and some green fibers throughout. Also, a lot of fine brown seeds gave added texture.

Grass Type Reed Grass
Location Togwotee Pass, Wyoming
Date Gathered May 19
Altitude 9658 feet
Average Annual Rainfall 26 inches

Process

Amount Gathered	1 1/2 pounds	**Gathered Green**	✓✓ **Gathered Dry**
Drying Time		**Precook Preparation**	48 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

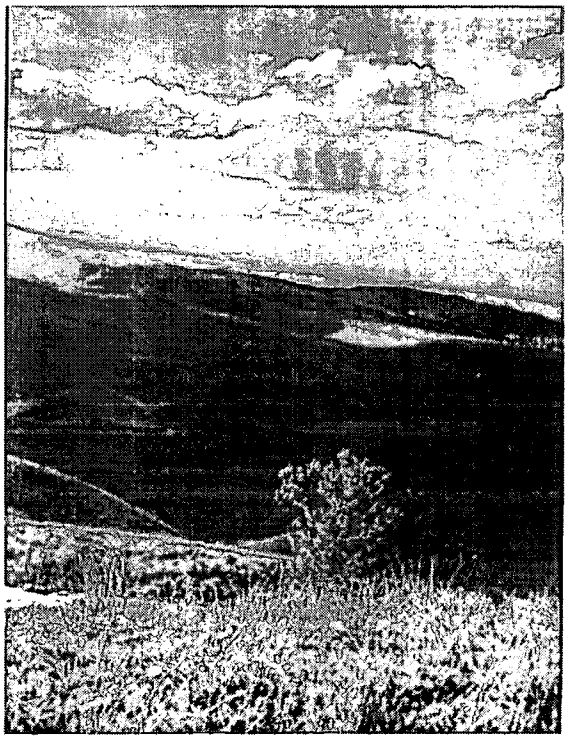
Paper Results

Number of Sheets	6	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics Too many large stems that wouldn't pulp up had to be removed leaving very little pulp. Only about 3 sheets were well formed.

Paper Strength Poor quality

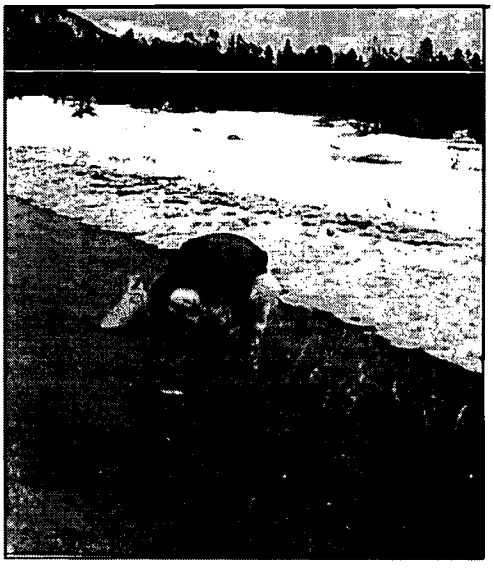
Appearance Fiber was soaked too long. Pulp turned out very grey. Short fibers in the few nice sheets are almost black which resulted in a nice design. Generally not a very satisfactory batch of pulp with poor paper.



Red Canyon near South Pass, Wyoming offers one of the most spectacular views in the region. Towgotee Pass still had a lot of snow and grass was scarce.

Upper photo was taken at the lower edge of Bear Lake in Idaho. Mountains in background were snow capped.

Lower photo is Calaveras Big Trees State Park near Arnold, California. The grass from this area made excellent paper.



Grass Type Unidentified
Location Red Canyon, Wyoming
Date Gathered May 18
Altitude 8000 feet
Average Annual Rainfall 13.3 inches

Process

Amount Gathered	1 1/2 pounds	**Gathered Green**	✓✓ **Gathered Dry**
Drying Time		**Precook Preparation**	48 hour soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	8	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics A lot of small stems that wouldn't pulp up required a lot of extra work to couch, press, and brush onto the plexiglass.

Paper Strength Poor quality

Appearance Soaked too long resulting in a grey pulp. Also, so many small stems resulted in a very coarse paper. An interesting design and texture were created by the black fibers and yellow stems, but overall not a very nice looking paper.

Grass Type Bush Grass
Location Bear Lake, Idaho
Date Gathered May 18
Altitude 5900 feet
Average Annual Rainfall 13 inches

Process

Amount Gathered	2 pounds	**Gathered Green**	✓✓ **Gathered Dry**
Drying Time		**Precook Preparation**	48 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	10	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics Pulp wouldn't form sheets by itself so kozo was added. Resulting sheets couched, pressed, and brushed very easy.

Paper Strength Poor quality without kozo—very strong with it.

Appearance Very fine pulp with few stems. A tannish-grey color with dark brown fibers throughout. Two days is just too long to soak the fiber. The color becomes greyish. This paper turned out well with a little extra work but was grey.

Grass Type Crested Wheat
Location Rock Springs, Wyoming
Date Gathered May 24
Altitude 6374 feet
Average Annual Rainfall 8.3 inches

Process

Amount Gathered	2 pounds	**Gathered Green**	✓✓ **Gathered Dry**
Drying Time		**Precook Preparation**	48 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	16	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics First sheets were too full of stem—paper like cardboard. Once the stems were removed the sheets had some holes but generally formed thin crisp sheets.

Paper Strength With stem material, very strong. Without so many stems, paper was thinner and more flexible.

Appearance Light avocado green with texture created by small, small seeds and fine yellow stem material. Final paper was quite nice but required a lot of extra work.

Grass Type Beardgrass or Blue Stem
Location Columbia, Missouri
Date Gathered April 15
Altitude 757 feet
Average Annual Rainfall 41 inches

Process

Amount Gathered	2 pounds	**Gathered Green**	✓✓ **Gathered Dry**
Drying Time		**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

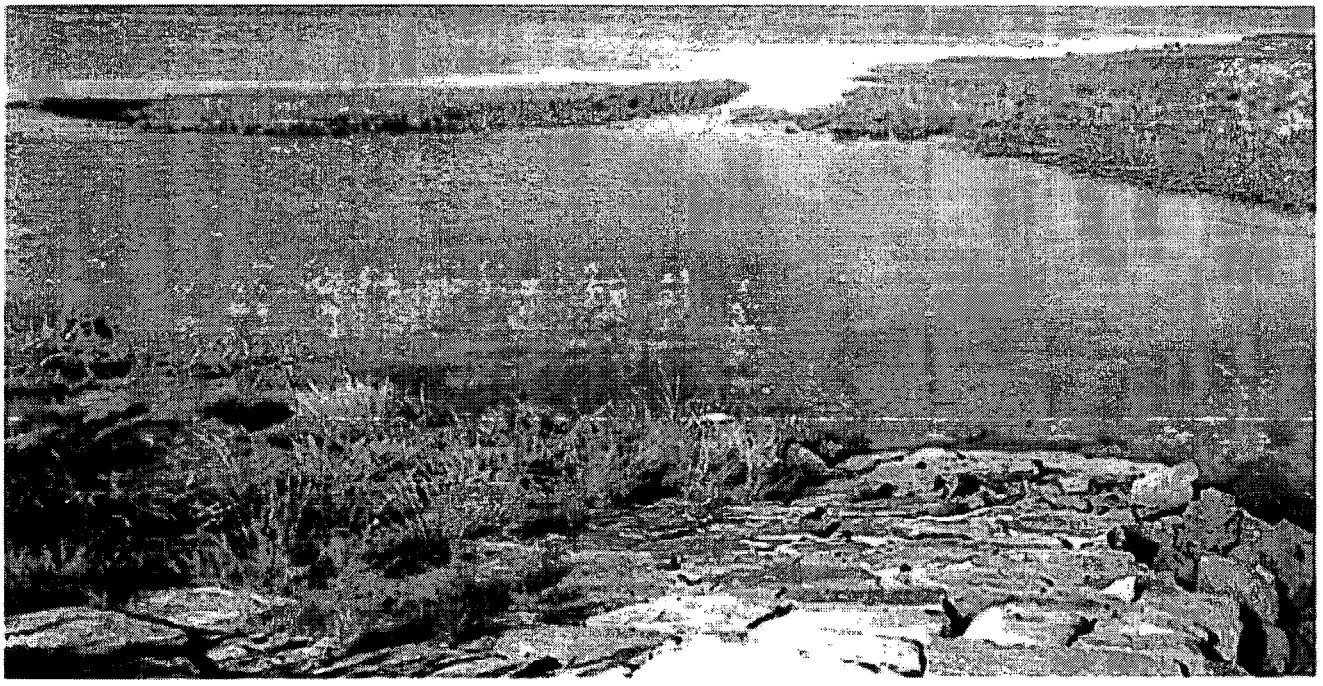
Number of Sheets	6	**Size of Sheets**	8 X 10 inches

Forming and Parting Characteristics Too many large stems that would not pulp up. Once the stems were removed there was very little pulp left. Also, this pulp was a little sticky.

Paper Strength Strong

Appearance A nice rich red color but most of it was too thick. Only 2 sheets were of any quality. It takes too much raw material to end up with any paper.

We collected grass while walking past a river near Norwood, Massachusetts. A duck was swimming near the far bank.



More rain and lower elevation along the east coast produces an abundance of grasses. The top picture is of the Maine coastline and the bottom picture is Massachusetts.

Grass Type Orchard
Location Norwood, Massachusetts
Date Gathered June 18
Altitude 137 feet
Average Annual Rainfall 41.2 inches

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	11	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics A heavily textured pulp that was very sticky. Some sheets stuck to the pellon.

Paper Strength Soft and flexible but strong.

Appearance A beautiful dark green flecked with black and yellow fibers. The sheets are so soft they are more like material than paper. Results were wonderful but required a lot of extra work.

Grass Type Blue Stem
Location Knoxville, Tennessee
Date Gathered May 20
Altitude 981 feet
Average Annual Rainfall 47.29 inches

Process

Amount Gathered	2 pounds	**Gathered Green** ✓✓ **Gathered Dry**	
Drying Time		**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	10	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics A very fine pulp once the large stems were removed. Couched, pressed, and brushed onto plexiglass very easy.

Paper Strength First sheets were very thick and strong. Final sheets were tissue thin but still quite strong.

Appearance A reddish tan color textured with yellow and brown fibers. Quite nice.

Grass Type India Lovegrass
Location Arnold, California
Date Gathered July 18
Altitude 3800 feet
Average Annual Rainfall 45 inches

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	14	**Size of Sheets**	8 x 10 inches
Forming and Parting Characteristics	A very nice fine pulp that couched, pressed, and brushed very easy.		
Paper Strength	Tissue thin but strong and crisp.		
Appearance	A pale yellow-green paper textured with a few yellow fibers and some long thin brown seeds. Quite nice paper.		

Grass Type Giant or Common Reed
Location Norwood, Massachusetts
Date Gathered June, 24
Altitude 137 feet
Average Annual Rainfall 41.2 inches

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	9	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics Large stems had to be removed leaving a rich thick pulp. However, it tended to stick to the pellon a little.

Paper Strength Strong but flexible.

Appearance A light gold color full of tiny, tiny brown seeds and some long green fibers. Very different—one of my favorites.

Grass Type Timothy
Location South Dakota
Date Gathered August 10
Altitude 1300 feet
Average Annual Rainfall 20 inches

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	15	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics A thick pulp that couched, pressed and brushed onto the plexiglass very easily.

Paper Strength Strong, first sheets were quite thick but final sheets were tissue thin.

Appearance A grey-green paper with lots of yellow fibers and some thin brown seeds adding a lot of texture. This paper smells a lot like hay.

Grass Type Cheat
Location Pocatello, Idaho
Date Gathered May 31
Altitude 4500 feet
Average Annual Rainfall 11.9 inches

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	13	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics Large stems had to be removed leaving seeds and not much pulp. There were so many seeds kozo had to be added to create pulp. This paper wrinkled badly when dry.

Paper Strength Strong

Appearance A light grey-green color with lots of dark medium sized seeds. The kozo stands out against the grass color instead of blending into the natural color.

Grass Type Canary
Location Minnesota
Date Gathered August 12
Altitude 900 feet
Average Annual Rainfall 28 inches

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	10	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics After large stems were removed, a wonderful pulp was created that couched, pressed, and brushed very easy.

Paper Strength Tissue thin and flexible but strong-crisp.

Appearance A variegated green with a feathery fiber design accented by a few dark seeds.

Grass Type Red Threeawn/Aristida
Location The new puppy ate paper stating the location so ???
Date Gathered First part of June
Altitude
Average Annual Rainfall

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	10	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics A bit sticky and quite stemmy but the sheets formed and brushed fairly easy.

Paper Strength Strong

Appearance A pale yellow color filled with darker yellow seeds and some yellow and green stems. This was the first paper made in this research project. If given a second chance, remove the stems first, this grass would make some nice paper.

Grass Type Bunch
Location The new puppy ate the paper listing this location
Date Gathered First part of June
Altitude
Average Annual Rainfall

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

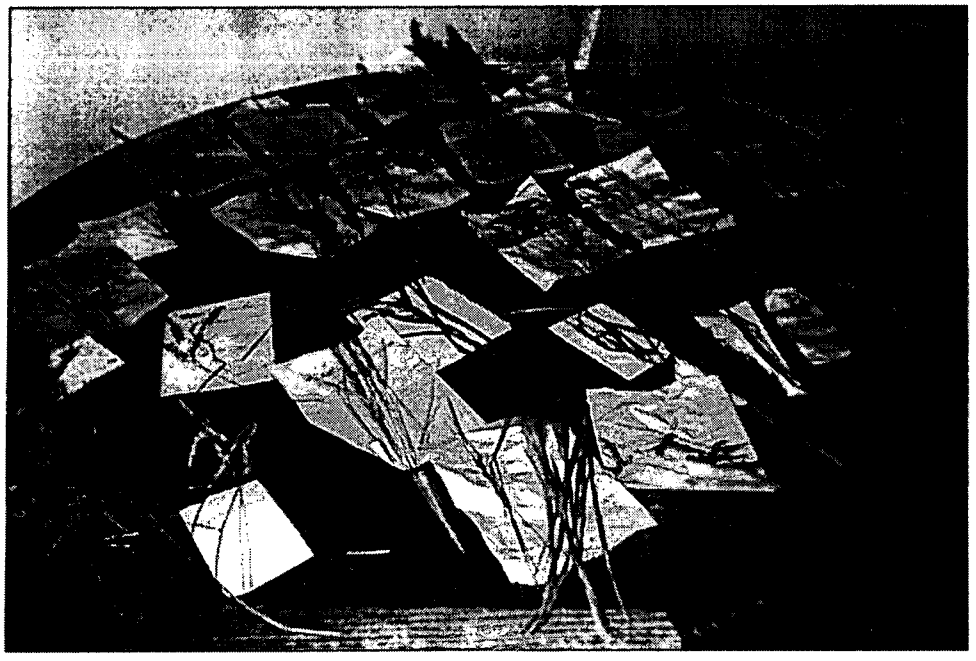
Paper Results

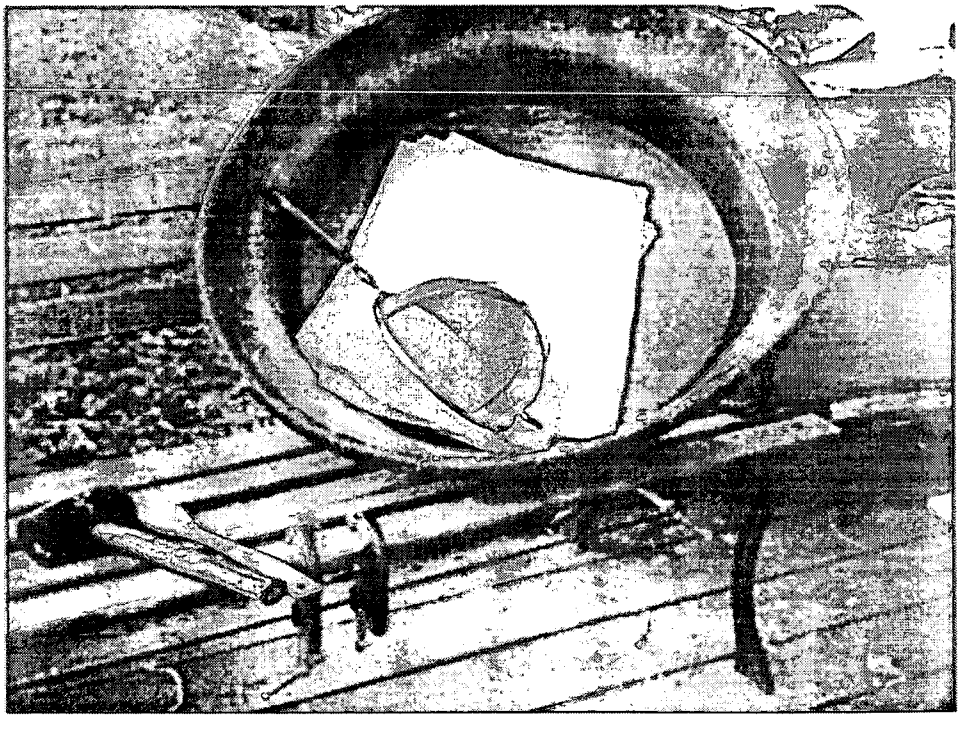
Number of Sheets	11	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics A fine pulp with kozo added for some reason (which I can't remember). Couched, pressed and brushed onto the plexiglass very easy.

Paper Strength Strong

Appearance A very pale tan with small gold fibers throughout. This was another of the first papers made. A second chance of making this paper without kozo should be given to this type of grass also.





Grass Type Wheat Grass
Location Show Low, Arizona
Date Gathered June 9
Altitude 6414 feet
Average Annual Rainfall 11.8 inches

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	14	**Size of Sheets**	8 x 10 inches
Forming and Parting Characteristics	Fine pulp filled with soft long fibers. Couched, pressed, and brushed very easily.		
Paper Strength	Strong - medium to tissue thin paper.		
Appearance	A yellow-gold color with long gold and green fibers adding texture to the paper.		

Grass Type Unidentified
Location Moab, Utah
Date Gathered June 9
Altitude 4042 feet
Average Annual Rainfall 8.6 inches

Process

Amount Gathered	1 1/2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	9 (sort of)	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics Pulp was full of stems that had to be removed. For some reason, this pulp stuck to the pellon. Sheets were full of holes and tore very easy when brushed onto the plexiglass.

Paper Strength Poor quality

Appearance Can't even call this paper. It just wouldn't work, no matter what was tried. Color was a very drab grey. A big disappointment.

Grass Type Needle and Thread
Location Flagstaff, Arizona
Date Gathered June 6
Altitude 7123 feet
Average Annual Rainfall 23 inches

Process

Amount Gathered	2 pounds	✓✓ **Gathered Green**	**Gathered Dry**
Drying Time	one month	**Precook Preparation**	24 hours soak in warm water
Cooking Time	1 hour boiling	**Alkali**	2 tablespoons
Rinsing Time	15 minutes continuous clear running water		
Beating Method	rubber mallot	**Beating Time**	20 minutes
Forming Method	Western	**Formation Aid**	PNS

Paper Results

Number of Sheets	7	**Size of Sheets**	8 x 10 inches

Forming and Parting Characteristics A fine pulp with lots of large stems that had to be removed. It should have worked once the stems were removed but it didn't. It stuck to the pellon.

Paper Strength Poor quality.

Appearance A beautiful gold color with dark gold fibers throughout. Unfortunately, it just didn't form sheets at all well and wouldn't release from the pellon. Very disappointing.

Teaching Papermaking

Papermaking is now being taught by many, many art teachers in grades Kindergarden through 12, as well as courses for adults in the community and at the college level. Children love it—according to Martha Blowen (1998) in a review of Gloria Zmolek Smith's book on papermaking, Teaching Hand Papermaking: A Classroom Guide, 1995. Smith's book gives a fresh perspective and new ways of working with children through papermaking. Other authors who are teaching papermaking to children as well as adults are David Watson in Creative Hand Papermaking, 1991. Watson gives simplified suggestions for reducing the work of papermaking. Sophie Dawson's beautiful book, The Art and Craft of Hand Papermaking, addresses the creativeness of papermaking.

A resurgence of interest in papermaking has been fostered by an increased interest in bookmaking. Many writers are now presenting their work in original books they have put together themselves out of paper they have hand made.

Methods of papermaking and teaching papermaking vary considerably depending upon what equipment is available and what results are expected. From homemade deckle and frame to preformed kits; from pre-macerated pulp to handpicked natural fibers, papermaking provides opportunities to introduce some basic chemistry and environmental issues to students. From small amounts produced in a kitchen by one person to production by classes in public school systems, papermaking offers artistic possibilities of homemade paper, limited only by the imagination of the papermaker.

Modern hand papermaking is based on two distinct methods, one Western and one Eastern. Western hand papermaking is

the craft most familiar to Americans or Europeans. Raw material consists mostly of linen or cotton rags or various types of processed new cotton fiber. The cellulose fiber is beaten into a pulp using the Hollander beater and diluted in a vat of water. Individual sheets are then formed using a flat sieve-like tool called a mould. Scooping up pulp from the vat, the papermaker shakes the mould—but only slightly—to even the sheet as the water drains from the mould. Each new sheet of paper is couched, or transferred, to a felt blanket; another felt is used to cover the damp sheet and the process is repeated until a pile, or post, (stack) is accumulated. The post is pressed to squeese out as much water as possible and the paper is then separated from the felts and dried in lofts or in specially designed machines.

The raw material for Eastern papermaking usually consists of bast fiber, or the white inner bark of certain small trees. The bark, most commonly of kozo (mulberry tree), is stripped from the inner wood, cleaned, cooked, cleaned again, and then beaten very lightly. The prepared fiber is mixed into a vat of water along with a viscous formation aid necessary to disperse the long fibers and control the drainage rate. Individual sheets are made by sloshing the viscous vat mixture repeatedly across the surface of the mould. In papermaking mills, sheets are then couched one atop the next with the aid of a flexible removable mould covering called the *su*. No interleaving felts are required mainly due to the long length of the bast fibers. The wet post of paper is pressed, and the individual sheets are parted while damp and brushed onto heated metal surfaces or boards for drying. The school or home papermaker can couch the sheet immediately onto a smooth surface such as plastic or glass, remove the mould, and allow to dry.

Twentieth century papermakers operate under a different compulsion than our pioneer predecessors. Today's artisans are exploring, discovering, and rediscovering ways of manipulating the chemistry, magic, and beauty of cellulose fibers. Papers used for art work require a different set of criteria. The paper should certainly last as long as

any other material also used in the artwork.

Permanence and durability describe the longevity of paper. Durability refers to the condition in which usage is taken into account; normal wear and tear. Permanence is resistance to the effects of time, brought about either by internal factors in the composition of the paper or by external factors in the environment.

There are some hazards in hand papermaking that should be brought to the attention of papermaking instructors, especially instructors of children. Some wood and plant materials can cause allergic reactions and skin irritation. The alkaline soda ash and lye are highly corrosive upon skin and eye contact, inhalation, and ingestion. Boiling solutions of these alkaline materials can be very dangerous because of the risk of boiling over and the fact that steam will contain trapped alkali. If chlorine bleach is used to whiten the pulp, it can cause skin, eye, and respiratory irritation. Machanical beaters can trap hands in the blades when cleaning out the pulp. Large amounts of water present hazards if splashed onto electrical outlets or other electrical equipment. Some coloring pigments can be hazardous. Hand papermaking is fun for all ages but instructors must adopt the "safety first" motto.

The following approach to handmade papermaking presented by the staff of the Ontario Science Centre is reasonably easy to understand and can be used to teach in elementary as well as secondary school.

1. Make yourself a wooden screen from scrap pieces of wood. (This should be somewhere near 8" x 8" x 1").
2. Staple fly screening tightly and smoothly across the frame. Nylon fly screening is easier on fingers and doesn't rust.
3. In a blender, mash up an old Christmas, birthday, or report card along with some potato peels, or carrot peels, or any vegetable fiber you happen to have around. You'll have to experiment.

4. Dump the mixture (called pulp) into a pail, tub, or kitchen sink filled with about four inches of water.
5. Then grasp your screen in both hands, place it in the tub. Shake it gently from side to side, and in a single straight motion lift the screen out of the tub. The water will rush through the screening, but the fiber will have evenly coated the screen. Remember, try to keep the screen level—if it tips, half the paper will be really thick, and half will be too thin.
6. Now, to get the paper off the screen (this is the tricky part). Locate a stack of old newspapers, cover with clean white paper, and place on a table Take your screen, turn it over, and place it on the newspaper/white paper stack. Mop up the excess water with a sponge; then very, very carefully lift up the screen. Your paper will remain on the newspaper stack. Next step is to iron the paper dry after putting another sheet of white paper over the new paper.

Students have made paper by hand from carrots, grass, straw, banana peels, old fish nets, artichoke hearts, hemp rope, horse chestnuts, various weeds, seeds, lint from clothes dryers, silk, sawdust, moss, leaves of trees, pine cones, potatoes, roof shingles, marsh-mallow, nettles, oak, willow bark, yucca, and many different flowers. Most of the experimental materials can be obtained locally.

Much of the equipment needed for papermaking on a small scale can be found in your household. You will need a set of non-corrosive measuring

spoons—either stainless steel or heavy plastic. Try to make your measurements as consistent as possible. You will also need a strainer and a large boiling pot. Again, stainless steel with a fine mesh is a good choice for the strainer. The boiling pot may be enameled but make sure there are no chips in the enamel. A Pyrex measuring cup will also be needed. Plastic measuring cups are not suitable as they tend to corrode and can melt with hot liquids.

Many fibers such as cotton and abaca can be pulped with a regular kitchen blender. This is hard on the blender so don't expect it to last very long. A blender is a good substitute if a beater is not available.

For safety wear rubber gloves and safety glasses. If you are using powdered pigments to color your pulp, a face mask is also suggested. Elaine Koretsky's book, Color for the Hand Papermaker, has many safety suggestions, references, and lists of equipment and supplies.

A large rubber tub was used to hold the fiber and water. A strainer and large enameled pot were used to boil and rinse fibers. C-clamps in combination with pieces of 3/4 inch plywood were used for pressing the excess water out of the stacked sheets of paper. A wide, soft paint brush was used to brush the paper sheets onto a plexiglass surface. (Picture on page 74.)

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