The Environmental Paper Listening Study

Chapter Four: Tree Free Paper

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Conservatree is a nonprofit catalyst and advocate for ecologically sustainable paper markets, combining environmental expertise with paper industry and technical proficiency. It provides practical tools and realistic strategies for successful conversion to environmentally sound and sustainable papers.

Conservatree began in 1976 as the for-profit Conservatree Paper Company, specializing in identifying, developing and supplying commercial quantities and qualities of cutting edge recycled printing and writing papers. After the company closed in 1997, Susan Kinsella and Gerard Gleason converted its information and advocacy mission to an independent nonprofit project of The Tides Center. It does not sell paper, does not represent any paper company or distributor, and networks with people with all types of perspectives on environmental paper issues.

As director of the Listening Study, Conservatree creates partnerships, conducts interviews, researches reports and tests, oversees the comprehensiveness of the information, writes the synopses, and compiles and publishes the reports.

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Promoting Innovative Fibers from Alternative and Non-wood Sources

Fiber Futures is a dedicated advocacy and consulting group that focuses on catalyzing the use of agricultural residues and fibers from non-wood plants for building materials, pulp & paper, textiles and other industries.

As an advocacy group, Fiber Futures has built bridges with industry to convey the benefits, opportunities and challenges of using non-wood fiber resources.

To promote enterprise development of such opportunities, Fiber Futures provides a variety of technical assistance services such as engineering assessments, market research, business plan refinement, educational forums and financing expertise.

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THE LISTENING STUDY

Questions about environmental printing and writing papers have proliferated over the past 20 years or more. Arguments about some of the issues have been intense and often contentious. On some issues, industry and environmentalists have become deadlocked and purchasers have become confused or uncertain about the "right" answers to guide them in their paper choices. In too many cases, this has resulted in no progress at all.

What if, instead, there were a place for everyone to discuss these issues in a respectful, thoughtful, candid and objective way? What if each of us were able to step back, take a deep breath, and *listen* . . . . Get a better idea of the whole, multi-faceted complexity of each issue. Hear what's behind each argument and understand better why each side holds fast to it?

What if paper purchasers and environmental paper advocates could get the benefit of the latest know-how from paper and equipment manufacturers, printers and other paper experts – conversations many otherwise have little access to? What if purchasers and industry representatives could see the in-depth research and thinking behind many of the environmental arguments? What if all of us had a place where we could truly *"listen"* to each other without feeling that that jeopardized our own position?

That is the purpose of the Listening Study. Questions of environmental impacts, technology and production are too big, too complex, and have too many effects on the larger society to be decided by only one side of an argument. Rather, and especially with arguments as rancorous as many have been within environmental paper issues, each side generally has a piece of the truth. Success only results from finding a way to put those pieces together.

In order to see what each of these pieces of the truth is, in order to start putting them together, in order to find a way to resolve them, we need to lay out all the different aspects and arguments, with value and respect for each, so that all of us are on the same – very large – page. Then we can begin to make sense of it all and find a way through.

Providing that kind of "place," facilitating that kind of dialog, is the purpose of the Listening Study, a project of the nonprofit advocacy organization, Conservatree. Funded by grants from the U.S. Environmental Protection Agency and the Weeden Foundation, the Listening Study is being carried out with the help of nonprofit research collaborators such as the Recycled Paper Coalition, Fiber Futures, INFORM, and the National Wildlife Federation.

What the Listening Study Is

- A representation of the broad range of perspectives on many of the most contentious arguments or questions regarding environmental papers today,
- An opportunity for all sides to "listen" to the others, to hear why opponents believe their point of view cannot be ignored,
- A place for laying arguments on the issues "side-by-side" so that each proponent has a more complete understanding of others' thinking, especially some of the nuances that often escape notice,
- A potential for unraveling and discussing "knots" – arguments that have become so heated they're almost "black holes," with each side frequently unable to hear the others,
- A belief that rational presentation of views and perspectives will help sift through opposing arguments to find reliable foundations for building resolution,
- A belief that many of those interested in these questions have not had sufficient access to the wealth of knowledge and studies that underlie perspectives on many of these questions.

What the Listening Study Is Not

- A popularity contest. A position stated by many respondents suggests that it is widespread and essential to consider in any deliberations, but it does not automatically mean it is the "right" one,

- A definitive study pointing to the "right" answer. In fact, the "right" answer might turn out to be a composite of two or more listed here, or something that no one has yet identified.

Goals of the Listening Study

- Provide as complete a picture as possible for each issue, in order to get everyone "on the same page" about how others are thinking and why they're arguing their points,

- Pinpoint where the obstacles are to environmental paper development and clarify what steps could to be taken next towards either resolution or more resolution-oriented discussions between parties affected,

- Develop more paths of communication between those with differing opinions,

- Develop consensus on specific issues when possible,

- Catalyze research, technical development, education programs and discussions to help resolve issues and move environmental paper development forward,

- Provide thorough data sets for discussing issues,

- Get people talking about environmental paper issues,

- Let people hear the whole conversation – most don't have the opportunity to ask all these questions of people at paper mills, printers, environmental groups, and more.

Caveats

- Statements in Listening Study compilations reflect beliefs, opinions, experience and expertise. In some cases, the technical statements conflict. Even these differences are important. Much of the technical information in the Listening Study is cutting edge. Still, some statements may represent information that others consider debatable or inaccurate, some statements may represent outdated but still cited studies (although older studies may well still represent currently reliable information), some may change with new information, and some may be addressing different aspects of similar questions. These differences are important to record as part of sorting out what information needs to be clarified. Readers should evaluate technical statements by date (when relevant and available), by source and by comparison to other information available, as well as recognize that there may be a need for more definitive technical information on some questions.

  In particular, readers should keep in mind that this is not a study to determine ultimate answers. Rather, it intends to lay out the wide range of perspectives, knowledge and beliefs that must be taken into account in order to answer or resolve the questions. Please read the whole presentation on a question in order to evaluate as complete a picture as possible.

- If you find that a point, perspective or information is missing, please provide it to us, or let us know who could provide it.

- Some quotes are identified only by the respondents' relationship to the question – what specific type of manufacturer or service company they may be from, or what type of office they work in. This is because some respondents could not provide public comments on behalf of their organization, or in some cases because they *are* providing public comments on behalf of their organization. The Listening Study is focused on representative perspectives on these issues, not on individuals or

specific companies. Therefore, we believe that even those quotes that are not publicly identified are valuable because they represent a point of view that is undoubtedly shared by many more as part of the concern under discussion. We provide as much identification as respondents are willing to approve, in order to give readers as much information to assist in their evaluation as possible. This covers the range of some respondents approving full inclusion of names, titles and organizations, to others wanting only their organizations identified, to others wishing only their work sector to be identified. All are appreciated.

- We include Conservatree's perspectives on some questions, as well. We think it is appropriate to add our opinions based on experience over decades of interaction with environmental paper markets, both to include our expertise but also to give the reader a basis for evaluating our biases. Although we hold opinions on many questions in the Listening Study, our intent is to express them only in clearly identified quotes, similar to everyone else's opportunities to comment. In the rest of each report, we hope that the body of quotes speaks for itself, without filtering through our lens. If you believe we did not succeed at that, please let us know so we can correct it.

PLEASE JOIN THE LISTENING STUDY DISCUSSION!

E-mail Listen@conservatree.org

PURPOSE OF EXECUTIVE SUMMARY SYNOPSIS

The original Listening Study plan called for simply listing all the responses we received to each question. But as we collected more and more answers from people, we realized that many, if not most, readers would appreciate a synopsis of what these responses reveal. Many people are unlikely to read through dozens of pages of discussion and answers for each report. The challenge, though, is to present the information contained in the responses in as unbiased a manner as possible.

Of course, the original responses are also included, for those who want to make their own evaluations. In fact, we encourage people to read through the entire collection of responses. There is a wealth of information in them, and no synopsis can do them justice.

We expect the publication of this report to elicit more responses on this question, as readers realize that information has been left out, or some responses need to be given more weight, or discussions need more clarity. We regard it as an initial draft, and welcome your comments and additions. This current executive summary, therefore, is likely to change in future editions of this report as more information is added. We will publish new reports as additional comments are received that change or enhance the information here. Each edition will be dated so that readers can identify the latest edition.

EXECUTIVE SUMMARY

Many environmentalists have a vision: One that includes amber waves of grain and fields of plenty instead of chainsaws in forests. They hope that plant fibers can take the place in paper mills of today's forest fibers. But there are many questions about whether this shift is appropriate and feasible and how it could best be accomplished. Despite disagreement on many of the specifics, virtually all non-wood fiber experts agree there is much research still to do.

This report includes some of the data produced by nonwood fiber researchers, but it is not by any means an exhaustive collection. We intend to continue adding links and references to data sources. But the Listening Study is focused especially on the thinking that shapes these issues, interprets the data and chooses what to explore – or not to explore. Some of this thinking is informed by data – which may or may not be readily accepted by others – and some is not. Our purpose is to sort out the arguments on these issues to find ways of moving through them to more progress in advancing environmentally sustainable paper production.

Plant Fibers vs. Tree Fibers

How do alternative plant fibers compare to using tree fibers for paper production? This is not a simple question with a simple answer. Many different systems and sub-systems mesh to produce either paper source, and each system influences the environmental, social, technological, geographic, and production evaluations necessary. In fact, the most important point that our respondents made over and over is that there can be no general answer to this question. Indeed, there was also some debate about whether this even is a valid question. John Mechem of the American Forest and Paper Association was quoted in a magazine article as saying, "We think finding a replacement for wood fiber is a problem that does not need to be solved."

But Maureen Smith, author of an extensive environmental evaluation of the U.S. paper industry, thinks that assertion is premature: "Overall, the dominance of the wood-based industry perspective and the associated research corpus has strongly tended to overwhelm the debate as it has emerged and to claim the benefit of the doubt. . . . an important example of how a conventional wood-based perspective could undermine the nonwoods idea before it could even be argued."

For almost all respondents, however, there are so very *many* questions about nonwood fibers, in part because every potential nonwood fiber source has a different profile from the others. As Jeanne Trombly of Fiber Futures told us, "Considering that nonwood plant fibers and ag-residues were pulped and used for paper going as far back as [105] AD, there are hundreds of sources of non-woods for paper, each with a rich and diverse history that can be explored depending on where one needs the fiber and what the final product needs to be."

The Listening Study responses identified four different categories of sources for these plants:

1. "On-purpose," or dedicated, crops grown specifically for paper fiber, such as hemp, kenaf, jute and flax,
2. Agricultural residues left over from food production, such as cereal, rice straw and bagasse (sugar cane),
3. Industrial residues (sometimes included with agricultural residues) such as cotton linters snipped from cottonseed after ginning for textiles but before pressing for oils; cotton or linen scraps from clothing production; and flax residue from oilseed, and
4. Naturally occurring uncultivated crops such as wild grasses, sisal, and bamboo.

Virtually all the respondents would agree that each type of plant fiber must be evaluated individually for its advantages and disadvantages for use in paper production. Many of the arguments surrounding different nonwood options involve environmental comparisons. These are critical to deciding whether it is worthwhile to pour resources into developing one type of fiber over another, as well as whether any nonwood fibers offer sufficient advantages over the use of wood fibers to warrant the investment. But

environmental comparisons are not the only consideration. A list of critical factors developed through the discussions of each question in the tree free section of the Listening Study shows a wide range of hurdles a nonwood option has to meet:

- How does the plant fiber compare environmentally to tree fibers and to other plant fibers? Is its sourcing more benign than from natural forests? Is it more benign than from tree plantations? Does its life-cycle require pesticides, herbicides, excessive energy or water? Does its sourcing or use benefit the environment, such as kenaf rebuilding depleted soil or grain crop residues providing a means for changing waste into a beneficial product?

- Does using the fiber for paper provide social benefits, such as income for family farmers which in turn might strengthen communities? Or does it lead to social detriments, such as encouraging landowners to sell off or cut down their forests or farmers to neglect sufficient return of organic material to their soil?

- Is it easily available in large quantities and compatible with its environment? For example, the reed Arundo donax was considered to have great potential for papermaking in California until farmers objected that its invasive qualities threatened their production and others became concerned about its potential to block salmon streams. But it may be an excellent candidate in a different location.

- Can it be grown in sufficient quantities near a mill that can pulp it? Can it easily be transported to a pulp mill?

- How easily can it be pulped and does its pulping produce problems that must be addressed? Plant fibers drain water at different rates than wood fibers and than each other, yet almost all the pulp mills in North America are engineered for wood. The problem of large amounts of silica produced when pulping agricultural residues remains to be solved.

- Do the fibers make good paper? Some are too short for the strength required for some products, others are too long.

- Is the non-wood paper compatible with recycling? Some nonwood fibers have already been proven to be recyclable. There are concerns that others, particularly agricultural residues, might break down more than wood fibers in the strong mechanical action in a deinking pulp mill, slowing drainage, reducing yield, and making weaker products. Is that true or simply a negative myth that needs to be debunked?

Some of the attractiveness of one option over another has to do with the currently uneven development of different possibilities. For example, Jeff Mendelsohn, president of the environmental paper merchant New Leaf Paper, pointed out, "It's easier to get low impact agricultural fiber than FSC offcuts. However, it's easier to take advantage of FSC certified woods because the systems are already set up for pulping wood."

International Paper, primarily a wood-based paper manufacturer, argued for its predominant fiber source when it stated, "While managed forests are entirely hospitable to biodiversity, wildlife and endangered species, alternative fibers are agricultural crops, which means they're monocultures requiring the near eradication of any competing plant or animal species."

Peter Hopkins, a spokesperson for Crane Paper Company, summed up the dilemma over comparisons by saying, "There are too many variables to do anything close to a life-cycle analysis between 'ag fibers' and 'tree fibers.' Now, if you take two specific cases and directly compare them, you could complete a good study. Something that would compare a specific fiber grown in a specific place with specific conditions, processed in a specific way for a specific paper. Then you could compare accurately and with certainty."

Yield

Still, there are many bases for comparison. Some argue on the basis of yield, which varies widely for different plants, at different times, in different places, and by different methods. As Jeanne Trombly from Fiber Futures told us, "Even in comparing the same fiber, such as wheat straw, one may have drastic variations in fiber yield. The density of wheat grown in eastern Washington is four times that in Kansas, for instance. This is due to climate conditions and soil quality. With bamboo, there are over 1000 varieties that will have a different yield per acre. Flax grown for linen grows much higher than the seed kind, yet the seed kind yields a beautiful fiber."

There are also different ways to calculate yield. Is it most important to measure the volume in the field per acre? Or should we look at how much land is necessary to grow the equivalent amount of pulp? Maybe the most important comparison is how much pulp the fiber produces after going through a pulping process. Some of the reason for sometimes contradictory claims may be that "yields" are being measured based on different assumptions.

Tom Rymsza of Vision Paper even argues that some of the yield tables in the Paper Task Force report on nonwood fibers are calculated using incorrect conversion factors, yet they are used by many as the source for arguments about the preference of agricultural residue fibers over on-purpose crops. He asks, "How can we have a science-based discussion attempting to arrive at a well-thought-out comparison of the merits of different types of fiber if the basic data – and even the basic conversion factors – are wrong?"

Environmental Impacts

How do nonwood fibers compare to tree fibers in their papermaking impacts on water, energy and pollution? Answers to these questions seem to be tied up in systemic differences that factor into the whole picture. The International Institute for Environment and Development (IIED) points out that, "Small mills are preferable for nonwoods because of limited fiber supply, therefore capital costs are lower. However, small mills by nature will be more polluting because chemical recovery does not make economical sense. The higher proportion of silica in most nonwood fibers makes traditional chemical recovery processes ineffective."

Silica, present at high levels in some agricultural residues such as straw and corn stalks, is a serious problem. Tom Rymsza of Vision Paper describes that it "accumulates and hardens on machinery, creating the need to frequently stop production and clean with caustic chemicals. Regularly shutting down machinery in a pulp mill decreases any chance of creating an economically viable product." Research is ongoing to resolve this problem. Meanwhile, production with agricultural crops that do not create this silica problem has moved ahead.

On other environmental factors, nonwood fibers shine. Tom Rymsza also reports, "Most annual crops, when compared with trees, contain lower levels of lignin. Since chemical pulping methods remove non-cellulose components, many annuals can be pulped using milder chemistry and less energy." Robert Hurter, in a TAPPI publication, notes, "Bleaching of nonwood pulps . . . typically is easier than woodpulp and requires fewer bleaching stages and lower chemical consumptions." Ernett Altherimer of Nile Fiber calls Arundo donax "a carbon sequestration giant. It takes in carbon and effluents and stores them in the leaves, stems, etc. . . . Compared with wood it is 90% more efficient at sequestering carbon. Arundo donax enhances the soil by processing toxic chemicals to an inert form." Steve Shaffer of California's Department of Food and Agriculture makes a similar point: "Kenaf's long roots remove salt deposits in the soil and can be used as an excellent rotation crop for improving the soil . . . and can pull up lost nitrogen leached farther down in the soil."

Peter A. Nelson of AgroTech Communications sums it up by saying, "In theory, the wear and tear on the land (topsoil) over ten years growing trees would be less than an annual crop, while the production of pulp from trees would require more energy and water based on lignin content, etc."

International Paper would beg to differ, though, saying, "Annual agricultural crops are more energy intensive than sustainably managed forests. Much of the additional raw material cost stems from the

additional work and energy required to deliver the material. In addition, it is necessary to invest additional money in facilities to convert them to produce paper made from agricultural fibers. Reducing the cost of agricultural fiber crops would not eliminate the fundamental biodiversity and energy use problems associated with these crops."

Pesticides and Fertilizers

One of the key points made in debates about the environmental value of fibers from agricultural crops vs. forests revolves around the use of pesticides and fertilizers. Richard Denison at Environmental Defense puts it this way: "The available data indicate that pesticide and fertilizer usage even for plantation-grown trees is generally lower than it is for kenaf and hemp. The main reason for this is that trees are grown on multi-year rotations with chemicals applied at most every few years, in contrast to annual crops, where such chemicals are applied annually." Yet perhaps there is room for improvement, as IIED states that, "Most farmers use pesticides and fertilisers on their non-wood fiber crops, although it is possible to grow most types of fibre without those inputs."

The consideration is skewed, as well, by the fact that agricultural residues, by definition, derive from crops that would have been planted and grown whether or not their residues are used for paper. Therefore, their use of pesticides and fertilizers is considered irrelevant to the paper fiber question, while on-purpose crops must account for inputs from the very beginning. Yet Peter Nelson at AgroTech is concerned about the effect of financial incentives for residues, commenting, "I discourage the idea of using crop residues. . . . Farmers are an efficient bunch and if there were a 'commodity price' for residues it would be too tempting to take off too much residue. You have never heard of a farmer intentionally leaving beans, cotton, or corn in the field at harvest; the same farmer would not leave enough residue for ground cover if he already took the time to bale and move the residues."

There are additional points that put a different spin on the pesticide question. For example, some respondents pointed out that sorghum is a fast grower and therefore has less weed competition and less cultivation requirements; kenaf is host to beneficial insects; a farmer harvesting for fiber rather than for fruit or grain needs less herbicide and no insecticide.

Social Realities

There are social realities, as well. IIED states, "There are two main advantages for farmers in growing fibre crops rather than trees. Firstly, the area under the crop can be changed every year depending on the relative benefits from the crop. Secondly, income is generated every year, avoiding the need for credit to support tree growing costs over many years." At the same time, perception may play a role, according to Russ Clark, of the U.S. EPA's Environmentally Preferable Purchasing Program, who points out, "[Nonwoods] may not have an advantage because people may not see trees as toxic. Whereas consumers might believe that agricultural products were grown with pesticides, they could believe trees just grew in a forest and must be natural."

Agricultural Residues vs. On-Purpose Crops

The question of whether nonwood fibers would be better for papermaking than tree fibers is tied up with the question of exactly which nonwood fibers would be used. There is a strong camp arguing for only the use of agricultural residues, since they already exist and would otherwise be waste products (beyond the volume that is turned back into the soil for amendments). Maureen Smith points out that, "By one estimate, depending on growing practice and soil type, an average of more than 50 percent of harvested cereal straw is available as surplus." Jeanne Trombly put it well by saying, "The biggest opportunity for using non-wood fibers with little land impact is simply to use the residues of the millions of tons of crops that are already being grown for food and oilseed."

The Paper Task Force report argued, "Using agricultural residues to make paper helps solve a waste management problem for farmers and provides an additional source of fiber for papermaking. Chemical use throughout the fiber acquisition process is also low. Paper industry experts think that agricultural residues will be more competitive than annual crops because no additional land is required and the

agronomic practice has already been developed. Harvesting straw for pulping eliminates the burning of straw and the resulting air pollution." But it also recognized some downsides: "Harvesting the straw can lead to a loss of nutrients in the soil. Farmers must then balance the cost of a smaller straw harvest with the application of fertilizer to compensate for the nutrient loss."

There are also many supporters of on-purpose crops. Tom Rymsza, in arguing for kenaf, states, "In the US, almost 80% of all annual row crop land is used to produce three main crops – corn, soybeans and wheat. That does not represent diversity or sustainability. The intensive agricultural practices currently used require high levels of fertilizer and chemicals on those crops. Adding new crops that are rotated with conventional crops will reduce overall pesticide and other chemical use, will contribute to maintaining soil fertility, and will help to reduce surpluses. . . . When prices are low [because of surpluses], the government steps in with deficiency payments to farmers (subsidies), which cost you, the taxpayer, money, and which create an un-level playing field in the world trade picture."

The Association for the Advancement of Industrial Crops agrees, reminding us that, " . . . overconcentration and overproduction in a relatively small number of food and feed crops have created global problems. Clearly, diversification in agriculture is of high priority." Russ Clark, at EPA's Environmentally Preferable Purchasing Program, suggests that, "As sustainable forestry issues become more defined, we have to also look at sustainable agriculture." To the nonwood papermakers at Living Tree Paper Company, that means using on-purpose crops for rotation crop farming, which they say "is far less damaging than current industrial chemical agricultural practices."

Often advocates for ag residues voice a worry that markets for on-purpose crops would encourage landowners to cut down their forests for farming. EPA's Russ Clark demurs, "I don't think anyone is thinking of cutting down existing tree farms or forests to plant crops. With a life cycle analysis, we would understand the implications of such a replacement," and Tom Rymsza points out, "There are over 75 million idle agricultural acres in the U.S. If only a portion of this went to growing kenaf, the supply would be adequate."

Still, Richard Denison at Environmental Defense believes that, "It is hard to imagine that the biological value of even the most intensive of tree plantations would ever be lower than that of an agricultural field of comparable size. Indeed, I would argue that, acre for acre, from an ecological perspective, habitat value, biodiversity and water quality protection and soil carbon storage would all be higher for silviculture relative to agriculture because harvesting, replanting, fertilization and pesticide application only occur on a multi-year basis rather than annually."

But Nicole Rycroft, of Canada's Markets Initiative, points out that these arguments can be situational: "From a Canadian perspective, it makes a lot of sense to further explore annual crops as viable fibre options. I understand there have been some lifecycle studies that point to Southeastern U.S. tree farms as more benign than on-purpose crops. In the Canadian context, wood fibre and pulps primarily originate from old-growth or intact forest eco-systems. . . . Because the biodiversity values, ecological functions and services of old growth forests are very different from Southeastern U.S. tree farms, it may well be that many on-purpose crops actually are preferable from a life-cycle analysis perspective to pulp and fibre from intact old growth forests."

Kelly Sheehan, at North Carolina's Dogwood Alliance, questions whether tree plantations can be seen in a positive light: "It is important to follow and support research into on-purpose crops. I think we should be careful not to refer to pine plantations as benign in most any context. Giving the impression that plantations support biodiversity is inaccurate. (Unless of course we're talking about deer populations!) The conversion of natural forests in the Southeast to pine plantations, requiring an intensive use of herbicides and fertilizers, is one of our greatest challenges to forest protection in this region."

For the late environmental luminary David Brower, there was no contest. In an article called “Kenaf: A Tree-Free Alternative,” he wrote, "The forest plantations that cover ancient forest soils are not the answer. These plantations tie up useful land, and after only a few rounds, leave the soil decimated. We cannot pretend that we will turn these areas back into forests. Kenaf offers us a viable alternative."

Susan Kinsella at Conservatree questions the premise underlying the debate: " I think there is way too much focus on comparisons only to forests. . . . [T]his question is more complex than that. It crosses over to also include agricultural sustainability issues, where there is a whole different set of thinkers and activists working to re-orient the agricultural status quo to be more sustainable both for farmers and the land. So the question of ag residues vs. on-purpose crops cannot be analyzed only from a forest paradigm. We have to bring in an additional set of experts with sustainable agriculture expertise and perspectives to add to the forest considerations."

Arguing for "the practical and implementable, not just the theoretical," Conservatree maintains that "the only U.S. or Canadian nonwood fibers that have gotten to consistent marketplace printing and writing paper products, other than cotton and a very small amount of bagasse, are on-purpose crops. The companies that produce them . . . have taken enormous financial risks, put in decades of phenomenal dedication, built complex sourcing systems from the ground up, responded to environmental issues, and turned out extremely high quality products in a highly technical and demanding industry." While clearly encouraging more work on developing ag residue paper fiber potentials, Conservatree urges that nonwood fiber supporters not "turn our backs on the people who have actually already made nonwood papers in the U.S. a reality."

Research and Infrastructure

In creating that reality, there has been a good deal of in-depth research and experimentation with both on-purpose crops and agricultural residues. The U.S. federal government reports, "Since the 1930's, the U.S. Department of Agriculture has devoted some attention to possible use of nonwoody plant fibers (especially crop residues such as sugarcane bagasse and grain straw) in pulp and paper. . . . As a first step in identifying new sources of fibers for pulp, a botanical-analytical screening system was established. . . . Among 387 species that were subjected to the entire screening evaluation, kenaf and sunn hemp were most promising. The later decision to concentrate on kenaf rather than sunn hemp was based largely on the ability of kenaf to produce consistently higher yields with much better standability."

Al Wong, an innovative papermaker who works with straw and grain crop residues, recommends that researchers "re-examine the supply of papermaking fibres from a zero-base viewpoint, without technical prejudice. The obvious sensible approach is the reinforcement of the basic tenet: Reduce, Reuse and Recycle, and with the addition of a '4th R.' The fourth 'R' is replacement of traditional virgin wood fibres with other fibres. Replacement with agricultural cropping residues in paper manufacture, in conjunction with 'reduce, reuse and recycle' practices, would have a significant impact on 'saving trees.'"

Both the Agricultural Research Service of the USDA and the Alberta Research Council in Canada are researching new crops that can be used for industrial – in this case papermaking – purposes. Purdue University has an Internet New Crop Online Resource Program. The USDA's Forest Products Laboratory as well as several university paper and / or forestry schools conduct studies into agricultural options.

And yet, most of the comments by leading experts in the field are laced with acknowledgements that more study and more development is needed. Peter Hopkins of Crane Paper Company points out, "Tradition is a major holdup. Since just after the Civil War, paper has been made from trees. Every piece of papermaking machinery has been designed for trees. You can't just dump a bale of kenaf into a pulper, because the pulper was designed specifically for trees. The tree paper industry has built economies of scale from research to distribution. On the other hand, how much is spent on ag-fiber paper research in the last couple of years? Pretty close to $0 has been spent for kenaf, hemp, bagasse, sisal, jute, straw, flax, you name it. Meanwhile, millions are spent each year to develop higher-yielding, shorter-rotation tree-crops. We're really just starting to figure out how to get ag fibers grown and processed efficiently."

Another basic requirement is infrastructure. Other than about a dozen cotton pulping mills and three or four mills that pulp flax for specialty items such as filters, cigarette papers and teabags, there is virtually no non-wood pulping in the U.S. and Canada. Al Wong's small experimental pulper in western Canada has advanced the knowledge and technology for pulping ag residues, and there is some pulping of bagasse (sugar cane residue) in Mexico.

The nonwoods expert Michael Jackson says, "Most agricultural fibers will not process in the raw material handling and pulping stages of existing wood pulp mills," and, as AgroTech's Peter Nelson points out, "Conversion [to nonwood fibers] is more complex than just the pulp; the existing infrastructure is a part of the larger wood products industry. . . . A pulping mill conversion would affect the far-reaching markets of wood products," and therefore presumably be contradictory to interests of paper companies that rely on virgin wood fibers. However, Andrew Kaldor, in a TAPPI Journal article, notes a contradiction: "[A] commonly held view today among the pulp industry experts of developed countries is that the production of nonwood fibers is not viable or competitive in their economic environment. The same industries, on the other hand, are prepared to accept a heavy long-term reliance on wood fibers due to a perceived lack of alternatives."

Even despite the lack of infrastructure, though, there are a surprising number of high quality printing and writing papers that already contain nonwood fibers. Conservatree's website Guide to Environmental Printing and Writing Papers lists nearly 80, with almost half of those containing nonwood fibers other than cotton, including hemp, flax, bagasse, kenaf, banana stalk fiber, coffee and tobacco plant residue, seaweed, old currency and blue jeans.

Towards the Future

What does the future hold for nonwood fibers? That depends on many factors, including financial. Jeanne Trombly describes the fiscal realities: "The price of raw material wood chips is maintained artificially low because of many resource tax breaks and other give-aways of public agencies that own large swaths of forestland, not only in North America but all over the world. Only when wood increases in price do the paper companies get interested in non-woods. . . . One of the biggest factors in the costs of non-woods is the price of pollution control technologies to recover the pulping chemicals. The wood pulping chemical recovery systems have not worked for non-woods and new inventions have been introduced, but the entrepreneurs providing lab-scale alternatives have not been able to raise the capital needed to get these new technologies into pilot scale. Yet this may change as one major development is about to break due to the demand for non-wood pulping in China."

Plans are underway for a kenaf pulp mill in the U.S. Southeast and research is going into the feasibility of an agricultural residue pulp mill in Alberta, Canada. But, as with recycled content and other environmental paper characteristics, the deciding factor will be demand. Peter Nelson says, "Many of the efforts in the past have focused on beating out other crops such as corn or soybean and promoting one specific fiber. A more effective technique is to win the consumer's heart for natural ingredients from the ground as better than synthetics. Then the individual fibers can develop their own niches. The nonwood industry would be better off to market nonwood fibers as a diversified sustainable opportunity." Paper industry consultant Peter Hopkins agrees, "Industry is not going to change just because we want them to start using ag fibers to make paper. Consumer demand has to change in the absence of other motivating factors for the paper industry. . . . [If] there are enough consumers out there saying they won't buy virgin wood paper, the industry will find the economic advantage and take heed."

Which comes first, the demand or the capacity, the chicken or the egg? James S. Han, a research chemist at USDA's Forest Service Forest Products Laboratory, suggests, "A perfect scenario would be establishment of small pulp mills at the heart of the wheat belt, corn belt, etc., compact the straw and send it to the mills, then pulp during the off-season, hiring the farmers. Pulps can then be shipped to the paper mills. Thus, combine farming and pulping. It is no different than sending grains to the mills to be processed as flour." Maureen Smith expands the vision, saying, "Generally, the transport issues associated with nonwoods, the corollary emphasis on smaller-scale pulping formats, and the issues of heterogeneity in fiber types, sources, and applications, are the basis of an increasingly strong regional theme that runs through the debate."

Indeed, over and over again, comments in the Listening Study show that environmental issues and desirable nonwood fiber profiles vary considerably between geographic areas. Answers in one region may actually create problems in another. While the paper produced may be sold nationally or even internationally, the appropriate fiber sources and processing systems may be very different from one part of the country to another. Perhaps some of the controversies around nonwood fibers have developed

from attempts to impose one answer on such a variety of situations. Peter Hopkins, representing Crane Paper Company, explains, "Supply for ag residues is a regional issue: A mill in Maine might want to use rice straw. It doesn't matter if there are millions of tons in California, the cost of transportation might mean that there is effectively no supply for that mill in Maine."

So are there enough tree free fibers to produce paper? In theory, yes, of course, says Peter Nelson, "However, it is hard to know when to stop counting — in theory, we could pulp tree clippings from town, but the land management, collection, and transportation is complicated. Pound for pound, hauling trees is generally far more efficient than hauling baled hay. In practicality, all the existing residue cannot and should not be harvested." Of course, regional variations provide the potential for many different successful scenarios.

Whatever types of nonwood fibers are pursued, there is a daunting amount of work ahead to develop competitive systems. "Just think of all the effort than has gone into developing the collection, processing and use of recycled fibers," says Michael Jackson. "A similar effort and capital investment would have to go into systems for agricultural fiber use." Fortunately, there are a number of entrepreneurs and advocates already tackling developing those systems.

Future Directions

Clearly, the nonwood fiber portion of environmental paper development is fraught with a number of knotty problems:

- What data can we rely on to evaluate whether nonwood papermaking fibers are environmentally worthwhile to pursue in comparison to wood fiber?
- What fibers are worth pouring research and development resources into advancing?
- Should we support the use of both agricultural residues and on-purpose crops or only one or the other?
- How do we solve production problems such as silica burdens?
- How do producers juggle attracting investment financing to build nonwood fiber mills while at the same time developing customer demand that will motivate and justify it?
- How do we develop that customer demand in the first place?
- Can the prices of nonwood products be competitive with wood fiber products produced in long-established, highly stable and well-capitalized manufacturing systems, or can they create niches that allow them time to build the necessary economies of scale?

Russ Clark at EPA sees practical requirements: "The [nonwood paper manufacturing] industry needs to do a better job at putting their nonwood materials side by side with trees to understand as a country which papers are preferable. There is a lot of support on 'the Hill' for agriculture-based products. On the other hand, the forestry industry has a lot of lobbyists. Without good information, the [nonwood] industry is not going to get far."

New Leaf Paper's Jeff Mendelsohn continues that point, "To address the technical barriers, there needs to be a combined effort from private industry and public research. When fighting an entrenched industry with significant barriers to entry, public support is critical." Peter Nelson clarifies, "The inherently impossible question seems to be: Overall, how do we minimize impact of industries that by existing destroy the earth? There is a clear role for the public dollar in nonwood research. There is already a ton of federal research money going into tree genetics, lower energy, and water use. We have to tap into this research."

Tyson Miller, program director for the Recycled Products Purchasing Cooperative, which makes environmental office papers available at competitive prices, spells out some of what he thinks is needed:

- There should be more public funding for R&D to develop new hybrids and varieties that are resistant to pests. Cooperative extensions would be good entities to accomplish such research.
- Additionally, cooperatives that pool fiber producers together to reduce transportation and production costs would be ideal.

- There should also be government participation in the fiber production. The government could use public lands to set cheap rates or grow it themselves.
- The industry should identify the potential users to determine their price point and what preference they would give to alternative fibers, if any. Then they should balance the demand against the costs of production to see how much the price can be pushed down.
- The collection infrastructure should be targeted. The industry could reduce the overall costs of getting pulp to industry by developing regional collection programs to get high volumes shipped. With this model, the pulp purchasers can reduce their fiber unit costs.
- Promoters would also need to target producers to show that there would be a demand for tree-free papers. With demand numbers they could get the "big four" to invest in capital equipment and conversion costs.

Some of this is already happening. Peter Nelson of AgroTech relates, "To help develop the marketing end, AgroTech Communications, Inc. is participating with 40+ biobased companies to develop the Biobased Manufacturers Association (BMA) to help in marketing biobased products based on their inherent attributes. . . . One aspect of the program is setting up cooperative purchasing. . . .The nonwood industry would be better off to market nonwood fibers as a diversified sustainable opportunity. Particularly after September 11, the industry needs to market to Washington. They also need to heal wounds with the wood industry to come up with the best balance."

Russ Clark sees more, "As sustainable forestry issues become more defined, we have to also look at sustainable agriculture. To compare how an acre of trees versus an acre of agriculture is managed, we need a clear standard for comparison. The criteria for organics are primarily related to human health, how much residue is on the fruit or vegetable. It might be appropriate to develop a non-food standard. It would have to be beyond the organic requirements and focus on the life cycle issues: runoff, irrigation, transportation limits of inputs, etc."

James Han at USDA's Forest Products Laboratory sees an even larger agenda, "Future outlook seems to me is based more on the control of imports and national policy rather than availability of agricultural pulping facilities. Without a national policy, cheap imported chips, pulps, and papers will flood the U.S. market."

With so much basic work still needed, why is there nevertheless so much motivation to develop nonwood papermaking fibers? After all, as Maureen Smith so aptly puts it, "If the question is one of fitting a heterogeneous and disbursed alternative fiber supply into a geographically concentrated, technologically rigid, vertically integrated, capital-intensive industry, one begins to better understand the modern history of nonwood paper commercialization efforts. The question becomes less why the commercialization of nonwood fiber pulping has yet to succeed, than why anyone in his or her right mind would still be trying."

But there are two sides to this picture. On one hand, Maureen comments, "When one views the issue from a broad perspective of social and environmental opportunity . . . one sees nothing short of abject failure and gross irresponsibility reflected in the modern industrial status quo." Yet on the other hand, "One also sees an area of potential remarkable for its reach, its regional variability, and its human and ecological significance."

It is that second view that inspires this report on tree free paper questions.

Recommendations for Next Steps

As we point out in this summary, and as is obvious in reading the full comments, there are a number of difficulties in the nonwood paper fibers field that hamper its development. The obstacles cover all the different kinds we initially contemplated in developing the Listening Study:

- **Developmental** – The North American infrastructure for nonwood fiber sources other than cotton is mostly either fledgling or nonexistent, with agricultural sources, transportation, pulping and

distribution systems all needing development. The fibers now available are often pulped as special cases in mills built for other types of fibers.

- **Economic** – Successful development requires a great deal of investment and capitalization in order to achieve economies of scale that can mainstream the products.

- **Technica**l – New pulping processes need to be developed to overcome the silica problem with agricultural residues. All kinds of research and testing are needed for all the potential fiber choices.

- **Cognitive** – Studies and debates need to be presented with much more clarity about exactly what fibers are being discussed, in what geographic regions with what kinds of contexts. Readers will notice in reading through the comments in this report that many discuss "nonwood fibers" as one entity, yet the comments are clearly applicable to only on-purpose crops, or only agricultural residues, or only a particular fiber and not another. We have reached a point in this field's development where it is essential to be specific about the statements made so that others will be able to accurately apply them.

  There also clearly is a need to enlarge the knowledge-base for nonwood paper issues by bringing in expertise about sustainable agriculture. Much of the discussion so far has been framed by those with expertise in forest issues, primarily because the product we are discussing – paper – has been so overwhelmingly produced from wood fibers. Nonwood fibers require equal expertise in agriculture.

- **Value-driven** – Of course, the traditional wood-based paper industry has a great deal invested in maintaining its tree-fiber-based systems, and this informs their viewpoints and considerations. Environmental advocates bring in-depth knowledge of ecosystem issues to the questions, but generally do not have business backgrounds. Some are even suspicious of business needs that are in the forefront for entrepreneurs trying to bring nonwood products to the marketplace. Rather than always seeing these values in competition, those involved in these discussions have many opportunities to enlarge their understandings enough to incorporate many competing needs, in order to encourage development of the prototypes and systems necessary to build towards success.

- **Political** – U.S. economic values and capital systems that encompass only the most overt financial costs while disregarding environmental, social, infrastructure, and other non-monetary costs (often labeled "indirect costs") are encouraging the traditional paper industry to make almost all new investments outside of North America in order to be "competitive." This global focus by large companies could possibly increase opportunities for entrepreneurs who think locally and regionally, but they will likely be faced with the same sort of investment critiques and expectations that undermine domestic investments by large companies.

  Subsidies to forestry and wood-based papermaking, as well as generous subsidies to paper companies in a number of other countries, discourage development of new types of papermaking facilities in the U.S. However, there are also bio-based research funds available through the U.S. Department of Agriculture (although these are often interpreted to apply to wood-based products) and other federal sources that could support some of the necessary nonwood research.

In addition, the current comments in the Listening Study suggest some specific steps that would help move these issues forward:

Research Evaluations

Much of the specific technical research necessary will be identified by those developing specific nonwood fiber sources. But there are some points that will make it easier for others to evaluate the data available, as well as which studies are sound foundations for choosing directions.

- **Address research study criticisms.** There are many reasons why studies of similar issues might show quite different results, or why researchers might arrive at very different opinions. But advocates, policymakers, purchasers, and other researchers deserve explanations so that they can effectively evaluate which studies to rely on. If calculations or conclusions are criticized, they

should be actively addressed and substantiated. If there are errors, the data should be recalculated or withdrawn.

- **Provide transparency for opinion articles.** This field needs a solid footing in order to move forward. Some opinion pieces have substantiated their conclusions with compilations of statistics but not cited the background data that would let readers assess whether they agree that the statistics chosen for the compilations were appropriate.

- **Bring sustainable agriculture perspectives into the discussion.** Network with agricultural experts on paper issues, both to bring more of their knowledge into illuminating fiber sourcing discussions and also to bring more of a paper perspective into their sustainable agriculture considerations.

Research Studies

- **Translate applicable studies**, particularly life cycle and environmental analyses, from other languages. Researchers in Japan, China, India, Thailand and other countries that have established expertise in nonwood papermaking have valuable information to add to North American evaluations of nonwood fibers.

- **Pursue life cycle analyses** of the nonwood fibers most likely to be used for papermaking in the U.S. and Canada. This will require also developing accepted frameworks for analysis. It may also require life cycle analyses of tree fibers in different contexts (e.g. old growth forests, sustainably certified forests, second- and third-growth forests, plantations) for comparison.

- **Explore incentives, disincentives and laws** that could alleviate concerns about converting forests to crops.

- **Determine whether potential nonwood pulps can be recycled**.

Processing

- **Develop solutions to the silica problem** that hampers pulping many types of nonwood fibers and bring them to production-scale applications.

- **Develop and build pulping mills** appropriate for specific nonwood fibers that will be used for papermaking.

- **Experiment with creative options** to the traditional large-scale mills developed by wood-based paper companies, particularly small-scale, regional and cooperative models.

Market Development

- **Support entrepreneurs' efforts** in developing specific nonwood papers, unless there are serious and proven environmental problems involved. Environmental obstacles should be solidly substantiated, not simply theorized.

  The nonwood fiber pulp and paper markets are currently so miniscule that mixed messages or opposition from environmental groups can dissuade paper purchasers and undermine market development. Especially because nonwood fibers appear to be most successfully approached as regional sources, the more options allowed to develop, the better the possibility of developing thriving nonwood alternatives to wood-based pulps.

- **Develop a consensus** among environmental groups on which nonwood fibers they can support in a unified way. The process for reaching consensus should include a wide range of expertise, including agriculture and papermaking as well as forestry.

LISTENING STUDY: A little history helps to set the stage for this discussion. Even on an immediate timeline, note that there have been changes in terminology over the past few years. In the late 1990s and up until 2001, when the questions for the Listening Study were first formulated, environmentalists commonly used the term "tree free fibers" or "alternative fibers." Now, however, most respondents are more likely to use the term "nonwood fibers," which has long been common among researchers. Atchison and McGovern give us a longer view of nonwoods' history.

A Brief History of Nonwood Paper Fibers

from **Atchison and McGovern 1999**

Wood as a papermaking raw material is a relative newcomer; for nine-tenths of its history, paper was made almost exclusively from nonwood plant fibers. The first true paper is credited to Ts'ai Lun in 105 A.D. in China, and he apparently made it from textile wastes, old rags, and used fish nets, i.e. the fibers of true hemp and China grass. Because of the processing that these fibers had already received in the textile-making process, they could be prepared for papermaking by little more than beating, which was done by macerating them in a mortar.

. . . The demand for [this type of paper] became so great that a search soon began for additional fibrous raw materials. The first suitable raw fiber the Chinese found – i.e. straight from the plant – seems to have been the inner bark of the paper mulberry. This needed to be first separated from the outer bark, and then soaked in an alkaline solution of lime or wood ash, before being macerated. Another raw fiber used was bamboo, which needed an even longer soaking, up to several months. These procedures represented the beginnings of the technique of pulping, as distinguished from that of making pulp into paper.

. . . [T]he technology of making pulp and paper spread. . . .In regions where paper mulberry, bamboo and China grass were not available, they were replaced as raw materials by linen and cotton rags.

. . . In 1450, however, printing from movable type was invented in Germany. . . . This created a demand for printing surface. . . . In the next 150 years, therefore, mills for making paper by hand were built in nearly every country of Europe, and also in Mexico. The lower cost of printing books on paper stimulated the foundation of many more schools and universities. This increased literacy and led, around 1600, to the publishing of newspapers. Thus conduct of government and commerce, as well as of education – in fact the social, technical, and economic progress of nations – became linked to the production and use of paper.

But the resulting increased demand for paper could not be met only from rags and old rope, and the search for alternative raw materials intensified.

. . . Finally in 1827. . . William Shryock of the Hollywell mill near Chambersburg, PA brought straw into successful commercial use. Shortly thereafter, several mills in Pennsylvania and New York were making straw paper. . . .

Between 1840 and 1885, the experiments on wood pulping resulted in four commercially successful processes . . . [that] proceeded to displace straw from a number of grades. . . . Nevertheless, the production of straw pulp continued to expand, because of its use for paperboard. This use took a spurt after the acceptance in 1895 of straw paperboard by Wells, Fargo for shipping containers, in competition with wood boxes. Straw pulp production expanded particularly into the U.S. Middle West, where wheat farmers had moved previously and were producing an abundance of straw. . . . In the early 1940's straw corrugating board achieved a production record of 2/3 million tpy.

From then on, however, straw corrugating board as a product of U.S. mills was doomed – not by lack of quality, but by the economics of straw supply. In 1960 only one small mill making straw pulp remained, and in the 1970's the last of the U.S. mills using straw pulp switched to hardwoods and waste paper. Other developed countries experienced similar trends. . . . Similar case histories could be written showing how other nonwood plant fibers, once important in many developed countries, have now been almost entirely replaced there by wood pulp.

LISTENING STUDY Question 40: How do alternative fibers compare to tree fibers on environmental impacts?

General Comments

LISTENING STUDY: Several comments point out the complexity of this question.

It's almost impossible to make such comparisons. We prioritize the fibers based on their overall environmental impact:

- Combination of ag residues to reduce the waste stream and post consumer waste,
- Behind that is deinking of preconsumer papers,
- Next are sustainably harvested virgin fibers,
- Behind those is tree fiber and agricultural fiber grown in sustainable ways.

It's hard to make across-the-board statements. If you have a responsibly managed farm for on-purpose crops versus FSC-certified forests where the offcuts are used for pulping, both are good. Sure, it begs the question: Which is better? But both scenarios are great. The answer depends on circumstance: currently, it's easier to get low impact agricultural fiber than FSC off-cuts. However, it's easier to take advantage of FSC certified woods, because the systems are already set up for pulping wood." — Jeff Mendelsohn, President, New Leaf Paper

"Alternative Fibers" is a very broad category. It may be so broad that it will create confusion in the analysis being performed. There are very big differences between the various straws, corn stalks, cotton, kenaf, flax, bamboo, arrundo donax, etc. While it may be useful to categorize alternatives by various characteristics, it may be more useful to rely upon the "Search for New Fiber Crops" work of the USDA, wherein over 500 "alternative" fibers were evaluated and categorized. — Tom Rymsza, President, Vision Paper

It depends on many factors. It's not a black and white comparison. There are many different tree free fibers just as there are many different trees used for papermaking. There are different processing and manufacturing processes and different end use applications. Trees are grown differently, with different inputs depending on where they come from. The same is true with agricultural fibers. They all have such different fiber lengths, amounts grown per acre, ways they are processed from the farm gate to the pulping mill.

There are too many variables to do anything close to a life-cycle analysis between "ag fibers" and "tree fibers." Now, if you take two specific cases and directly compare them, you could complete a good study. Something that would compare a specific fiber grown in a specific place with specific conditions, processed in a specific way for a specific paper. Then you could compare accurately and with certainty.

Many times we try to bring it down to science and math - to quantify which is "better" once and for all. For me and many others, it's much more simple. We see forests cut down to make paper and we don't like it one bit. Our forests are being destroyed and replaced with tree plantations, while the pulp and paper industry and the forest products industry is telling us that they are "reforesting." Well, they're not. They're just planting trees for the sole purpose of cutting them down again to make more paper." — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

Compared to wood-based papermaking, the information available on this topic is limited. In the U.S., we only can draw conclusions from a small number of pilot stage projects and an even smaller number of commercial operations. — Environmental Defense Fund Paper Task Force, White Paper 13, Non-Wood Fiber Sources

A Ph.D. candidate at the Yale School of Forestry set out to answer this question and he gave up after several years of research.

One simplistic answer is to put ag-residues in the same category as recycled fiber, as providing the highest and best use due not only to displacing virgin wood fiber but also providing a higher and better use compared to burning field crop stubble. Like recycled (except for high grade white), residues may not have the highest fiber quality (except maybe with flex and hemp residues). This is what I mean – every time there is a statement about non-wood fibers, there is an exception.

Considering that non-wood plant fibers and ag-residues were pulped and used for paper going as far back as 150 AD, there are hundreds of sources of non-woods for paper, each with a rich and diverse history that can be explored depending on where one needs the fiber and what the final product needs to be. People point out the negatives about monoculture component of a dedicated fiber crop, such as kenaf, but it is important to remember that a lot of farmers want crop rotation opportunities. – Jeanne Trombly, Fiber Futures

Despite the fact that I wrote this question for Conservatree when we first started the Listening Study, and that the wording represents how environmentalists and paper purchasers often initiate the discussion, it really is not the most helpful framing of the issue in trying to reach a practical answer. There are so many different possibilities for plants that can be used for nonwood paper fiber and each is an individual case, complicated by the fact that geographic region, climate, soil quality, agricultural practices, governmental subsidies, societal customs, and so many other factors also further individualize each case, that there is no one right answer. In addition, some nonwood fibers may be great environmentally but lousy for papermaking or otherwise undermine the sustainability of the system. So I appreciate all the information that respondents have brought to this question, fleshing it out with a great deal of both nuance and detail.

I do think that it would be good to develop more fiber options for papermaking in order to take some of the pressure off forests, although I expect that they will exist along with forest fibers in most cases for a long time to come. I am most focused on the practical and implementable, not just the theoretical. It takes such enormous effort and dedication to prevail with any kind of alternative to the huge, long-term investments and established system and sub-systems of using forest fibers for paper that I want to cut to the chase: What fibers best fulfill all the steps that are necessary to create a viable new paper; who is willing to put in the time, money and dedication to develop it; and how can we create something good and real in the present or the near future instead of waiting endlessly for perfection.
— Susan Kinsella, Conservatree

LISTENING STUDY: Some identify different interests based on specific relationships to the question.

Interests and perspectives vary by constituency. Some members of the *environmental community* identify the use of non-wood fibers in paper as a way to preserve natural forests. These constituencies strongly support the use of annual crops, such as kenaf and hemp. Unlike trees, these crops are grown and harvested on a yearly basis. Some supporters claim that kenaf and hemp produce more usable fiber per land area than trees, are naturally pest-resistant and can be grown without use of large amounts of herbicides and fertilizers. They further point out the potential for non-woods to be pulped without sulfur and bleached without chlorine. Supporters of bioregionalism consider non-woods as an opportunity for small-scale pulping close to areas of fiber production, thus reducing transportation needs and aiding local communities.

In contrast, the *paper industry*, as represented by the American Forest & Paper Association, compares non-wood pulping with prevailing large-scale wood kraft pulping operations. From that perspective, the widespread utilization of non-woods constitutes a fundamental change in the industry's raw material supply and procurement infrastructures. Individual paper companies in areas of wood shortage, however, may explore non-wood fibers to expand their fiber supply. Non-wood industry experts see the highest current potential in agricultural residues, i.e. by-products of the production of food and other crops, because of their immediate availability and relatively low cost.

Farmers are interested in both annual crops and agricultural residues as additional income sources. Governments in the U.S. and Europe are interested in curtailing surplus grain production by encouraging farmers to grow non-food crops on agricultural land. Annual fiber crops are considered attractive rotational crops. Using agricultural residues would allow fiber production without additional land use. — Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

Eliminate paper manufactured solely of virgin fiber and fundamentally reduce reliance on virgin tree fibers. . . . Increase the use of other recovered materials (e.g., agricultural residues and pre-consumer recycled) as a fiber source in paper. . . . Use alternative crops for paper if comprehensive and credible analysis indicates that they are environmentally and socially preferable to other virgin fiber sources.

— Environmental Paper Network, "A Common Vision for Transforming the Paper Industry," November 20, 2002

"We think finding a replacement for wood fiber is a problem that does not need to be solved," John Mechem of the Washington-based American Forest and Paper Association told *Well Journal*. — Jim Motovalli, "The Paper Chase"

Overall, the dominance of the wood-based industry perspective and the associated research corpus has strongly tended to overwhelm the debate as it has emerged and to claim the benefit of the doubt. . . . an important example of how a conventional wood-based perspective could undermine the nonwoods idea before it could even be argued. — Maureen Smith, ***The U.S. Paper Industry and Sustainable Production***

LISTENING STUDY: Some responses indicate differences between types of nonwood options.

There are three broad categories of fibers: dedicated fiber crops, agricultural residues and industrial residues.

There is a need for a complete life cycle analysis of both agricultural residues (e.g. cereal straws) and dedicated fiber crops (hemp, flax, kenaf)to determine the environmental impacts.

Industrial residues, byproducts of textile production (rags) though limited in volume would have a distinct positive environmental advantage over wood. — Living Tree Paper Company

For over 1700 years paper was entirely made from a variety of non-wood fibres, yet today the vast majority is produced from wood. There are three main categories of non-wood fibres which are used to make paper:

- crops purpose-grown for fibre production such as hemp, kenaf, jute and flax;
- agricultural residues such as cereal, rice straw and bagasse from sugarcane processing; and
- naturally occurring uncultivated crops such as wild grasses, sisal, and bamboo.

— IIED 1996, ***Towards A Sustainable Paper Cycle***

Nonwood plant fibers suitable for papermaking . . . can be placed into four general categories of sources:

1) Agricultural residues,
2) Nonwood fiber crops, or industrial fiber crops,
3) Wild plants,
4) Industrial or post-consumer textile and cordage wastes (e.g. pure cotton or linen textiles, garments, and manufacturing wastes, cotton linters, which are a byproduct of cotton ginning, old rope, and many others).

— Maureen Smith, ***The U.S. Paper Industry and Sustainable Production***

LISTENING STUDY: Some present a general overview of the issues, both pros and cons.

First, I believe that many ag fibers are byproducts so they have the benefit of being secondary fibers, unlike trees which are harvested for fiber as the primary use. — Jeff Lindenthal, President, Green Field Paper Company

Tree free papers have the advantage of offering the consumer an alternative paper. The impact of tree based papers is a widely publicized problem focused around issues such as deforestation. Tree free papers, however, change the focus of the impact to issues such as transportation. Some of the potential advantages of these alternative sources consist of: less energy required for fiber processing, decreased production time, and increased yield. However, when considering these alternative sources potential disadvantage include excessive water usage, increased pesticide and fertilizer demands, transportation impacts and price. — Green Seal, Choose Green Report: Alternative Fiber Papers

Using agricultural fibers in place of tree fiber is detrimental to the environment. Even some of the most intensively managed forests are much more biologically diverse and hospitable to surface waters, soil,

and wildlife, and they require far less chemical treatment than annual agricultural crops. By definition, annual crops like kenaf must be re-established every year, and that means at a minimum the soil has to be disturbed and chemicals applied 25 to 30 times more than the equivalent tree stand for roughly the same fiber yield over 30 years. While managed forests are entirely hospitable to biodiversity, wildlife and endangered species, alternative fibers are agricultural crops, which means they're monocultures requiring the near eradication of any competing plant or animal species. — International Paper

High quality paper can be made from agricultural fiber crops such as hemp and kenaf, and from crop residues of wheat or other cereal grains. In some cases, and particularly those involving crop residues, there are environmental advantages of non-wood paper. However, there are substantial environmental costs of producing dedicated fiber crops that must be considered when comparing paper made from these vs. traditionally used wood fibers. When all environmental impacts are considered, it is debatable whether tree-free paper made of dedicated crops such as kenaf and hemp is environmentally better than paper made of wood. — Dr. Jim L. Bowyer, et al, Dovetail Partners

There are advantages and disadvantages in using non-wood fibres for paper-making compared to wood. There is no strong environmental case for supporting non-wood fibres. With existing agricultural practices and current processing and chemical recovery technologies, non-wood fibres are generally more polluting than wood, although less energy is required to pulp the fibres. There is no doubt that increased utilisation of non-wood fibres would reduce the need for wood. Whether this offers any benefit depends on the sustainability of wood production (or the potential for improvement). The effect on incentives for keeping land under forest cover also needs to be considered. — IIED 1996, ***Towards A Sustainable Paper Cycle***

With some 60-65 million acres of farmland presently idled each year, at a taxpayer cost estimated at up to $15 billion, the subsidy reducing potential of alternative cash fiber crops is . . . compelling. — Maureen Smith, ***The U.S. Paper Industry and Sustainable Production***

The Agricultural Research Service of the U.S. Department of Agriculture (USDA) conducted an extensive study of 500 plant fibers as alternatives to wood in pulp and papermaking in the late 1950s and found *kenaf* to be the most promising annual fiber crop. — Environmental Defense Fund Paper Task Force, White Paper 13, Non-Wood Fiber Sources

The advantages of alternative fiber paper are many. "Under favorable conditions, kenaf can be several times more productive than trees on a per-acre basis," says fibers expert E. L. Whitely. "Kenaf dry material could be produced at about half the cost per unit of producing pulpwood." Kenaf paper can also be produced without chlorine bleaching, advocates say. A Technical Association of the Pulp and Paper Industry (TAPPI) study called "A Search for New Fiber Crops," demonstrated that alternative fibers require less energy and chemical use in processing than standard wood sources. According to the "Using Less Wood" fact sheet, energy use can be cut by 30 percent in the mechanical pulp and refining process with alternative fibers. — Jim Motovalli, "The Paper Chase"

The kenaf industry wants to take paper-making away from loggers and hand it over to the kinds of farmers who are now leaving the land in droves. Instead of paper being made by large international conglomerates, they see it being made by family farmers, people with an investment in the community and kids in the schools. "It will be a low-input crop," says [Tom] Rymsza [of Vision Paper]. "It doesn't need much in the way of pesticides and herbicides because bugs don't bug it, and it outcompetes most weeds." — Jim Motovalli, "Pulp Friction: Debating the Paper Alternatives"

LISTENING STUDY: Many responses compared nonwood fibers to forest fibers based on specific factors.

Growth in paper and paperboard consumption in the developed countries continues at the rate of 2 to 3% annually. Most of the papermaking fibres are sourced from wood harvested from the primary forests. Because of economic greed, the accessible supplies have diminished considerably during the past 40

years. The demand to increase forest harvesting rate remains unabated. Culturally-valuable and ecologically-important forests are being destroyed unnecessarily.

It is timely to re-examine the supply of papermaking fibres from a zero-base viewpoint, without technical prejudice. The obvious sensible approach is the reinforcement of the basic tenet: Reduce, Reuse and Recycle, and with the addition of a "4th R". The fourth "R" is replacement of traditional virgin wood fibres with other fibres. Replacement with agricultural cropping residues in paper manufacture, in conjunction with "reduce, reuse and recycle" practices would have a significant impact on "saving trees." — Al Wong, "How Many Trees Can Be Saved?"

The most important factors in assessment of agricultural fibers in paper making is how to define the agricultural fibers. There are several interest groups whose interests are different - for example in kenaf, hemp, straw, etc. The general classification that we or I would apply is first, **primary fiber** (on-purpose crops) such as Kenaf, cotton, etc. and, second, **by-** or **co-products**, such as straws and sugar cane bagasse that are a secondary or by-product of agriculture. Therefore, it depends upon the classification, the yield could be different. For example, kenaf is considered as a good virgin fiber with yield of about 8 tons per acre, but this figure could be misleading because kenaf will grow in Canada, but very poorly. Hemp can grow almost anywhere but many countries prohibit growing hemp. Most of the primary fibers have higher yield per acre per year than wood fibers. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

Nonwood and wood fiber crops, used for similar grades of paper and grown under similar conditions, generally yield roughly the same amount of paper-making fiber per hectare (original quote from Atchinson 1994). Hence, there does not seem to be any benefit to annual crops in terms of production per acre of land. — IIED 1996, ***Towards A Sustainable Paper Cycle***

The only way to answer this is to specify what kind of tree / wood fiber compared to what kind of non-wood fiber, where.

Even in comparing the same fiber, such as wheat straw, one may have drastic variations in fiber yield. The density of wheat grown in eastern Washington is 4x that in Kansas, for instance. This is due to climate conditions and soil quality. With bamboo, there are over 1000 varieties that will have a different yield per acre. Flax grown for linen grows much higher than the seed kind, yet the seed kind yields a beautiful fiber. – Jeanne Trombly, Fiber Futures

This section focuses on regions where land could be used to grow *either annual fiber crops or trees*. To reduce pressure on natural forests and other rare or declining natural communities, we need to obtain fiber from less ecologically sensitive land. The question we explore in this section is whether this land should be used to grow annual crops, such as hemp and kenaf, or trees.

Supporters of annual crops for paper production claim two environmental benefits of using non-wood fiber rather than wood fiber in paper. They claim that (1) annual crops grown for papermaking generally produce significantly higher yields of fiber and pulp than do trees; and (2) such crops require lower agricultural inputs such as fertilizers and pesticides. The validity of these claims depends on several variables, including the type of non-wood fiber and the type of paper being produced. In assessing these claims, it is appropriate to compare annual crops to wood plantations rather than to natural forests because landowners essentially choose between planting annual fiber crops or planting trees to provide fiber for paper. It is also important to compare not only *fiber* yields, but also the yields of *pulps* made from the various fibers. The pulps being compared also must be *functionally equivalent*, that is, they can be used in the same papermaking application(s). — Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

Table 1. Comparison of Environmental Impacts of Dedicated Fiber crops, Agricultural Residues, and Tree Fibers

	Dedicated Fiber Crop	Agricultural Residual Material	Trees
Yield, Dry T/acre/year	5-15	1-4	Pacific NW – 1-2 Southern US – 2-4 Hardwood plantation US – 4-6 S American Plantations – 4-10
Yield over time	High yield expectations may diminish over time	Constant	Constant
Pesticides – Weed Control	Medium	As already used for main crop	Zero except at time of replanting, once in 10-60 years
Pesticides – Insects	Not known	As already used for main crop	Zero except in isolated instances of beetle infestations
Fertilizers	Medium yearly requirement	As already used for main crop	Low twice in 10 years for plantations, Zero for forests
Need for bleaching	10-15% less than hardwood	10-15% less than hardwood	Based on softwood as standard, hardwoods 15% less.
Water for irrigation	Probably needed if rain fall less than 30 inches in growing season.	As already used for main crop	Not required
Water in pulping process	May be higher due to poorer drainage	May be higher due to poor drainage	Standard, being reduced by the industry
Energy in supplying the raw material	High, especially in annually harvested crops	Medium as some charged to main crop product	Low due to non annual harvesting
Pollution	Possibility of polluted run off from fields	Already exists for main crop	Low
Pollution from pulping	Slightly higher due to lower yields and poorer drainage	Slightly higher due to lower yields and poorer drainage	Standard

— Michael Jackson, Consultant, Tolovana Park, OR, personal response to Fiber Futures regarding differences between fibers, August 2002

SUMMARY OF ENVIRONMENTAL FINDINGS

Annual crops

Whether there are environmental benefits from using annual fiber crops to make paper depends on several factors.

- In regions where tree plantations do not exist or are not economically viable, growing annual crops for paper may provide an additional source of fiber. Hemp cultivation may increase the fiber supply and papermaking capacities of these regions given its broad geographic range (although it is illegal to grow hemp in the United States today.)
- In regions where landowners can plant trees or annual crops for fiber, planting trees usually results in pulp yields in the same range as those of kenaf or hemp. We did not find evidence to support the markedly higher yields frequently attributed to annual crops.
  - Yields of whole-stalk kenaf mechanical pulps are about 60% higher than those of mechanical pulps made from plantation-grown Southern pine.
  - Yields of kenaf and hemp bast fiber chemical pulps are lower than that of plantation-grown Southern pine bleached kraft pulp, with yields about 70% and 50%, respectively, of that for Southern pine.
  - Land requirements to produce fiber for use in printing and writing paper are somewhat higher for paper made from chemically-pulped kenaf bast fibers or from a combination of bast and core fibers, than for the combination of softwood and hardwood bleached kraft pulps typically used in wood-based paper.
- On average, pesticide and fertilizer use are lower for trees than for either kenaf or hemp.
- Annual fiber crop fields can be expected to provide less water quality protection; plant and animal habitat and overall species diversity; and recreational value than do tree plantations.

— Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

Yield per Acre/Over Time

Table 2. Fiber and Pulp Yields of Various Fiber Sources

Plant	Fiber yield (tonnes/year/ha)	Pulp yield (tonnes/year/ha)
Scandinavian softwood	1.5	0.7
Fast-growing softwood	8.6	4
Temperate softwood	3.4	1.7
Fast-growing hardwood	15	7.4
Wheat straw	4	1.9
Rice straw	3	1.2
Bagasse	9	4.2
Bamboo	4	1.6
Kenaf	15	6.5
Hemp	15	6.7
Elephant grass	12	5.7
Canary grass	8	4.0

Source: Pande 1998

The yield data [in the White Paper] indicate that, on average, annual fiber crops produce higher yields than softwood plantations, but not hardwood plantations. — Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

LISTENING STUDY: Several experts specifically argue about the yields of kenaf vs. wood. Some present data they consider definitive, while others offer explanations for legitimate variations. The basis for calculations in a key reference document is challenged.

We would argue that where there are not local sources of wood that are accessible for harvesting, the use of agricultural fiber, whether it is ag residues or annual crops, may be a reasonable supplement or alternative to wood fiber.

The question of yield should be answered by comparing usable pulp yields, rather than simply biomass or fiber yields per acre. For mechanical pulp applications, virtually the entire crop can be used. However, chemical pulping processes result in far lower overall plant usage. A lot of the initial literature on nonwood fibers compares only biomass or fiber yield and not usable pulp yield. In our assessment, the pulp yields for nonwoods may be lower, the same or higher than for wood, depending on the application and pulping process used. In particular, when the whole stalk of kenaf is used, as should occur in a mechanical pulping system, usable pulp yields are on average higher than those for loblolly pine in the South. Typically, plantation-grown loblolly pine has the highest usable pulp yields of the trees. On the other hand, when a chemical pulping process is used, for wood or nonwoods, usable pulp yields are lower for kenaf or hemp relative to yields from loblolly pine. On average, kenaf pulp yields are 70% that of the bleached southern pine pulp. Hemp pulp yields are on average 50% of the southern pine in a chemical pulping system.

Another way to compare yields is based on the equivalent land requirement: How much land is necessary to grow the equivalent amount of pulp? These comparisons depend on the usable pulp per acre estimates. It follows that for the chemical pulps, a higher land use was necessary for kenaf than for soft or hardwood. Our estimate shows the required land use to be 0.59 acres per ton for separated 100% bast fiber for kenaf, 0.40 acres per ton for a mix of whole stalk-bast and core fibers, and 0.36 acres per ton for a typical mix of hardwood and softwood. These estimates are conservative." — Richard Denison, Ph.D., Senior Scientist, Environmental Defense

Environmental Defense's Paper Task Force White Paper #13, on Non-Wood Fiber Sources, provides data that many organizations still use to make decisions and promote viewpoints on the economic and environmental viability of kenaf fiber compared to forest and other types of fiber. Yet there are serious mistakes in White Paper #13's calculations. When others use these data, they are continuing arguments based on very basic mistakes.

For example, Table 3 in the White Paper is labeled, "Fiber yields of kenaf, hemp and plantation woods (bone-dry tons / acre)." In fact, there is kenaf data and hemp data, but no plantation woods data. Yet the missing tree yield data is referred to many times throughout the report.

There are also problems with the conversion factors listed at the top of the table. These conversions are important because much of this type of numeric data from the studies referenced in the table may be presented in either metric terms or U.S. terms and therefore must be converted to consistent measurement. Yet the conversion factors include these mistakes:

- A U.S. short ton (2,000 pounds) is described as equal to 1.1 metric tons (2,20224 pounds), when in fact a short ton is .9 metric tons.
- The conversion of tons / acre to metric tons / hectare is off by a factor of 6.
- A cubic foot of softwood is represented as equivalent to 60.30 tons. Think about that. A cubic foot is a little bit bigger than a gallon of milk. If it was lead, it would weigh 705 pounds. Three tractor trailers weigh 60 tons. A cubic foot of softwood does not weigh 60 tons.
- A cubic foot of hardwood is listed as being equivalent to 40 tons. First, it's impossible for it to weigh 40 tons. But second, the relative values are wrong. Hardwoods are denser, therefore heavier, than softwoods.

Results are further skewed when the report says that you can only use part of the kenaf plant to make chemical pulp for high-grade papers. But Environmental Defense's own report refers to whole stalk chemical kenaf pulp produced in Thailand in at least three places, contradicting their own assertion. And conclusions are drawn based on confusion of pulp yields with raw fiber yields, two very different types of data.

How can we have a science-based discussion attempting to arrive at a well-thought-out comparison of the merits of different types of fiber if the basic data – and even the basic conversion factors – are wrong?

— Tom Rymsza, President, Vision Paper

Research results from around the world indicate that the kinds of kenaf and hemp yields as seen in Table 1 (U.S. hemp average 2.2 tons / acre / year, Non-U.S. hemp avg. 3.8, U.S. kenaf avg. 6.3) are not attainable

without attention to a number of production factors, including soil moisture and fertility, competition from weeds, and problems posed by insects and disease. It appears that regardless of claims to the contrary, production of both kenaf and hemp require regular application of fertilizer and various chemicals, and sometimes irrigation, similar to other forms of high yield agriculture. **—** Dr. Jim L. Bowyer, et al, Dovetail Partners

. . . [T]he amount of land required to produce printing and writing paper from wood is slightly lower than that required for kenaf. — Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

Kenaf yields 2-2.5 tons of pulp fiber / acre / yr and 6-8 tons of fiber / acre per 4-5 month growing period. One ton of kenaf has a 52% fiber yield, higher than the average 45% for trees. Awhile back, International Paper grew test plots in Texarkana and presented negative yield results. They yielded only 3-3.5 tons of fiber / acre / yr, but that was due to poor harvesting methods. — Tom Rymsza, President, Vision Paper

On the yields - If you take 100 lbs. Arundo donax, 100 lbs. kenaf, and 100 lbs. wood, kenaf yields about 25 lbs. usable material, wood 44, Arundo donax 49.5 lbs. — Ernett Altherimer, Founder and Chairman, Nile Fiber

Compared with trees, kenaf, at 6-10 tons per acre, produces 3-5 times more fiber per acre per year. The yield depends on the specific "alternative" fiber. The yield for kenaf is roughly 50%. The yield for trees is about 46%. — Tom Rymsza, President, Vision Paper

There are lots of opinions, though not sufficient documentation on how contradicting claims can be reconciled. For examples, kenaf advocates will claim that yields per acre of kenaf are greater than for trees. Wood proponents will make the opposite claim. Clearly, there are underlying discrepancies on how we arrive at these numbers. In short, it is impossible to compare an acre of trees grown in the northwest to an acre of kenaf grown in the southwest. The different climates give these areas different growth potentials for different plants. A true comparison of yields would look at the growth potential for the softwood and the kenaf on the same acre of land. **—** Russell Clark, Environmentally Preferable Purchasing Program, US EPA

Impacts on Water, Energy, and Pollution

LISTENING STUDY: Some responses refer to factors involved in acquiring the fiber, whether through logging or farming.

Several initiatives [in the U.S. and other countries] have looked at utilising waste straw, particularly since a number of countries no longer allow straw burning. — IIED 1996, ***Towards A Sustainable Paper Cycle***

Sorghum is a low input crop (Kent Kaulfuss) - less irrigation (2 / 3 less water on average). — Lieberman 1995

In terms of environmental impacts of growing ag fibers vs. trees, I don't have specific data. My general impression is that those sources of cellulose fibers which are most pure (cotton) compared to those with a lot of impurities (wood) are much less chemically intensive to process. — Jeff Lindenthal, President, Green Field Paper Company

LISTENING STUDY: There are significant differences in environmental impacts when specific types of fibers are pulped for papermaking. Many respondents went directly to evaluating the result of using different fibers for pulping. While all the factors are inter-related, some responses bring out details of one over another.

Pollution from Pulp Processing

There is uncertainty when comparing the effluent quantity and quality of tree free versus tree pulping processes because of mill scale issues. In many cases, non-integrated nonwood mills are small compared to tree based pulp mills, and may not possess comparable systems for recovery or treatment of effluent, in which case effluent quantity and quality will likely be worse than for a larger wood-based mill. In a larger mill, recovery of pulping chemicals and effluent treatment are far more prevalent and economic. If annual crops are integrated into existing mills that already have effluent recovery or treatment, they would be able to take advantage of these technologies and the result would be very different than for small mills like those we see in developing countries.
In mechanical pulping processes, effluent quantity and quality are better compared to chemical pulping processes, regardless of fiber source. In our study, the quantity of effluent from a soda-process kenaf bleached pulp mill should be comparable to a softwood bleached kraft mill, and effluent quality should be similar as well. However, the soda process, which is more common in Europe, is almost non-existent in the US. For the typical kraft process applied to kenaf, the effluent flow is almost twice that of the same process applied to softwood. Effluent quality should be fairly similar.
A note on the [Paper Task Force] study: there is a much greater range in the numbers obtained for wood mill effluent quality parameters than for kenaf. This may be due to there being less data for kenaf mills. — Richard Denison, Ph.D., Senior Scientist, Environmental Defense

Small mills are preferable for nonwoods because of limited fiber supply, therefore capital costs are lower. However, small mills by nature will be more polluting because chemical recovery does not make economical sense.

The higher proportion of silica in most nonwood fibers makes traditional chemical recovery processes ineffective. This results in a highly polluting effluent and an uncompetitive production process since the chemicals are not recovered and cannot be reused. In addition, the cost of installing chemical recovery systems is prohibitive for most small mills. This is one of the most serious problems associated with the use of nonwood fibers compared to wood, although the small capacity of many non–wood mills means that the overall impact is relatively low. . . with sufficient investment, a cost-effective and suitable process could be developed.

The pollution levels from non-wood mills can be improved by reducing the amount of silica going into the effluent, developing a more efficient chemical recovery system for effluent with high silica content or introducing an alternative pulping process where there is less need for chemical recovery.
— IIED 1996, ***Towards A Sustainable Paper Cycle***

Silica can pose a significant problem for some agricultural fibers. Silica accumulates and hardens on machinery creating the need to frequently stop production and clean with caustic chemicals. Regularly shutting down machinery in a pulp mill decreases any chance of creating an economically viable product. Some agricultural residues such as straw and corn stalks have high levels of silica. Kenaf does not contain silica. — Tom Rymsza, President, Vision Paper

One Indian mill solved silica removal problems by washing the straw before processing, but they still had problems disposing of the silica water. — Atchison 1999

Non-woods generally use less energy and less water and fewer chemicals for pulping, but the pollution impacts to recover the chemicals have been a real bugger. Only now are there actual and affordable chemical recovery technologies that are emerging out of the laboratory and just past pilot stage. Once the silica issue is solved, the resource "footprint" of most nonwoods (cereal straws, grasses and reeds) will clearly be less than wood-based pulping. With papermaking there is very little difference. — Jeanne Trombly, Fiber Futures

Energy

Agricultural fibers have a slight advantage in energy consumption and pollution due to low lignin contents, but wood fibers have high cellulose contents. See below, Table 3. Dimensions and Chemical

Composition of Some Common Straw Fibers — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

Table 3. Dimensions and Chemical Composition of Some Common Straw Fibers

Type of Fiber	Cellulose	Lignin (%)	Fiber Dimension (mm)	
			Length	Width
Cereal straw	31-45	16-19	1.5	0.023
Corn straw	32-35	16-27	1.5	0.018
Wheat straw	33-39	16-23	1.4	0.015
Rice straw	28-36	12-16	1.4	0.008
Coniferous wood	40-45	26-34	4.1	0.025
Deciduous wood	38-49	23-30	1.2	0.030

Source: James S Han, Research Chemist, USDA Forest Service Forest Products Laboratory

The total energy consumed to produce a ton of whole-stalk kenaf mechanical pulp is about 35% lower than the total energy consumed to produce a ton of softwood mechanical pulp. The total energy consumed to produce a ton of kenaf soda pulp using an ECF bleaching process is about 37% lower than the total energy consumed to produce a ton of softwood bleached kraft pulp using an ECF bleaching process. However, the purchased energy [electricity purchased off the grid and fossil fuels burned on-site] consumed by the kenaf soda mill is about 50% higher than the highest purchased energy consumed by a wood-based kraft mill. — Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

If you look just at purchased energy, the kenaf processing uses 50% more. This is because the wood-based mill generates considerable energy by burning wood-derived materials that are by-products of the chipping and pulping process. The wood industry tends to argue this energy is "free" and even claim that they use less total energy than nonwood mills. However, the entire tree – both the part that becomes usable fiber and the part burned for energy – has to be grown and harvested. Therefore, any impacts of harvesting and growing trees, including natural resource depletion or damage, and air pollution from combusting the wood-derived materials, applies to this energy source." — Richard Denison, Ph D, Senior Scientist, Environmental Defense

Summary of Environmental Findings

- The total energy consumed to produce a ton of kenaf mechanical pulp is about 35% lower than the total energy consumed to produce a ton of softwood mechanical pulp.
- The total energy consumed to produce a ton of kenaf soda pulp using an ECF bleaching process is about 37% lower than the total energy consumed to produce a ton of softwood bleached kraft pulp using an ECF bleaching process. However, the purchased energy consumed by the kenaf soda mill is about 50% higher than the highest purchased energy consumed by a wood-based kraft mill.
- Effluent flow and quality are similar for the kenaf and the wood-based chemical pulps.

— Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

Since there is no such kenaf soda mill in the world, how can EDF make this assertion?
— Tom Rymsza,, President, Vision Paper

Bleaching

LISTENING STUDY: The relative need for bleaching can be determined, in part, by the lignin quantity in the fiber. Table 4 compares the chemical properties of various nonwood fibers.

Table 4. Chemical Properties of Various Nonwoods

Fiber Source		Alpha Cellulose (%)	Lignin (%)	Pentosans (%)	Ash (%)	Silica (%)
Bast Fibers						
Jute (1)			21 – 26	18 - 21	0.5 - 1	<1
Kenaf		31 - 39	15 – 18	21 - 23	2 - 5	
Oilseed flax tow		34	23	25	2 - 5	
Textile flax tow		45 - 68	10 – 15	6 – 17	2 - 5	
Leaf Fibers						
Abaca		61	9	17	1	<1
Sisal		43 - 56	8 – 9	21 - 24	0.6 - 1	<1
Seed Hull Fibers						
Cotton staple		85 - 90	3 – 3.3		1 - 1.5	<1
Cotton linters		80 - 85	3 – 3.5		1 - 1.2	<1
Stalk Fibers						
Canes	sugarcane bagasse	32 - 44	19 – 24	27 - 32	1.5 - 5	0.7 - 3
	bamboo (wide range)	26 - 43	21 – 31	15 - 26	1.7 - 5	1.5 - 3
Cereal straw	barley	31 - 34	14 – 15	24 - 29	5 - 7	3 - 6
	oat	31 - 37	16 – 19	27 - 38	6 - 8	4 - 7
	rice	28 - 36	12 – 16	23 - 28	15 - 20	9 - 14
	rye	33 - 35	16 – 19	27 - 30	2 - 5	0.5 - 4
	wheat	29 - 35	16 – 21	26 - 32	4 - 9	3 - 7
Grasses	arundo donax	29 - 33	21	28 - 32	4 - 6	1.1 - 1.3
	esparto	33 - 38	17 – 19	27 - 32	6 - 8	2 - 3
	sabai		17 – 22	18 - 24	5 - 7	3 - 4
	switchgrass	43	34 – 36	22 - 24	1.5 - 2	
Reeds	phragmites communis	45	22	20	3	2
Woods - for comparison						
Coniferous		40 - 45	26 – 34	7 - 14	1	<1
Deciduous		38 - 49	23 – 30	19 - 26	1	<1

Note: For well cleaned raw material - the composition of uncleaned raw material will be different with respect to pentosans, solubles, ash and silica content in many cases.
Source: Hurter 2001

Most annual crops, when compared with trees, contain lower levels of lignin. Since chemical pulping methods remove non-cellulose components, many annuals can be pulped using milder chemistry and less energy.

The ability to bleach a fiber with low or no chlorine depends on the fiber properties. Al Wong has previously reported that hemp is difficult to bleach. Kenaf is naturally whiter than tree pulp and can be bleached in a totally chlorine free environment. — Tom Rymsza, President, Vision Paper

On bleaching, it is generally clamed that agricultural fibers can have less lignin so less bleach is needed to get paper white. I haven't seen the scientific studies demonstrating this, but they're probably out there. The claim that nonwoods might use less water in the pulping and bleaching process might have to do with the type of bleach used. For a smaller run, it might be more economical to use a more expensive process where the chemicals are reused rather than thrown out because it uses less bleach. In this case, the smaller process may allow a better technology. — Russell Clark, Environmentally Preferable Purchasing Program, US EPA

The brightness of rice straw paper is 88 and wheat straw is 80-85, in comparison to hardwood 85–90, and softwood 88–90. Thus, wood fibers have a slight advantage over agricultural fibers. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

Bleaching of nonwood pulps, however, typically is easier than woodpulp and requires fewer bleaching stages and lower chemical consumptions. — Hurter 1998

Need for Pesticides and Fertilizers

LISTENING STUDY: Some argue that agricultural crops require more pesticides and fertilizers than plantation trees.

We found relative little data characterizing agrichemical use on annual crops. The available data indicate that pesticide and fertilizer usage even for plantation-grown trees is generally lower than it is for kenaf and hemp. The main reason for this is that trees are grown on multi-year rotations with chemicals applied at most every few years, in contrast to annual crops, where such chemicals are applied annually. With respect to pesticide use on annual crops, there is geographical variation based on endemic pest problems. Fertilizer input can also vary, but it is important to realize that fertilizer use and yield go hand in hand. In our yield estimates, the highest yields corresponded to the highest fertilizer inputs.
In our comparisons, a typical pine stand planted on a 25 year rotation receives 8 lb. fertilizer / acre / year. Kenaf received a greater range and a considerably higher average amount of nitrogen based fertilizers: from 0-130 / 150 lb. / acre / yr. Most of the hemp information indicated more than 100 lb / acre / yr. — Richard Denison, Ph D, Senior Scientist, Environmental Defense

Most farmers use pesticides and fertilisers on their non-wood fibre crops, although it is possible to grow most types of fibre without those inputs. Amounts applied vary significantly, as with tree plantations, but generally, it would seem that approximately the same amount of pesticides and fertilizers are used on a single rotation of trees (minimum seven years) as for a single rotation of agricultural crops (one year). — IIED 1996, ***Towards A Sustainable Paper Cycle***

Most annual plants need pesticides and fertilizers, including virgin fibers. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

LISTENING STUDY: There are situations in which each alternative might use more.

Any farm fiber used for large scale papermaking will require some level of pesticides and fertilizer. Since the farmer is harvesting for fiber instead of fruit or grain, less herbicide and no insecticide are used for a crop such as kenaf. Agricultural waste fibers would have a different chemical use profile, since they are grown for grain or fruit.

EDF and the Paper Task Force reported in its White Paper #13 that tree farms used fertilizer at rates between 0-34,000 pounds per acre per year. Compared to the high- end estimate, a kenaf field has less inputs. — Tom Rymsza, President, Vision Paper

LISTENING STUDY: There are also arguments that agricultural crops used for papermaking require less pesticides and fertilizers, often because of beneficial properties of the plants.

There are specific studies on particular fibers, such as hemp and kenaf that insist they need fewer chemicals than wood plantations, which can be resource intensive, depending on the grower. But again, there are no broad studies to provide the data that is needed to answer this question. — Jeanne Trombly, Fiber Futures

[Sorghum is a] fast grower, so less weed competition, less cultivation requirements. Low pest pressures (both kenaf and sorghum) - kenaf is host to beneficial insects. — Lieberman 1995

High growth of above-ground biomass corresponds to high nitrogen fertilizer uptake … a law of nature. See for example, my presentation, "Socio-Economic and Technical Issues of On-Purpose Fiber Cropping and Food Cropping." — Al Wong, Founder, Arbokem

Currently, the only legal chemical to use on kenaf is Treflan, made by Dow AgroScience. Though not benign, it is generally safer than others. Most kenaf fields do not use fertilizer, as kenaf is ideal to rotate in after soybeans. No post-planting herbicides are needed. The fast growing tall stalks shade out other plants. Application would be too difficult anyway because the plant grows too tall. — Tom Rymsza, President, Vision Paper

Soil Impacts

Arundo donax is a carbon sequestration giant. It takes in carbon and effluents and stores them in the leaves, stems, etc. … Compared with wood it is 90% more efficient at sequestering carbon. Arundo donax enhances the soil by processing toxic chemicals to an inert form. For example, Alabama had a five-year drought but everything growing around the Arundo donax did fine. Arundo donax uptakes toxins from air and soil and every kind of effluent from the air. — Ernett Altherimer, Founder and Chairman, Nile Fiber

Kenaf's long roots remove salt deposits in the soil and can be used as an excellent rotation crop for improving the soil … and can pull up lost nitrogen leached farther down in the soil (originally quoted from Steve Shaffer of California Department of Food and Agriculture). — Lieberman 1995

The disturbance of soil, which has carbon loss implications relevant to global warming, is typically much higher for agriculture than for silviculture. The frequency of entry for tree plantations is lower, and the impacts of such entries are less intense, than for annual crops. There are lower-impact crop practices such as conservation tillage, though we are unaware of data as to how often these are applied on kenaf and hemp fields. Soil conservation is an important consideration because it also has erosion and runoff rate implications, a particular concern when agrichemicals are applied. — Richard Denison, Ph.D., Senior Scientist, Environmental Defense

Before we advocate the use of a particular non-wood fiber from an identified area, we always pull in the expertise of a soil scientist. Some soils need the biomass from ag-residues. Other soils cannot absorb the density of material. With wheat straw, many Agriculture Extension representatives and farmers are discovering that they prefer not to till the straw back into the earth because that exacerbates erosion. This is why they prefer to burn it, and it would point to another advantage for removing the straw for a fiber use. – Jeanne Trombly, Fiber Futures

The specific blend of fibers in each material, coupled with how the product is made, affects the sustainability. Diversity is the key for an economically and strategically positioned fiber supply. In theory, the wear and tear on the land (topsoil) over ten years growing trees would be less than an annual crop, while the production of pulp from trees would require more energy and water based on lignin content, etc.

Perennials such as Arundo donax and switchgrass have the same arguments. You've still got a tractor going in every year for harvesting. This causes more damage to the soil than trees. Generally, the harvesting, baling, etc. … are never factored in comparisons between agricultural fibers and trees.
Arundo donax would be somewhere in between an annual and a tree. While you have to cut it out every year rather than every 12 or so years, it has a lower energy consumption in the pulping process. You only have to handle the tree once every life cycle, but the entire life cycle of the tree is always going to expose the soil to the elements for the least amount of time. Annual crops have the greatest mean exposure to the elements. Next are the herbaceous crops.

If we hold Arundo donax as a token fiber, as the U.S. Dept. of Energy has done with switchgrass, then we shoot ourselves in the foot, because diversity is the key. Each fiber source has a growing condition and other environmental factors that make it superior in a given application. — Peter A. Nelson, President, AgroTech Communications, Inc.

Use of Land

The forest plantations that cover ancient forest soils are not the answer. These plantations tie up useful land, and after only a few rounds, leave the soil decimated. We cannot pretend that we will turn these areas back into forests. Kenaf offers us a viable alternative. Kenaf, unlike tree plantations, can be integrated as a rotation crop. Plantations tie up land for six to 17 years, while a kenaf crop reaches a harvestable height of 12 to 18 feet in only 150 days and yields five to 10 tons of fiber per acre annually (as opposed to two to three for southern pine). — David Brower, "Kenaf: A Tree-Free Alternative"

Eradicating creek beds of the non-native (Arundo donax) has provided some production material and the seed stalk. We harvested rhizomes to cultivate. We are also researching stem cell cultivation. — Ernett Altherimer, Founder and Chairman, Nile Fiber

The Stockton Pacific Enterprises pulp mill [in Samoa, California] says it has abandoned plans to grow a giant reed in the Central Valley and ship it to Humboldt County to make wood-free pulp. The pulp company also will not ship the invasive reed, Arundo donax, from sites in Southern California where it is being eradicated [because t]he costs of moving a raw material over such long distances are too high . . . That may be just as well, according to some who worry that the giant reed could become a giant pest, like it has as far north as the Russian River. The reed grows up to 30 feet tall, and spreads when floods break off pieces of cane, which root downstream. It isn't thought to sprout from seed.

. . . It was also planted around bridge abutments and erosive areas to shore up problem spots, but it has spread like wildfire. Experts say an infestation in the North Coast's salmon streams could be disastrous. Stockton Pacific was Samoa Pacific when the Arundo plan was hatched in 2002. That former company planned to ship the reed north in tightly covered trucks. But it takes only a little Arundo to spawn a big problem. — John Driscoll, "Pulp Mill Forgoes Wood-Free Pulp Plan"

LISTENING STUDY: Further debates about the appropriate land-use of trees vs. different kinds of agricultural crops are presented in Question 42.

LISTENING STUDY Question 41: Do the environmental impacts vary by type of tree free fiber?

Absolutely. — Jeanne Trombly, Fiber Futures

Yes. The raw material greatly affects the agricultural and processing impacts. Different fibers have varying impacts on land and water. If the source of the raw material is outside the United States, there may be additional humanitarian and environmental concerns. Pulping efficiencies will be based on the chemical makeup of the raw material. — Tom Rymsza, President, Vision Paper

Yes. The environmental impacts depend on what type of farming practices are being used. Rotation crop farming is far less damaging than current industrial chemical agricultural practices. — Living Tree Paper Company

Highly. They vary by fiber greatly. Some are darker/lighter; some require more mechanical input, some require more chemical input. Some can be grown specifically for paper. Other fibers are gleaned from crop residues. All fibers used for papermaking have some form of environmental impact. In an ideal world, which is not inconceivable in this instance, the paper industry would use a mixture of fibers from different sources to make paper. This would help relieve pressures on our forests, while adding income to struggling farmers. — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

Definitely, in general, if you can make use of an agricultural waste stream, that's better for the entire system. Kenaf and hemp are pretty similar in terms of their environmental impacts. — Jeff Mendelson, President, New Leaf Paper

Yes, some agricultural fibers require higher nitrogen fertilizer and pesticides. Crop residuals do not increase environmental impact. Crops that need not be harvested every year lower impacts. — Michael Jackson, Consultant, Tolovana Park, OR

Yes, very much so. Different fiber sources for different regions (ie: pine in the hills of the Southeast, switchgrass in Illinois, kenaf in the Mississippi Delta, and hesperaloe in the Southwest desert) build a diversified fiber supply and use natural resources most efficiently while minimizing impacts. — Peter A. Nelson, President, AgroTech Communications, Inc.

Yes. The principal variables that must be considered include the need for (and amounts of) herbicides, pesticides, fertilizers, and water by fiber type. Also critical to the overall environmental cost of such fibers is the intensiveness of the management required to raise and harvest the fiber, the soil types required, and the weather characteristics needed. Since environmental sensitivity is highly variable based on these factors, expect great variation by fiber type and variation within a fiber type based on location, soils, and growing season. — International Paper

Some agricultural fibers have lignin content of 3% (Table 4), some much higher and the pulping condition would be different. Also, being agricultural fibers, some fibers will contain nutrients and these have to be removed. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

Arundo Donax has a greater yield than kenaf and other alternative fibers. Arundo donax is a perennial so you only have to plant it once. You don't need to till annually. Generally an acre provides 100 green tons (complete mass of plant). The amount harvestable for pulp is that divided by 2.42: 41 dry tons/acre.
— Ernett Altherimer, Founder and Chairman, Nile Fiber

LISTENING STUDY Question 42: What is the comparison of impacts between agricultural residues and on-purpose crops?

Listening Study: The question of whether agricultural residues are environmentally preferable to on-purpose crops for paper pulp use has become a hot debate within the environmental community. This section captures part of that debate and will be expanded as more voices add their perspectives.

To begin, several respondents suggest criteria and processes for making these comparisons.

The evaluation of nonwoods for today's fiber needs should include raw material costs, chemical composition affecting yield, ease of pulping and bleaching and waste stream considerations. Economic viability, recyclability, and the environmental impacts of collection and production, or Life Cycle Analysis – all must be considered. — Tom Rymsza, President, Vision Paper

You should differentiate agricultural cropping residues from on-purpose cropped fibres. High growth of above-ground biomass corresponds to high nitrogen fertilizer uptake . . . a law of nature. Within the agri-cropping residue group, one should also differentiate again on food versus non-food cropping. Growing cotton on subsidized water may be a frivolous anti-social activity.

See for example, my presentation, "Comparative emission of methane from different rice straw management practices in California - A statewide perspective." — Al Wong, Founder, Arbokem

As sustainable forestry issues become more defined, we have to also look at sustainable agriculture. To compare how an acre of trees versus an acre of agriculture is managed, we need a clear standard for comparison. The criteria for organics are primarily related to human health, how much residue is on the fruit or vegetable. It might be appropriate to develop a non-food standard. It would have to be beyond the organic requirements and focus on the life cycle issues: runoff, irrigation, transportation limits of inputs, etc. — Russell Clark, Environmentally Preferable Purchasing Program, US EPA

LISTENING STUDY: The Environmental Paper Network achieved a consensus Common Vision among environmental groups for developing future environmentally sustainable papers. Following is a relevant part of the hierarchy.

Eliminate paper manufactured solely of virgin fiber and fundamentally reduce reliance on virgin tree fibers. . . . Maximize post-consumer recycled fiber content in all paper and paper products. Increase the use of other recovered materials (e.g., agricultural residues and pre-consumer recycled) as a fiber source in paper. . . . Use alternative crops for paper if comprehensive and credible analysis indicates that they are environmentally and socially preferable to other virgin fiber sources. — Environmental Paper Network, "A Common Vision for Transforming the Paper Industry"

Agricultural Residue Impacts

LISTENING STUDY: Many respondents praised or criticized agricultural residues as a source for paper fiber.

Using agricultural residues as a fiber source for paper offers clear environmental benefits. These residues are a by-product of a crop grown for other purposes, rather than being grown directly for use as fiber. Hence, using these residues as a source of fiber represents a beneficial use for an existing waste product while displacing the need for virgin fiber, whether from annual crops or trees. Farmers also avoid generating the air pollution that results from the widespread alternative practice of burning the residues in the field. — Richard Denison, Ph.D., Senior Scientist, Environmental Defense

Table 5. Residue Indexes* for Estimating Agricultural Residue Production

* Residue index = pounds of residue produced/bushel of grain produced
"The following is an example of calculating the quantity of residue based on the residue indices: 70 bushel grain sorghum crop, grain sorghum has a residue index of 60, 70 x 60 = 4200 pounds of residue per acre. Approximately 50 percent of the residue is removed; 2,100 pounds of residue per acre are available for live-stock removal."

			Residue Index (lbs. per bushel unless otherwise noted)				
Grain type			Thompson 1997	Patterson 1995 (originally Residue Management Guide: Small Grain Residue in the Pacific Northwest. Monsanto)	Patterson 1995	(USDA-NRCS, 2000. TG Notice KS-251)	Kok 1997
Wheat			100			102	100
	Winter Wheat			80-110			
		Irrigated			105		
		Dryland			85		
	Spring Wheat			70-100			
		Irrigated			95		
		Dryland			75		
Corn			60			56	
Grain Sorghum			60			56	
Oats			55	40-60		64 per bushel of grain	
					50		
Soybeans			45			75	
Sunflower			1.5			2.2 lb per lb of grain	
Barley							
	Spring Barley			.85-1.5			
		Irrigated			65		
		Dryland			50		
Millet						80	

Compiled by Fiber Futures, 2002

Using agricultural residues to make paper helps solve a waste management problem for farmers and provides an additional source of fiber for papermaking. Chemical use throughout the fiber acquisition process is also low. Paper industry experts think that agricultural residues will be more competitive than annual crops because no additional land is required and the agronomic practice has already been developed. Harvesting straw for pulping eliminates the burning of straw and the resulting air pollution.

Harvesting the straw can lead to a loss of nutrients in the soil. Farmers must then balance the cost of a smaller straw harvest with the application of fertilizer to compensate for the nutrient loss. More research is needed on the effects of taking away agricultural residues on soil fertility (loss of nutrients) and soil structure (faster penetration of water and thus increased irrigation requirements). — Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

The biggest opportunity for using non-wood fibers with little land impact is simply to use the residues of the millions of tons of crops that are already being grown for food and oilseed. This includes most of the cereal crops (wheat, rice, barley, oats) as well as bagasse, flax and hemp. The debate about land use then only comes into play when considering bamboo, kenaf, arundo and other dedicated fiber crops.
— Jeanne Trombly, Fiber Futures

The utilization of agricultural residues does not increase the inputs of pesticides and fertilizers since these would be applied whether or not the crops are used for paper-making. — IIED 1996, ***Towards A Sustainable Paper Cycle***

Direct comparison between virgin fibers and agricultural by-product fibers is not fair practice. The amount of land, need for pesticides and fertilizers, etc. are already counted in growing agricultural products (according to the principle of Life Cycle Assessment). The only expense to the agricultural residues should be the expense of removing the fibers after the removal of the main product's "grain." Therefore, the impact of these types of agricultural residues should be zero, or need readjustment. Sometimes, these residues are unwanted by the farmers and some farmers will pay to get rid of them. Thus, utilization of agricultural residues in the pulp and paper industry can be compared to killing two birds with one stone. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

The use of agricultural residues for papermaking is mostly positive, as it generates income and reduces waste. But this has to be weighed up against alternative uses of residues such as for fuel and fodder. — IIED 1996, ***Towards A Sustainable Paper Cycle***

Once again, without a life cycle assessment this is educated guessing. Agricultural residues would have less impact because it is an available resource that is often burned or landfilled. — Living Tree Paper Company

By one estimate, depending on growing practice and soil type, an average of more than 50 percent of harvested cereal straw is available as surplus, or roughly one metric tonne per hectare of cereal grain (0.4 ton / acre), with the remainder tilled into the soil to prevent erosion and preserve soil productivity.
— Maureen Smith, ***The U.S. Paper Industry and Sustainable Production***

In some places, particularly rural areas in countries with few wood resources (both developed and developing), it may be more appropriate to use locally available nonwood fibers for paper-making than to import wood, paper, pulp or waste paper. This is especially the case where excess agricultural residues are available. The benefits include savings in foreign exchange, increased local incomes and reduced long distance transport. Non-wood mills may be particularly suitable where high population densities or other factors preclude tree growing. Crops can be rotated depending on what is profitable that year, rather than being locked into cycles. — IIED 1996, ***Towards A Sustainable Paper Cycle***

Gathering agricultural residues shares field operations with other crops; they require less mechanical input than on purpose crops. Unfortunately, there are no ag residues that have much potential in the paper industry. The high silica and lignin levels of some of these fibers create problems in the pulp mill and lead toward high chemical use.

With all agricultural products, the farmer's main interest is in the primary crop. The technical fiber characteristics are of little concern to a farmer who makes most of his or her income from the grain. Maintaining a reliable raw material stream that reacts with demand would be difficult when using a byproduct of another industry. On purpose fiber crops such as kenaf provide a more consistent, viable product. — Tom Rymsza, President, Vision Paper

In general, I discourage the idea of using crop residues (except in specific situations that would otherwise require burning or create other problems). Farmers are an efficient bunch and if there were a "commodity price" for residues it would be too tempting to take off too much residue. You have never heard of a farmer intentionally leaving beans, cotton, or corn in the field at harvest; the same farmer would not leave

enough residues for ground cover if he already took the time to bale and move the residues. Natural Resource Conservation Service (USDA) takes a similar stance on crop residues (www.nrcs.usda.gov).

The USDA is still arguing amongst itself about harvesting crop residues. Their official statement is that unless it is to prevent soilborne diseases or other specific purposes, they've cut off funding towards research on harvesting. Some of their previous work on wheat straw shows it's promising, but the cost is the holdup. They claim that farmers can be competitive getting $40/ton of residue, whereas farmers actually should get $50/ton based purely on protein content (i.e.: hay production). A farmer is not going to start their tractor just to collect straw at such low commodity prices.

It would be more viable to develop a farmer's co-op directly connected to the industry. For example, if you have three farmers who own equity in a paper making factory then, unlike most commodity crops, these farmers can think year-to-year in a sustainable way. Then the straw price wouldn't be tied to a commodity price. So, the incentive for us to leave residue on the fields is much higher than if we put a commodity price on the residue (which the market would form based on volumes). This scenario encourages entrepreneurs and farmers to responsibly run the business. The same is true for the wood products industry. As a farmer, I love my land more than anyone else, and want the opportunity to manage it in a sustainable way. — Peter A. Nelson, President, AgroTech Communications, Inc.

LISTENING STUDY: Most of the arguments regarding agricultural residues vs. on-purpose crops reference straw and grain residues vs. kenaf or hemp, the two on-purpose crops that are available as paper pulp sources in North America. But not long ago, arguments were raging about the use of cotton to make paper, and whether it even should be included in discussions about nonwood paper fibers at all. In fact, the U.S. EPA categorizes cotton linters (the agricultural residue from which paper is made) as a preconsumer recycled industrial fiber source, and there are even a few postconsumer recycled sources such as used denim and currency. Peter Hopkins responds to some of the misunderstandings about cotton fiber sources.

With regards to cotton, cotton growth practices are the sole responsibility of those who grow the crop. Cotton-fibers used for papermaking are the waste products of cotton-ginning and the manufacture of textiles and finished garments. These papermakers have no influence on how cotton is grown. If cotton-fiber papermakers announced they were only going to make papers from organic cotton, not a single acre would be converted to organic cotton, because they don't make paper from field cotton. Those tree-free paper manufacturers, who have been in business since before trees were cut for paper, would immediately go out of business. — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

On-Purpose Crops Impacts

LISTENING STUDY: Some respondents praised or criticized crops grown "on purpose" for paper fiber.

In the US, almost 80% of all annual row crop land is used to produce three main crops – corn, soybeans and wheat. That does not represent diversity or sustainability. The intensive agricultural practices currently used require high levels of fertilizer and chemicals on those crops. Adding new crops that are rotated with conventional crops will reduce overall pesticide and other chemical use, will contribute to maintaining soil fertility, and will help to reduce surpluses, which drive prices down. When prices are low, the government steps in with deficiency payments to farmers (subsidies), which cost you, the taxpayer, money, and which create an un-level playing field in the world trade picture.

The clearly documented higher productivity of kenaf, when considering the amount of paper that can be produced from a given land area compared to trees, coupled with the benefits derived from a more diverse agricultural crop mix, and the subsequent benefits to rural economies, are compelling.
— Tom Rymsza, President, Vision Paper

Since the early 1930's the US Department of Agriculture has devoted some attention to possible use of nonwoody plant fibers (especially crop residues such as sugarcane bagasse and grain straw) in pulp and

paper. Limited amounts of pulps from nonwood plant species are used alone and in blends with wood pulps to develop special properties in the final papers.

Beginning in 1956, the Agricultural Research Service initiated a new approach to the fiber resource problem. This involved the identification of new plant species that could compete with pulpwood in furnishing satisfactory fibers for pulp and paper that could compete with crops of a given region in providing growers a new crop source of income. Pulp and paper producers should be able to use these fibers either alone or in conjunction with other fibers.

As a first step in identifying new sources of fibers for pulp, a botanical-analytical screening system was established. This approach was necessary to systematically evaluate samples from the large reservoir of higher plant species. Characteristics of pulpwood and other accepted pulping materials served as a guideline in determining which properties of nonwoody species should be measured. The resulting criteria by which the plant species were judged for their papermaking potential were as follows: (1) Botanical characteristics – based on normal habitat, form, agronomic adaptability and size; (2) Chemical Composition – based on crude and alpha cellulose and on solubility in 1% NaOH solution; (3) Fiber Dimensions; (4) individual appraisal; and (5) yield on maceration.

Among 387 species that were subjected to the entire screening evaluation, kenaf and sunn hemp (Crotalaria juncea L.) were most promising. The later decision to concentrate on kenaf rather than sunn hemp was based largely on the ability of kenaf to produce consistently higher yields with much better standability than sunn hemp. Other promising species included selected sorghums and hemp (Cannabis sativa L.). — "Search for New Fiber Crops," US Department of Agriculture

We have found that the financial returns [for kenaf] to farmers are greater than if they were selling agricultural residues for pulping. However, farmers can have difficulty obtaining a loan for kenaf because of the lack of experience with the crop. Farmers typically need to earn two times the cost of growing the crop. These returns are possible, especially as the excess core material can be sold to kitty litter and oil absorbent cosmetic markets, among others. — Tom Rymsza, President, Vision Paper

Hemp generally pulls in higher value for textiles than for paper. — Tom Rymsza, President, Vision Paper

LISTENING STUDY: Some compared and contrasted the two different kinds of sources.

From the purchaser's standpoint, we haven't heard much about the environmental impacts. [Nonwood fibers] seem like a viable fiber resource, though we'd like to see a life-cycle analysis that would show the optimal way of growing, harvesting, and transporting the fiber. For example, we need to make sure that the forests aren't converted to produce on-purpose crops. Ideally, alternative fibers would be grown in economically disadvantaged areas to promote rural development. If private lands were being cleared for on-purpose crops, I would offer no support, though I don't believe that is happening.

Agricultural residues would be a wonderful alternative if they have the same integrity and the capital costs were low. It would be interesting to see what producers have been finding. For example, what would they say about the fiber strength? — Tyson Miller, Program Director, Recycled Products Purchasing Cooperative

For farmers, residual fiber is added value but may impact soil quality adversely if current practice is to plow it in for soil amendment. Otherwise, there are no changes from growing the main crop. Time for residuals removal has to be made and is usually required when dry. Fiber-dedicated (on-purpose) crops require diversion of agricultural land from other (food) crops. — Michael Jackson, Consultant, Tolovana Park, OR

In some cases, and especially where fiber can be obtained from food crop residues, the use of nonwood fiber is quite attractive from an environmental perspective. In other instances, and particularly those in which fiber is obtained from dedicated fiber crops, the environmental impacts can be quite substantial, and often greater than impacts linked to the periodic harvest of trees. — Dr. Jim L. Bowyer, et al, Dovetail Partners

Generally, one would expect lesser environmental costs associated with the use of agricultural residuals than with fibers grown expressly for papermaking. This is because much of the environmental cost of

using residues would be allocated to the primary use of the plant. Where the intent is only fiber, all of the environmental costs must be associated with fiber production and use. This does not mean that consequences for the farmer, the land and resources are reduced; they are merely allocated differently. — International Paper

On-purpose fibre cropping and food cropping are the two means to supply non-tree based, cellulosic fibres for papermaking. For most papermaking applications, on-purpose fibre cropping is an inefficient supply approach. It is unnecessary to set aside arable land for fibre production only. Food cropping with co-production of surplus straw is the most practical and environmentally-benign means to deliver large quantities of papermaking fibres. The farm economy could be improved significantly with the collection and sales of surplus cereal straw for industrial uses. Greenhouse gas emission could be reduced concomitantly through such a practice. — Al Wong, "Socio-Economic and Technical Issues of On-Purpose Fibre Cropping and Food Cropping"

The common assumption about using agricultural residues is that the environmental impacts begin after the crop harvest; impacts from before that point are part of another process for food or grain production. The straw is a waste product that is often mishandled or burned, so we should begin counting the environmental impacts at the transportation and straw harvesting costs. With on-purpose crops, we need to look at the impacts from the very beginning. The on-purpose crops have to catch up from the other stages and account for all their stages of production. — Russell Clark, Environmentally Preferable Purchasing Program, US EPA

In general, the straws — wheat straw / rice straw / flax straw — are inefficient to get to pulp mills. The transportation costs are high. They are not grown for papermaking. They are grown for cereal crops. So a new collection and transportation system needs to be created in order to make these fibers more viable for papermaking. On-purpose crops will be subject to the same inputs and impacts as other crops, but can have the advantage of being grown closer to the pulp mill, thus greatly reducing transportation costs. If you grow crops specifically for papermaking, you then must attribute their environmental impacts, as well as benefits, to the paper produced. For waste fibers, there is a greater attribute-to-impact ratio, because they are not grown to make paper. — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

Evan Paul, a ForestEthics paper campaigner, says, "While it's better to be growing kenaf instead of logging, we want to really look at the whole life cycle of natural fibers. We're not sure of the full impact when it includes clearing land and using pesticides." Paul is, however, bullish on the use of existing agricultural waste in papermaking, including corn and rice husks. "But," he adds, "there hasn't been a lot of development in that field, either." — Jim Motovalli, "The Paper Chase"

Forest Impacts

LISTENING STUDY: One of the most contentious arguments revolves around whether or not on-purpose crops threaten intact forests. The following comments argue that they do.

Many are concerned with the implications of intensive forestry on habitat value and biodiversity. Indeed, many methods for intensive silviculture compromise forests' ecological values. It must be realized, though, that annual crops require the same considerations. It is hard to imagine that the biological value of even the most intensive of tree plantations would ever be lower than that of an agricultural field of comparable size. Indeed, I would argue that, acre for acre, from an ecological perspective, habitat value, biodiversity and water quality protection and soil carbon storage would all be higher for silviculture relative to agriculture because harvesting, replanting, fertilization and pesticide application only occur on a multi-year basis rather than annually.

Regionally, the biodiversity and habitat quality advantages over agriculture will vary. In some areas silviculture is not feasible. However, much of the loss of natural forest has historically been due to conversion to agricultural use as well as to tree plantations. Land owners in many parts of the country,

particularly the South where most paper fiber is grown, might have the option of *either* silviculture or agriculture. — Richard Denison, Ph.D., Senior Scientist, Environmental Defense

Forestry practices are changing, with ever-shorter growth cycles. What had been a 40-year cycle for Douglas fir is now often a seven-year cycle for eucalyptus or other fast-growing species. [Tim] Keating {who co-founded Rainforest Relief in 1989 and still heads the group] believes that if environmentalists push the [paper] industry into a corner by advocating kenaf, the paper giants would shrug their collective shoulders, then clear-cut their vast forest holdings for one-year-cycle kenaf. "As environmentalists, we want to use an annual rotation crop for paper, but we want to buy it from farmers," Keating says. "But that isn't what would actually happen, given the huge paper company land investments. I think, instead, we have to promote the use of agricultural residue instead of virgin fiber, and refuse to accept on-purpose crops."

Michael Klein, a spokesperson for the American Forest and Paper Association, agrees that a groundswell of interest in kenaf would not preserve trees. "Kenaf is not grown in anywhere near sufficient quantities to meet the demand for paper," he says. "But if the public demanded it you'd see the wholesale conversion of forests to row crops." — Jim Motovalli, "Pulp Friction: Debating the Paper Alternatives"

Pulp and paper companies in the South obtain only about a quarter of their wood from their own lands. They purchase the rest from private landowners. Widespread use of non-wood fibers could reduce demand, and thus, prices paid for wood in this region; lower prices might lead some owners to sell their forestland or convert it to other uses. — Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

Since kenaf grows in tropical climates, mainly within 35 degrees north and south of the Equator, additional expansion potential would exist mainly in the southern United States, an area also well suited to plantation silviculture. — Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

It is important to recognize that while fiber crops like kenaf must be planted, tended and harvested every year, tree plantations are typically planted and harvested only every 20-45 years. Less frequent soil disturbance can reduce topsoil loss, runoff and the rate of atmospheric loss of carbon in the form of carbon dioxide, a greenhouse gas. Compared to annual crop plantations, tree plantations also offer: a considerable degree of water quality protection; plant and animal habitat for some species and greater overall species diversity; and recreational value, although not to the extent of natural forests. — Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

From the earliest colonial times to the early part of the twentieth century, 2.1 acres of American forest were converted to agriculture for every person added to the population. Globally, conversion to agricultural uses is still the number one cause of deforestation today. Currently, both hemp and kenaf are being offered as alternatives to wood fiber in the manufacture of paper and similar products. Both of these materials are produced in mono-cultural, annual rotation, agricultural systems referred to as “dedicated crops.” . . . There are two key issues to consider with these materials: net productivity of the land and the direct environmental impacts associated with fiber production. Evidence suggests that the negative environmental impacts of commercial production of hemp and kenaf fiber can be greater than those attributed to the production of wood fiber. In addition, commercial production of these alternate materials potentially increases the land area required for agriculture, a need that is generally met by the conversion of forestland and other natural environments. — Dr. Jim L. Bowyer, et al, Dovetail Partners

LISTENING STUDY: Many comments argue that forests are *not* threatened by on-purpose crops.

Some have claimed that on-purpose crops will only replace forested land. However, there are over 75 million idle agricultural acres in the US. If only a portion of this went to growing kenaf, the supply would be adequate. — Tom Rymsza, President, Vision Paper

In 1960 there were some 760 million acres of forested land, about one-third of the land area of the fifty states. Of this a little more than 500 million acres could be classed as commercial – that is, capable of continuously growing timber crops. . . . The area of commercial forests gained several million acres per year as old farmlands reverted to woodlands. At the same time several million acres of commercial forest were lost to airports, highways, urban development, and additions to recreation and wilderness areas. Over the years, these shifts resulted in a net gain of 40 to 50 million acres of potential commercial forest. — Cox 1985

I don't think anyone is thinking of cutting down existing tree farms or forests to plant crops. With a life cycle analysis, we would understand the implications of such a replacement. Local conditions are important, as are the source and destination of the crop. If we end up getting the tree fiber from more sensitive places, or cutting down rainforest for eucalyptus trees, it's time to stop and think. — Russell Clark, Environmentally Preferable Purchasing Program, US EPA

From a Canadian perspective, it makes a lot of sense to further explore annual crops as viable fibre options. I understand there have been some lifecycle studies that point to Southeastern U.S. tree farms as more benign than on-purpose crops. In the Canadian context, wood fibre and pulps primarily originate from old-growth or intact forest eco-systems (~80%). These intact forest ecosystems can contain trees aged between 80-1400 years old and are incredibly important for habitat, clean water, and carbon sequestration, and act as biodiversity storehouses.

Because the biodiversity values, ecological functions and services of old growth forests are very different from Southeastern U.S. tree farms, it may well be that many on-purpose crops actually are preferable from a life-cycle analysis perspective to pulp and fibre from intact old growth forests. As many North American and global papers contain Canadian pulp – and this should also be accounted for in any life cycle analysis work – it is important that we are not just comparing on-purpose crops to SE US forests. On-purpose crops that don't work from a life-cycle perspective for SE forests may be fabulous if the alternative source is intact boreal or temperate rainforests.
— Nicole Rycroft, Campaigns Director, Markets Initiative

It is important to follow and support research into on-purpose crops. I think we should be careful not to refer to pine plantations as benign in most any context. Giving the impression that plantations support biodiversity is inaccurate. (Unless of course we're talking about deer populations!) The conversion of natural forests in the SE to pine plantations, requiring an intensive use of herbicides and fertilizers, is one of our greatest challenges to forest protection in this region. On-purpose crops may be a better choice when the alternative is intact or natural forests (in the Boreal, the Southeast, or anywhere). — Kelly Sheehan, National Organizer, Dogwood Alliance

Tom Rymsza, President of KP Products, . . . argues that unlike long-term tree plantation investments, kenaf constitutes an immediate, viable cash crop alternative for many small farms: "The farmer does not decide to plant trees or annual crops. The farmer has equipment (tractors, etc.) and mortgages, and an annual income is required to make payments to keep the farm operation going, and to pay salaries to the hired help who depend on farm operations for jobs and income. The farmer will either plant annual crops or cease conventional farming." He also raises the significance of ownership issues associated with tree plantations versus annual crops from the perspective of the local farm community, observing that "the crop farmer and family are resident members of the rural community with a vested interest in water, air and quality of life issues. . . . [A] tree farm owner may be a timber company or a large paper user like Time, Inc. They buy or lease the land and plant trees. . . . As corporate, absentee owners who view the tree farm as an investment, their interaction with the community is vastly different than the farmer. They are financially able to purchase large tracts of land and wait a number of years to begin realizing income from that investment. This strategy impacts the local community." — Maureen Smith, ***The U.S. Paper Industry and Sustainable Production***

. . . Tom Rymsza of Vision Paper, a dedicated kenaf promoter and entrepreneurial producer, sees the issues somewhat differently [from those who argue that on-purpose crops threaten forests]. "I think we have to get into the non-wood sector in a big way," he says. "The population is growing and so is the demand for paper. The industry's response is to grow trees faster, and that ends up manipulating the

natural environment so that we end up with problems like the pine beetle and the gypsy moth. It's taking the natural cycle and throwing it out of balance. The whole paradigm of cutting trees to make paper has a limited lifespan. Some 75 pulp and paper mills have closed in the last five years, and that's partly because of foreign competition – Asian producers have much lower land and labor costs, without environmental regulations." — Jim Motovalli, "Pulp Friction: Debating the Paper Alternatives"

If just 5% of US corn and soy acreage were planted to kenaf, prices for those crops would stabilize, with no net loss to the farmer, since they would be paid a competitive price for the kenaf, without any subsidy. The resulting 7.5 million acres of kenaf could supply more than 1/3 of all U.S. virgin pulp needs. If there was 1/3 less demand for wood fiber for pulp, the approach to forest management would change from intensive management of fast growing trees, to one of mixed species, longer growth patterns, producing timber rather than pulpwood. Mixed species, longer growth patterns would more closely resemble a "forest" than a "tree-farm" and would be better for watershed protection, habitat, and biodiversity. — Tom Rymsza, President, Vision Paper

Some say we will have to cut down the forests to make room to grow kenaf. Others fear kenaf will sterilize soil or increase chemical use. These fears are unfounded, and are promoted by timber industry interests in order to slow or prevent the emergence of kenaf as a competitive fiber source. The American Forest and Paper Association, an organization whose very name reveals its purpose, which is to maintain the link between forests and paper, does not support nonwood alternatives.

For example, in March 1995, Matt Van Hook, Vice President of AF&PA, wrote to the San Francisco Chronicle regarding kenaf that "millions of acres of land would have to be cleared to allow sufficient quantities of the plant to be grown, and that could mean leveling forests." In April 1995, Barry Polsky, a spokesman for AF&PA, was quoted in the Arizona Republic saying, "You have to clear a lot of land for (kenaf). It is a crop. Farmers have to give up land or cut down forests to make room to grow it."

In December 1995, W. Henson Moore, President and CEO of AF&PA, wrote to the Washington Post that, "Millions of acres of arable land would have to be cleared to grow enough hemp or kenaf to satisfy American and Foreign demand for paper products. Farmers either would reduce acreage devoted to food plants, or forests would have to be leveled, never to be replanted."

This is simply not true, and works to the detriment of sustainable agriculture and farmers who need new crops now. — Tom Rymsza, President, Vision Paper

I think there is way too much focus on comparisons only to forests in debates on this question. Those currently debating this issue are primarily forest issue activists, and of course the paper industry in North America is built on making paper from forest fiber, so it's no wonder that everyone right now sees the issue primarily, or only, in terms of forests. It is essential to protect the forests and forest activists have been doing profound work in challenging the status quo and searching for more environmentally sound production systems. But this question brings in another dimension of complexity. It crosses over to also include agricultural sustainability issues, where there is a whole different set of thinkers and activists working to re-orient the agricultural status quo to be more sustainable both for farmers and the land. So this question of ag residues vs. on-purpose crops cannot be analyzed only from a forest paradigm. We have to bring in an additional set of experts with sustainable agriculture expertise and perspectives to add to the forest considerations.

Frankly, the argument for undermining the value of on-purpose crops for papermaking because they *might* encourage some forest landholders to abandon trees sounds like a red herring to me. As a relative of a small forest landholder – and a large percentage of the trees that are cut for timber and paper in the U.S. come from small landholdings – it seems to me that they are a wholly different type of person from farmers. I find it difficult to imagine that someone who has invested in forest land, which doesn't need a lot of maintenance, would be very attracted to the idea of cutting down all the trees, hauling out all the stumps, and then becoming a farmer with all its daily risks, responsibilities and crises. So mainly we're faced with paper companies threatening to cut down their plantations to plant on-purpose crops, if they become valuable. How likely is that, realistically?

First of all, we are not talking about a black-and-white situation in which today we're making paper from trees and tomorrow we're suddenly making all our paper from hemp or kenaf. We don't even have mills that can efficiently pulp those fibers, although a couple have been jury-rigged on occasion to process a small amount. There are whole systems involving pulp mills and farming and transportation

that have to be built before those fibers can be considered real competition with forest fiber. This will build slowly and the changes can be integrated positively, if we plan well.

Second, the paper companies can threaten to abandon their trees, but should we allow this threat to abruptly stop promising agricultural fiber potentials? This is what zoning laws and land-use laws are for. If these are not strong enough, that can be changed.

Third, isn't it just as likely that small forest landholders and tree plantation owners could be encouraged by a shift in valuation of their trees to allow the trees to grow for a longer time-period in order to become much more valuable timber, rather than cutting them for pulp when they are only a few years old? Rotations are getting shorter and shorter. It used to be that trees were grown for 40, 50, even 80 years before they were cut, and by then they would have grown big enough around to be valued for lumber. Often, a landholder only harvested trees once or twice a generation. Fiber for paper was a byproduct of the lumber, not the primary goal. But now all the focus is shifting to how to turn the trees into cash fast, with rotations of only 15, or even 7, and in China down to 5, years. They're getting closer and closer to annual crops, and less and less like forests, all the time.

Fourth, my understanding is that often on-purpose crops can be grown as rotation crops, which rebuilds the soil and brings in additional income to a farmer. We do not have to have agricultural mono-crop "plantations." A number of respondents to the Listening Study have pointed out that there is a great deal of idle farmland, often paid for by taxes subsidizing farmers not to grow crops that are overproduced. Doesn't it make sense to use that land to produce something that we *do* want to use, and that they can sell for income rather than relying on a subsidy? It doesn't seem necessary to cut down more forests in order to plant kenaf or hemp – there's plenty of farmland already available, both idle and rotation. Statements that "lots of forests have been cut for farmland," while true, sound like scare tactics. The fact that, in general, forests have been cut for farmland in the past does not directly relate to whether *this* particular use would encourage that practice. At best, it warns us to put legal rules and market incentives in place to make sure that doesn't happen.

The fact is that the only U.S. or Canadian nonwood fibers that have gotten to consistent marketplace printing and writing paper products, other than cotton and a very small amount of bagasse, are on-purpose crops. The companies that produce and distribute them – including Living Tree, Vision Paper, Ecosource Paper and, up until recently, Crane Paper Company and Domtar – have taken enormous financial risks, put in decades of phenomenal dedication, built complex sourcing systems from the ground up, responded to environmental issues, and turned out extremely high quality products in a highly technical and demanding industry. There have been promising experiments with agricultural residues, and Neenah Paper imports some bagasse from Kimberly-Clark's Mexican mill for some of their paper, but non-cotton ag residues have not yet produced a wide array of consistent printing and writing paper products in North America. While I consider it very worthwhile for people to work on developing ag residue paper fiber potentials, I also think it would be disgraceful to turn our backs on the people who have actually already made nonwood papers in the U.S. a reality. Instead, they deserve encouragement and support to add another dimension to the development of sustainable paper fiber options.

When Conservatree was a company developing recycled printing and writing papers, it was constantly under attack from the paper industry, which did not want any competition with virgin tree fiber papers, as well as, regrettably, from some environmental groups who endlessly debated whether each step towards producing a sustainable recycled paper was "environmentally perfect" enough – while continuing to buy virgin paper. It takes a lot of imperfection to learn enough and develop enough to create "perfection" in the real world, especially in a cut-throat, monumentally capitalized industry. When people take on the nearly impossible task of developing all the systems necessary to bring an alternative fiber paper to the marketplace (elsewhere, Maureen Smith notes that the obstacles are so enormous that it's a wonder anyone in their right mind would do it), we should be cheering them on, giving them support, recognizing that they are taking our dreams and trying to make them into reality, rather than undermining them at every turn.

Yes, we should make sure the products and their production methods are not creating environmental and social damage but, except when there is substantiated evidence of that, I think that people who want nonwood options have a responsibility to give the entrepreneurs and inventors space to develop the systems, facilities and knowledge necessary to make *real* alternatives. It's easy to dream of perfection, much more challenging to create tangible results. — Susan Kinsella, Conservatree

50k acres of Arundo eliminates the need to cut down 1.2 mil acres of forest. Planting Arundo donax does not threaten what would otherwise be tree farms or forest lands; there are currently 60 million acres of corn and we only need 20 million to feed the world. We have corn in bins waiting to be sold. If we

planted 1 million acres of Arundo, we wouldn't have to harvest any more trees because the yields are so high. These yields tests have been performed by Perfeco labs in Japan, Econotech in British Columbia, U of W in Seattle, OG Corporation, Nepon, Mishima. — Ernett Altherimer, Founder and Chairman, Nile Fiber

Impacts on Farmers

There are two main advantages for farmers in growing fibre crops rather than trees. Firstly, the area under the crop can be changed every year depending on the relative benefits from the crop. Secondly, income is generated every year, avoiding the need for credit to support tree growing costs over many years. The opportunity cost of pulping agri-residues is generally low, since they are by-products of food crops which would be grown anyway. However, this depends on the alternative uses of the residues, such as for fuel or animal fodder and bedding. **—** IIED 1996, Towards A Sustainable Paper Cycle

The most environmentally sound option would be to have mini-mills near the source. For example, if the rice growing in areas of California that are required to cease field burning could supply a nearby mill, that would be ideal. — Jeff Mendelsohn, President, New Leaf Paper

The Association for the Advancement of Industrial Crops states," . . . overconcentration and overproduction in a relatively small number of food and feed crops have created global problems. Clearly, diversification in agriculture is of high priority." **—** Brochure referenced in Maureen Smith, ***The U.S. Paper Industry and Sustainable Production***

Farmers would be able to grow cash crops and become active members of the economy rather than passive receivers of subsidies. **—** Punya Chaudhuri, "Sowing the Seeds for a New Fiber Supply," P***ulp and Paper International*** (March 1995) 68-69, referenced in Maureen Smith, ***The U.S. Paper Industry and Sustainable Production***

Except for the root-nematode problem, kenaf is very pest-resistant. However, it is likely that in most areas fertilizers, and in some areas nematicides, herbicides and irrigation will be used. . . . The need for pesticide application is very location-specific. . . . When added to an existing crop rotation, kenaf can reduce pesticide requirements of other crops, improve soil conditions and thus increase the overall sustainability of a crop rotation. — Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

Hemp is susceptible to only a few pests, including some seed and soil-borne fungi and root-knot nematodes. The nematodes can be managed through plant breeding. Thus, hemp can be grown without or with only minimal use of pesticides.

Used as a rotational crop, hemp can reduce pesticide requirements of other crops grown in the same rotation because it is an effective weed suppressor and reduces some major soil pathogens. Because of its well developed rooting system, it also has a beneficial effect on the soil structure. — Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

Papermaking Qualities

LISTENING STUDY: The environmental impacts of agricultural residues vs. on-purpose crops are very important. But the ability to make each type of fiber into good paper is equally important and, ultimately, will be the determining factor in which fibers are used.

Straw Fiber Characteristics: Straw must be harvested in a time frame consistent with the harvest of the grain. Depending on regional practices, the straw may be cut and baled at the same time as the grain crop, or it may be harvested in a subsequent operation. The storage conditions and moisture content of the straw are important because it is susceptible to molds and rot, and subject to spontaneous

combustion. Weathered straw consumes more chemicals for pulping and yields less pulp, with relatively lower strength.

Fibers from **wheat and rice straw** are short (0.5 – 1.5 mm) and weak when compared to wood fiber. On their own, they cannot provide the technical properties demanded by modern pulp and paper manufacturers, nor can they meet the demands of the printing and packaging industries. While straw fibers could supplement wood fiber in some of the less demanding grades of paper and packaging (such as the corrugated section of a cardboard box), and when used in small percentages, could be incorporated into higher quality applications, they do not possess the necessary physical attributes to replace tree fiber in the majority of paper applications.

Straw contains significant amounts of silica, ranging approximately from 3-14%, and ash depending on type and regional growing conditions. In the process of pulping, silica is separated from the fiber and appears in the black liquor (waste stream) in the form of sodium silicate and/or other complex siliceous compounds. The black liquor also contains the noncellulose portion of the straw (lignin, pentosans and other degradable carbohydrates), and the process chemicals and water. Heat is used to reduce the water content. Upon evaporation, the resulting fluid is quite thick and difficult to process in a chemical recovery system. This silica accumulates and causes scaling in evaporator tubes and other parts of the recovery system, reducing their efficiency and adding to maintenance costs.

Corn Stalk Fiber Characteristics: There is no readily available evidence of current commercial use in the world. Historically, corn stalks were used to produce low grade wrapping paper and board in Austria around 1880.

Corn stalks' cellulose content (35-45%) ranges significantly depending on variety and regional conditions. Combined with the high lignin content (14-34%) and nodes and pith, pulp yields of 30-40% are optimistically misleading because the resulting pulp is dominated by non-fibrous elements (epidema, pith, barrel type vessels). Such a low pulp yield indicates a high cost of processing. The environmental compliance characteristics are challenging because there will be roughly two tons of waste stream solids for every one ton of pulp produced.

Fibers from corn are short (1.2–1.4 mm) and would be roughly comparable to a hardwood fiber in length and width. The strength properties reported are poor, and during refining the freeness decreases quickly and the drainage rate decreases even faster than with straw. — Tom Rymsza, President, Vision Paper

Impact on Sustainability Systems

LISTENING STUDY: In 2004, recycled content makes up 37% of the fiber used to make paper and packaging in the U.S. (Only about 5% is used in printing and writing papers, but considerably higher percentages are used in newsprint, tissue and packaging.) Most environmental groups see recycled content as the foundation for an environmentally sustainable paper production system. But there are some questions about how well non-wood fibers can be recycled, no matter what type of fiber is used to make the original paper. See Question 52 for a fuller discussion of this issue.

When paper and cardboard containing straw fiber are mixed with wood-based paper and cardboard in waste collection systems, then processed under the same conditions as the wood-content waste in a recycling mill, the weaker straw fibers break down more easily than wood fiber, and act as a contaminant, slowing the drainage time of the pulp, and producing weaker products. All fibers become shorter in the recycling process; since straw fibers are short to begin with, recycling them will make them too short to be retained in the process, and the shortest will pass through screens along with other process rejects. This will result in a lower yield for a recycling mill, which will have negative economic impacts. — Tom Rymsza, President, Vision Paper

LISTENING STUDY Question 43: What is the applicability of wood pulping mills to agricultural fibers?

LISTENING STUDY: Many respondents say that agricultural fibers cannot be pulped in mills built to pulp wood.

My understanding is that wood handling equipment in pulp mills is generally not compatible with the tooling needed to process ag fibers. — Jeff Lindenthal, President, Green Field Paper Company

In general, agricultural fibers are not suited to wood pulp mills. The agricultural materials are not available in the geographic vicinity of the wood pulp mills and the technologies for wood pulping are generally not suited for nonwood fibers. One exception is bamboo which can be used in wood pulping mills. — Living Tree Paper Company

Utilizing a tree based pulp mill to run ag fibers can be of some concern. Tree-based pulp mills are built to accept small wood chips or pellets instead of large agricultural bales. Some ag fibers would introduce the silica problem to a tree based mill. The chemicals used in most tree based pulp mills are too harsh for most agricultural fibers. When the mill is trying an agricultural fiber for the first time, sacrificing several batches of pulp while adjusting the chemistry is usually necessary. A dedicated nonwood facility provides optimum efficiencies. — Tom Rymsza, President, Vision Paper

Conventional chemical pulp mills are based on sodium chemistry. In the context of a low (zero) pollution pulp mill, the high potassium content of agri-fibers would overwhelm the sodium chemistry. There is also the specific "silica in agri-fiber" problem. In contrast, wood has very low content of potassium and silica.

See for example, my presentations, "Toxicity, BOD and colour of effluents from the Kraft pulping of bole wood containing high quantities of bark," "Impact of Biomass Potassium on Operation of Effluent-Free Agri-Pulp Mills," "Potassium Pulping of Straw,",and "New Direction in Industry Development and Environmental Protection for Nonwood Pulp Mills in Developing Countries." — Al Wong, Founder, Arbokem

The chemical processing (Kraft and sulfur based) is generally overkill for kenaf. — Tom Rymsza, President, Vision Paper

Converting existing mills would be a difficult transition. The tree pulping industry is enormous and is tailored for softwoods and hardwoods. It is generally very difficult to switch in other fibers other than bamboo. — Jeff Mendelsohn, President, New Leaf Paper

Most agricultural fibers will not process in the raw material handling and pulping stages of existing wood pulp mills. This is due to the high bulk volume of plant materials compared to wood chips. Therefore, new equipment has to be installed to receive the raw material, for temporary storage, and the digesters for pulping. Once pulped the material can be processed through existing bleach plants, although probably at reduced rates. — Michael Jackson, Consultant, Tolovana Park, OR

Many of the tree pulp mills may not be adaptable. Bleaching and fiber technologies differ. Converting a mill could render some of the bleaching and fiber processing machinery obsolete. It is possible to "rent" a mill, but changing the entire process without running large quantities is not economical. Internationally there are more kenaf developments; it might be interesting to see if converted mills or ground-up mills dominate overseas. — Russell Clark, Environmentally Preferable Purchasing Program, US EPA

The cellulose content of kenaf, hemp and wheat straw is similar to that in trees. Annual fiber crops generally have lower lignin content and higher hemicellulose content than wood. Cereal straws have relatively high silica and potassium contents. These differences in chemical composition determine the best pulping processes and pose challenges to pulping non-wood fibers.

The lignin content of kenaf (15-19 %) and of wheat straw (16-21 %) is significantly lower than that of softwoods (26-34%) and hardwoods (23-30%). The lignin content of kenaf and hemp bast fibers also is lower than that of the core fibers. For instance, for kenaf, the lignin content of the core is 17% whereas that of the bast fibers is only 8%. A lower lignin content generally reduces the amount of energy required to pulp the fiber using either mechanical or chemical processes.

In addition to the amount of lignin, its chemical nature also matters. The chemical structure of the lignin in non-wood plants differs from that of the lignin found in wood; these structural differences affect the ability of pulping chemicals to break down the lignin. Hemp, for example, has a low lignin content (4.3% for bast fiber and 20.8% for core fiber), however, its lignin structure makes it difficult to pulp and bleach the bast fiber using a chemical pulping process.

[This study] shows the high silica content of wheat straw and other cereal straws. High silica levels pose two problems: silica creates problems in the chemical recovery system, and it affects the paper quality. If the silica ends up in the paper, it makes the sheet more abrasive and thus creates problems on converting equipment. If the silica is removed from the straw fibers during the pulping process, it appears in the black liquor in the form of sodium silicate and/or other complex siliceous compounds. A high silica content may lead to scaling in the evaporator and recovery boiler tubes. — Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

Wheat straw pulping processes have to control the viscosity and the levels of silica and potassium in the black liquor sent to the recovery system. Silica can precipitate out of the black liquor and result in scaling of pipes in the evaporators and recovery boiler. High potassium levels in the black liquor affect the properties of the molten metal mixture in the base of the recovery boiler and can lead to the plugging of pipes in the recovery boiler. Straw's high hemicellulose content increases the viscosity of the black liquor and makes it difficult to fire at high solids concentrations. Currently, no good solutions exist for these challenges to recovery.
— Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

It is clear that for existing mills, which require upwards of one million tons of raw material per year, agricultural based raw materials are problematic. ~~it~~ It is not surprising that they do not support alternatives. But if we care about environmental impacts, and global warming and deforestation, we have got to take a longer term view. **—** Tom Rymsza, President, Vision Paper

LISTENING STUDY: Some claim that there are larger reasons for the incompatibility.

As Andrew Kaldor writes: ". . . a commonly held view today among the pulp industry experts of developed countries is that the production of nonwood fibers is not viable or competitive in their economic environment. The same industries, on the other hand, are prepared to accept a heavy long-term reliance on wood fibers due to a perceived lack of alternatives." **—** Maureen Smith, ***The U.S. Paper Industry and Sustainable Production***

Conversion is more complex than just the pulp; the existing infrastructure is a part of the larger wood products industry (rayon, etc.). A pulping mill conversion would affect the far-reaching markets of wood products. — Peter A. Nelson, President, AgroTech Communications, Inc.

LISTENING STUDY: Some report successful nonwood pulping in wood pulping mills.

Certain agricultural fibers, such as kenaf, have been successfully pulped with modified tree pulping processes. — International Paper

Most agricultural fibers will not process in the raw material handling and pulping stages of existing wood pulp mills. . . . The Arundo donax reed that I am currently working with is an exception. It can be cut into chips that have the same bulk density as wood chips and therefore can be processed in existing pulp mills without equipment changes as demonstrated during the recent trial at the Samoa, CA, pulp mill. — Michael Jackson, Consultant, Tolovana Park, OR

When I view the use of agricultural fibers in the pulp / paper industry I am looking at a world that already uses nonwood fibers in various applications, such as Buckeye Technologies' (www.bkitech) use of cotton linters; flax fiber in cigarette papers, etc. We will not see a time when the same wood infrastructure supporting various commodity papers just automatically adapts to nonwoods. We will see a time when consumers demand more specialized products that are manufactured from a diverse amount of fibers, in new factories outside of the traditional "typing paper" and newsprint. — Peter A. Nelson, President, AgroTech Communications, Inc.

The differences between wood and agricultural pulp mills are not much different, but the so-called "retooling" of wood pulp mills may be required to pulp nonwood fibers. Any wood pulp mills can be converted to agricultural pulp mills. Wood pulp mills are usually batch process and there are some continuous process mills handling only nonwood fibers. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

Most agricultural fibers will not process in the raw material handling and pulping stages of existing wood pulp mills. . . . The Arundo donax reed that I am currently working with is an exception. It can be cut into chips that have the same bulk density as wood chips and therefore can be processed in existing pulp mills without equipment changes as demonstrated during the recent trial at the Samoa, CA, pulp mill. — Michael Jackson, Consultant, Tolovana Park, OR

If the mill uses our patented process, it can run on any regular Kraft mill or TCF process. It runs with 1/3 the chemicals or no chemicals in the TCF process. In both, the processing time is 1/3 that of tree processing. It cooks faster and brightens faster. The Arundo donax H cooking factor is 650-800 whereas for trees it is 1600-2000. There is no concern with silica as with ag residues and other alternative fibers. — Ernett Altherimer, Founder and Chairman, Nile Fiber

It is fairly feasible to convert all or part of the supply for a tree pulping mill to nonwoods. Some of the large mills are attempting this in areas where the nonwood can supplement their wood supply. There have been few or no obstacles to doing that. The conversion is somewhat akin to the introduction of recycled content. Adaptations have to be made depending on the fiber, but the process is not fundamentally different. — Richard Denison, Ph.D., Senior Scientist, Environmental Defense

Although non-wood fibers can be pulped with the same processes used for wood, the technology to do so has not been tested on a commercial scale in the United States, with the exception of the . . . kenaf pulping operation at P.H. Glatfelter's mill in Ecusta, North Carolina. . . . In addition, specific technical issues remain to be solved for certain non-wood fibers:

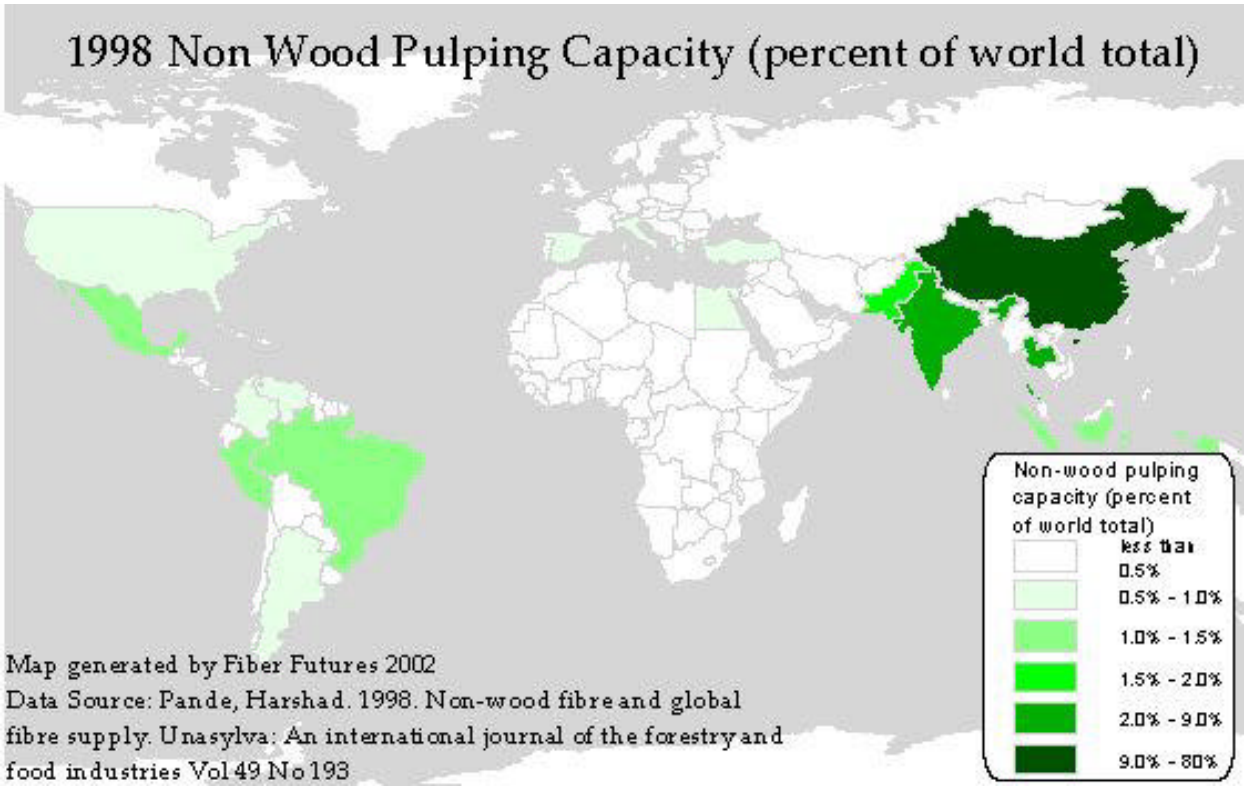
- As already discussed, for agricultural residues, such as wheat and rice straw, the high silica and potassium content poses technical problems in the recovery of pulping liquors in chemical pulping operations. . . .
- Generally, pulping equipment and processes have to be adjusted and / or specifically designed for the different fiber types.
    - Fiber handling and storage systems have to modified to handle bales of non-wood fiber rather than pulpwood and wood chips.
    - Continuous digesters seem to be more appropriate for non-woods than the batch digesters used to pulp wood chips in chemical processes. Non-woods such as wheat straw have a low density and are very bulky. Continuous digesters reduce cooking time and improve pulping productivity. However, for very long fibers, batch digesters are used because the long fibers get entangled in continuous digesters.
    - Paper machines with a longer wire are needed for pulps from short-fibered nonwoods that have low drainage rates, such as wheat straw.

— Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

We have produced our pulps and papers with existing mills, mostly in the US. While the existing processes can be used to produce good results, we know that designing a mill specifically for nonwood fibers would produce excellent technical properties at an economically advantaged price, and with significantly less environmental impact. — Tom Rymsza, President, Vision Paper

LISTENING STUDY Question 44: What is the availability of tree-free pulping facilities, and future outlook?

Figure 1. 1998 Non Wood Pulping Capacity



Current Status, U.S. and International

Ag pulping facilities are very limited at the moment. I am aware of very few such facilities (2-3) in the US that can presently pulp ag fibers. — Jeff Lindenthal, President, Green Field Paper Company

There are several mills in North America with the ability to process and make paper out of certain tree-free fibers, mostly recovered cotton fibers. And some of these mills can and do make papers using other tree-free fibers.

But the vast majority of papermaking facilities are geared toward making paper from trees. For example, with alternative fibers, it can be more difficult to remove the water during papermaking, and that can create a large cost disadvantage. Tree-based paper machines would not be able to efficiently drain water out of tree free fibers at their current configuration, which is designed to make paper profitably.

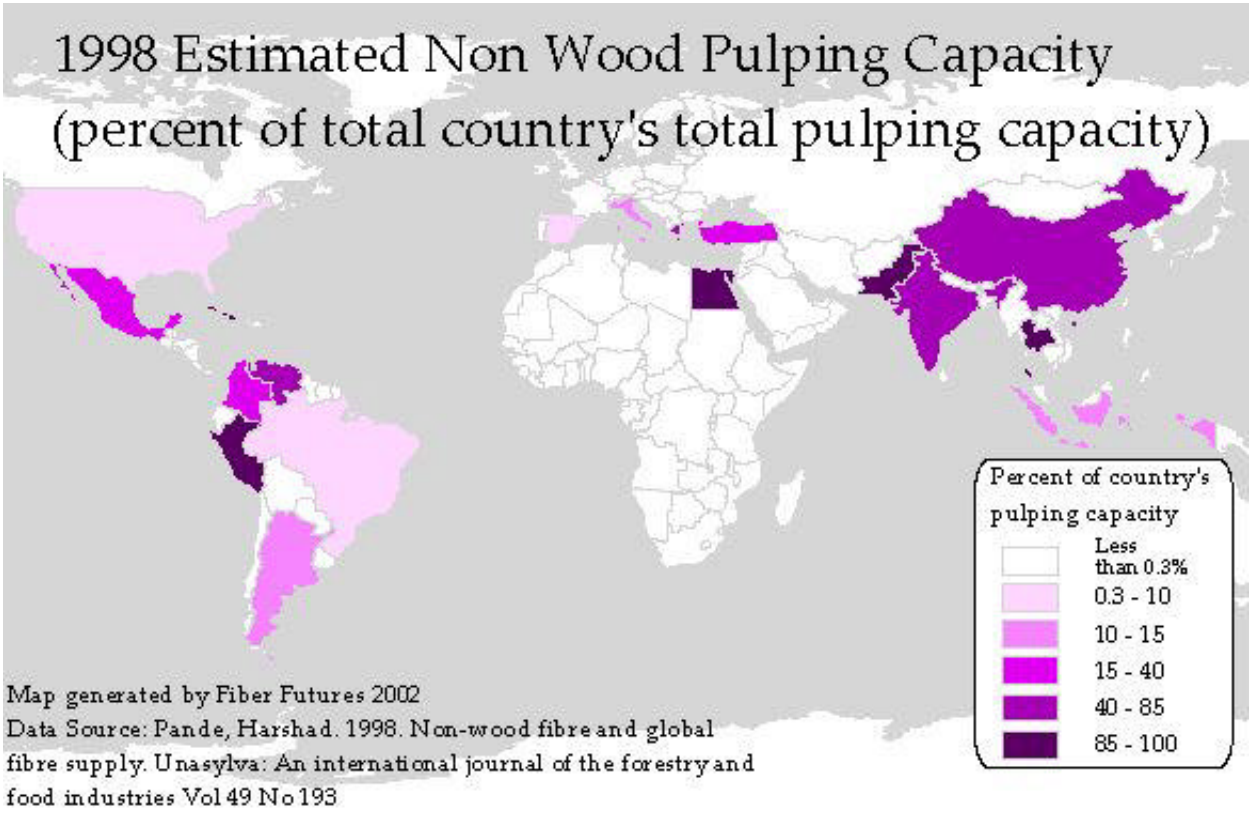
The paper machines that are currently making cotton, kenaf, or hemp are generally set up differently to be able to make paper profitably from these different fibers, but the cost structure is higher. I'm sure tree-based paper manufacturers could use cotton/hemp/kenaf on their big machines, slow the machines, increase suction, and increase drying temperatues and make the hundreds of other alterations that need to be made. However, there's no financial incentive for them to do that until people say they only want papers that include alternative fibers. They, like everybody else, have to make a profit. — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

There are three to four mills that can pulp nonwood fibers (Kimberly Clark, Ecusta, and Dexter). Dexter pulps nonwoods for high quality, highly specialized medical and technical grade papers. There were a

number of small Chinese straw pulping mills, but the government is shutting them down due to their high effluent output. Mexico has a bagasse pulping mill. — Tom Rymsza, President, Vision Paper

Currently agricultural fiber pulping facilities are very limited and generally dedicated to producing technical pulps for specific applications. — Living Tree Paper Company

Figure 2. 1998 Estimated Non Wood Pulping Capacity



In Australia, Arisa is raising funds to build a 38,000 ton/yr bleached wheat straw market pulp mill at Horsham, Vic. Pulping is to be by the Naco Process, with start-up aiming for 2001. Silica content removal (desilication) will take place at 3 stages — namely, on the straw (NaOH treatment); in the green liquor (lime addition); and in the effluent treatment plant. — Higgins 2000

China pulps both wheat and rice straw, and accounts for 75% of total world straw production. The large pulp mills utilizing wheat straw are mainly located in Europe. The Danish Fredericia mill, which was the only dedicated wheat straw market pulp mill in Europe (the other mills being integrated with paper production) and the Spanish Saica pulp mill are both thought to have been shut down.

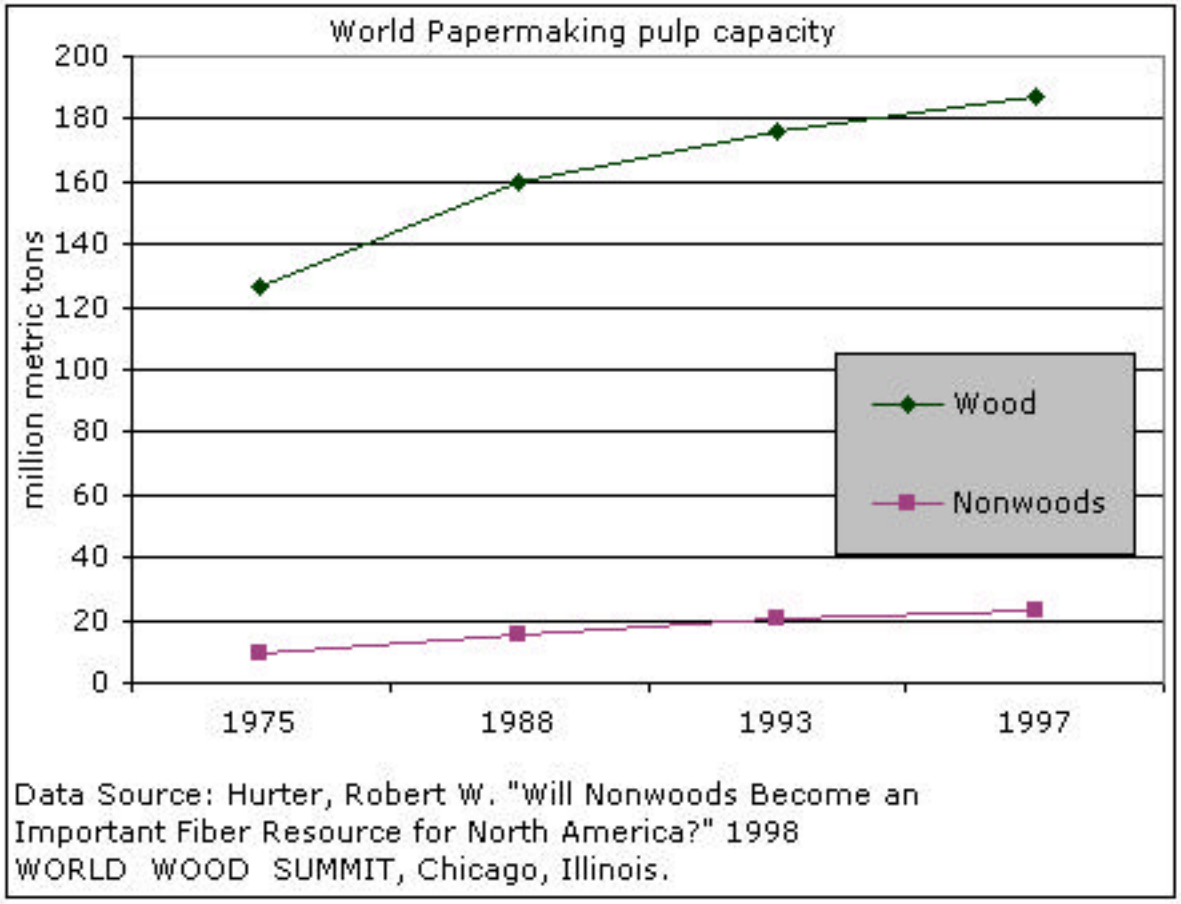
The new Cellpaille mill, in France, is using a Saica digester and soda cook, with spent liquor recovery/treatment by the LPS Process (Granit). The spent black liquor is acidified to pH 2.5-3 to precipitate the lignin, which is then processed, washed, dried and sold for uses similar to those for lignosulfonates (although it is sulfur-free). The resulting filtrate is treated by wet air oxidation (SRS Process; sodium recovery system), with oxygen being utilized rather than air**.** — Paperloop.com, "Wheat Straw and Rice Straw"

There are essentially no pulping facilities for agricultural fibers in the U.S. or Canada. Exceptions are two facilities for pulping high value, specialty fibers and the very small straw pulping unit of Arbokem. There

is a mill in Mexico that pulps bagasse, the residual cane after sugar extraction. This pulp is used in various paper grades. Worldwide, 7-8% of the total virgin pulp fiber production is from nonwood materials. — Michael Jackson, Consultant, Tolovana Park, OR

14 flax pulp mills, production capacity about 75,000 tpa
23 hemp pulp mills, production capacity about 80,000 tpa
9 abaca pulp mills, production capacity about 35,000 tpa
U.S. - 2 mills w / max 20,000 tpa hemp pulp production
Phillipines – 1 mill w / max 8,000 tpa abaca pulp production
— Judt 1993

Figure 3. World Papermaking Pulp Capacity



In the U.S., paper was traditionally made from non-woods, mainly waste products from the textile industry. During World War II, there were 25 mills in the midwest producing corrugating medium from wheat straw. The last straw pulp mill closed by the end of 1960. Non-wood fibers were no longer competitive for four reasons:

- development of the kraft recovery system as an efficient means for recovering spent chemicals in wood pulping;
- increases in labor cost in a labor-intensive industry: straw harvesting, storage and pulping technologies were less economic than similar wood-based processes;
- westward shift of the agricultural production: straw as a fiber source moved further away from the pulp and paper industry and its customers; and

- increases in fuel cost: paper mills' access to bagasse, a waste product from sugar refining, declined as sugar mills switched back to using it as a fuel source when prices for other fuels increased.

— Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

Future Outlook

Pandia digester, a continuous digester specially designed for nonwood pulping, is available. But a wood digester can be also used in nonwood pulping. As far as future outlook, especially in the U.S., the price of wood chips is falling and the U.S. trade deficit in paper and board has widened significantly since 1996. For the first time in many decades, U.S. paper and paperboard production capacity has actually declined. American farms are already subsidized and two major crops — corn and wheat residues — could be converted into pulps. Several dozen small digesters can be installed in corn and wheat belts and start producing pulps. Future outlook seems to me is based more on the control of imports and national policy rather than availability of agricultural pulping facilities. Without a national policy, cheap imported chips, pulps, and papers will flood the U.S. market. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

There is the potential for large-scale commercialization of tree-free paper, but there remain a number of obstacles, many of them agricultural. As Daniel Kugler's report "Non-Wood Fiber Crops" demonstrates, a major barrier is the lack of processing plants and commercial-scale agricultural equipment. Many of the test plots have been harvested using equipment borrowed from other industries, including sugar cane and cotton. But kenaf harvesters have been built and tested. These problems would be easily overcome if the industry were focused on them. **—** Jim Motovalli, "The Paper Chase"

There are a couple of projects underway, though we cannot expect to see results for 2-5 years. — Jeff Mendelsohn, President, New Leaf Paper

Two of the characteristics of nonwood fiber use about which there appears to be relatively widespread general agreement are the seasonality of annual crops and the transport costs of moving low bulk density agricultural fibers. From the established paper industry's point of view, both compare unfavorably to wood, which can be harvested year-round and stored indefinitely, and is much denser than agricultural fibers and thus comparatively less expensive to transport. Agricultural pulp mills continue to be contemplated (though not built) at scales of up to 500-600 tpd. However, there is increasing agreement that for reasons of transport efficiency and fiber supply security, the optimal scales for agricultural pulp production, even in developed countries, should be much smaller. . . . Generally, the transport issues associated with nonwoods, the corollary emphasis on smaller-scale pulping formats, and the issues of heterogeneity in fiber types, sources, and applications, are the basis of an increasingly strong regional theme that runs through the debate. **—** Maureen Smith, ***The U.S. Paper Industry and Sustainable Production***

There are limited nonwood pulping facilities. Cotton pulp mills are probably the most readily available. Vision Paper is working on developing a dedicated pulp mill focusing on kenaf.

A new nonwood mill will give kenaf viability in the mainstream paper market. Many pulp mills that are in use were built over fifty years ago. It has been over a decade since a new pulp mill has been constructed. There have been improvements in the efficiencies and environmental systems for pulp mills in recent years. Vision Paper's mill will take advantage of these advancements. Working with a raw material which pulps with less chemicals and energy than trees gives kenaf another economic advantage. We expect that the mill will be producing tree-free pulp that will cost less than tree-pulp, furthering market advancement.

The mill is designed to use local agricultural resources. The design can be easily replicated so subsequent mills can be constructed as demand increases. — Tom Rymsza, President, Vision Paper

Led by entrepreneurs such as Nile Fiber, Mells Industries, etc. on the forefront, and traditional leaders such as Buckeye Technologies, the future of nonwoods is exciting in all of the fields (annuals, herbaceous, residues, processing waste). We will continue to see more natural product such as feminine hygiene,

cigarette papers, etc., where consumers prefer cotton and other natural fibers over the synthetics. For example, we will have kenaf placemats with an antimicrobial agent to ensure a clean eating area. The markets are limitless. — Peter A. Nelson, President, AgroTech Communications, Inc.

All Kraft and TCF mills can run Arundo donax. We are negotiating new licensees as we speak. Also, Samoa-Pacific has the ability to sub-license. — Ernett Altherimer, Founder and Chairman, Nile Fiber

It doesn't seem like there are many, though I'm not an expert. Arbokem was built to focus on agricultural fiber use. All the others sound like they're on the West Coast. As far as the market expanding in the next years, there are a number of hurdles such as raw materials only being available once a year rather than year round. Trees can store for extended periods of time whereas rot and decomposition threaten bales of straw.

The industry needs to do a better job at putting their nonwood materials side by side with trees to understand as a country which papers are preferable. There is a lot of support on "the hill" for agriculture based products. On the other hand, the forestry industry has a lot of lobbyists. Without good information, the industry is not going to get far. — Russell Clark, Environmentally Preferable Purchasing Program, US EPA

Economics are the biggest barrier for nonwoods going into the niche markets. They may not have an advantage because people may not see trees as toxic. Whereas consumers might believe that agricultural products were grown with pesticides, they could believe trees just grew in a forest and must be natural. — Russell Clark, Environmentally Preferable Purchasing Program, US EPA

The issue of agri-pulping in developed countries is complex. Some of these barriers are very difficult to overcome. One of the most important pathways to "save trees" is to use less paper, but this approach is contrary to the growth-oriented market economy.

See for example, my presentations, "Agricultural Fibers for Pulp and Paper Manufacture in Developed Countries," "How Many Trees Can Be Saved?," "Experience in the Technical and Market Development of Agri-Pulp Printing Papers in North America," and "Obstacles and Opportunities in the Development of an Agri-Pulp Industry in the Pacific Northwest." — Al Wong, Founder, Arbokem

While some experimentation has been done with agricultural residuals in papermaking, there is a very small opportunity to use residual fibers based on the fact that papermaking facilities are often far from sources of agricultural residuals. Shipping, handling, and storing costs would be high relative to those for wood. Building facilities dedicated to pulping agricultural materials would seem to be a very high risk venture. — International Paper

Various companies are working on a desilication process. So far, the best process has been developed by the Central Pulp and Research Institute (CPPRI) for a newsprint mill in India, with assistance from the United Nations Industrial Development Organization (UNIDO). The process should eliminate 70-80% of the silica, but requires further testing in commercial operations.
— Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

My goal is to build a series of dedicated kenaf pulp mills that would be the cleanest pulp mills in the country (world), utilizing bioenergy, and producing cost-competitive products. — Tom Rymsza, President, Vision Paper

The Malaysian research and development center, Technology Park Malaysia (TPM) . . . is conducting research on manufacturing paper from banana stems. . . . [I]t plans to work with companies in Australia and Japan that are already in the early stages of banana paper production. TPM laboratory technician and researcher Nurul Huda Muhammad estimates that around 1 billion tonnes / yr of banana stems are left to rot. Japan's Banana Paper Project Supporting Association (BPPSA) is still in talks with the country's Ministry of Foreign Affairs and the United Nations on plans to establish banana paper mills in 100 developing countries. . . . The BPPSA has already set up facilities in Haiti and Jamaica and hopes to build the others by 2015. — Paperloop.com, "Malaysia studies banana paper production," July 2, 2004

Table 6. Leading Users of Nonwood Fibers in Papermaking

Country	Nonwood Pulping Capacity 1993		Nonwood Pulping Capacity 1998 (estimate)		Nonwood Raw Materials 1998 (estimate)		Wheat and Rice Straw Pulping Capacity 1998
	Capacity (Oye 1991)	% of Total Pulping Capacity (Oye 1991)	Capacity (Oye 1991)	% of Total Pulping Capacity (Oye 1991)	Raw Material Capacity (Paperloop)	% of National Capacity (Paperloop)	Pulping Capacity
	('000 tonnes)	(%)	('000 tonnes)	(%)	('000 tons/yr)	(%)	('000 tons/yr)
China	15,246	86.9	16,830	84.3	17,672	84.2	9,702
India	1,307	55.5	2,001	61.3	2,000	61.3	296
Pakistan	415	100	415	100	491	100	260
Mexico	321	29.2	324	29.3	230	24.1	
Peru	298	95.2	296	95.2	50	100	
Indonesia	267	22.1	267	10.1	86	1.4	21
Colombia	218	45.1	218	37.2	217	46.8	
Thailand	209	100	509	100	158	27.5	3
Brazil	196	3.1	238	3.3	139	1.9	
Venezuela	185	75.2	187	75.4	255	68.0	
United States	179	0.3	204	0.3	380	0.6	
Greece	150	85.7	160	84.2	155	83.8	15
Spain	140	7.9	141	7.7	140	7.3	125
Argentina	140	14.6	140	12.8	140	12.8	
Egypt	127	100	127	100	127	100	67
Italy	120	13.3	120	13.3	165	26.0	20
Cuba	108	100	108	100	108	100	
Turkey	103	16.5	103	16.5	191	27.4	187
Vietnam					100	38.0	6
France					150	4.0	
South Africa					115	7.1	
Iraq					101	100	
Iran					90	25.0	30
Australia					255	18.1	
Romania							64
Denmark							50
Hungary							30
Yugoslavia (former)							28
Algeria							25
Bulgaria							12
Sri Lanka							9
Kenya							6
Cambodia							5
World							10,961
	Source: Oye et al., 1991				**Paperloop Nonwood Raw Materials**		**Paperloop Wheat and Rice Straw**
Compiled by Fiber Futures and Conservatree					**Source: Atchison, J.E., "Progress in the Global Use of Nonwood Plant Fibers and Prospects for Their Greater Use in the Future." Inpaper International, Apr-Jun 1998, pg 21**		

Transform Australia is rebuilding its PM to raise output of banana tree fiber-based paper to 20,000 tonnes/yr. The unit produced just 2,000 tonnes last year. The plant, which is located in North Queensland, the banana-growing region of Australia, is touted as the world's only manufacturer of 100% banana paper. . . . "There's just one hurdle to go through," Johnston told Paperloop. The director explained that the firm needs more investors. Transform Australia claims banana paper is 300 times stronger than pulped paper, is water resistant and greaseproof, but fully biodegradable and environmentally friendly in that it is made using what is currently a waste product. The firm indicated that no additives, chemicals, glues or dyes are used in production. Water is not used either as the trees contain enough of their own sap to re-bond. The company believes banana paper can replace 85% of current world consumption. — Paperloop.com, "Transform Australia to Boost Banana Paper Output," June 18, 2004

How does a paper qualify for environmentally sound manufacturing practice?

- When it does not deplete the forest cover,
- when it makes use of waste agricultural residues like cereal straws, which otherwise pose a problem in proper disposal,
- when there are no effluents from the process which are toxic to the environment - land, water and air natural resources,
- when it offers sustainable practice by not depleting a limited quantity of natural resource,
- when it is less dependent on external energy inputs by using internal process energies like cogeneration of steam and electricity,
- when it allows blending with wood fibres to make better quality paper at lower cost and lesser negative impact on the environment.

Taking cognisance of all available state of the art pulp and paper making technologies available in the world today, we have the solution which satisfies all above criteria and in addition it is also economical and cost efficient.

We know how to make paper from cereal straws. This is a plentiful agricultural waste in India and we thought why not put this to good use. In India many small plants were set up. One of them was ours - Amrit Papers. The pollution control Board of the Punjab state government told us that we couldn't enhance capacity unless we cleared up the mess we were creating with the black liquor effluent. We searched worldwide and took a lot of efforts (for a small enterprise). So we finally achieved success with the homegrown MKCR (Mahesh Khaitan Chemical Recovery technology, named after the inventor) and were given a patent too.

We made bench and lab models and finally a pilot facility was run for 5 years until we had tweaked the process to perfection.

We want to set up the first facility of 150 Tonnes per day pulping capacity based mostly on cereal straws, somewhere near Delhi or in Punjab. . . . We want to team up with a financial investor.

— R. Santhanam, Vice President, Amrit Environmental Technologies

LISTENING STUDY Question 45: Are there environmental problems in pulping tree free fibers?

Using agricultural fibers in place of tree fiber is detrimental to the environment. Even some of the most intensively managed forests are much more biologically diverse and hospitable to surface waters, soil, and wildlife, and they require far less chemical treatment than annual agricultural crops. — International Paper

There are some problems in any pulping, but there are a lot less problems in nonwood pulping due to low lignin contents. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

Most of Europe's non-wood pulping infrastructure has shut down in the past three decades due to pollution problems. China's non-wood pulping accounts for 3x that of its wood-based pulping and the Chinese have identified their traditional (non-wood) pulp and paper industry as the number one source of pollution in the rural countryside. However, this is expected to change now that new technologies are coming on line fast.

In North America, the mills that pulp flax and kenaf and the like are much cleaner.
— Jeanne Trombly, Fiber Futures

The environmental problems are essentially equivalent to those related to the pulping of wood. However, most agricultural residue pulping systems are smaller than wood based pulping facilities which allows for the closed loop system to be effectively implemented. — Living Tree Paper Company

There is no environmentally benign way to manufacture pulp. Silica in agricultural fibers can pose a set of issues at the pulp mill. The existing papermaking model relies on diverse forest ecosystems for a raw material. Changing that model to one that utilizes a low input crop instead will have far less environmental impact. Kenaf produces 3-5 times more fiber per acre per year than trees and displaces high input crops that are currently being grown. In addition, most on-purpose crops can use milder pulping chemistries and bleaching sequences when compared to tree fibers. — Tom Rymsza, President, Vision Paper

Environmental problems from use of agricultural fibers include: Greater pollution in run-off and round water from the fields, a dust containment problem when handling the raw material as it is fed into the pulping unit, potentially higher water use in pulping and bleaching due to lower drainage characteristics. Water is more difficult to separate from the pulp with most nonwood fibers, possible higher BOD/COD discharges due to lower pulping yields with nonwoods resulting in higher dissolved materials. — Michael Jackson, Consultant, Tolovana Park, OR

My understanding is that waste water, and the spent "liquor" used to cook ag fibers, pose the biggest environmental problem. — Jeff Lindenthal, President, Green Field Paper Company

Nonwood pulp mills have a reputation of being high polluters. This has arisen from the many small (5-50 tons/day) mills in Asia that pulp straw, bagasse and other nonwoods and discharge the cooking liquors to the environment after little or no treatment. — Jackson 1997

Depending on the appropriate selection of pulping technology. There are considerable opportunities to be substantially better than the pollution footprint of conventional chemical pulping of wood.

See for example, my presentations, "Industry Development and Environmental Protection – Compatible Goals?", "Alkaline Pulping of Kenaf Fibers from Crops Grown in Northern Territory, Australia and Anhui, China," and "Alkaline Sulphite Pulping of Sisal Fibers Grown in Brazil, China (Guangxi), Kenya and Madagascar." — Al Wong, Founder, Arbokem

Kenaf uptakes heavy metals at serious rates. This means that the heavy metals from the commercial fertilizers have to be removed in the pulping process, or there can be complications with the machinery.

Academic and lab fertilizers typically will not have any heavy metals, so this complication may not show up in the testing stages. — Tom Rymsza, President, Vision Paper

It depends on how one defines problems. Pulp and papermaking, no matter what the material, no matter what the process, has environmental impacts. Papermaking requires lots of water and energy, and creates waste. Depending on the fiber, the process and the end application, greater or lesser inputs are required, and environmental impacts vary. But the overriding issue remains. Tree-free fibers for papermaking will take pressure off our dwindling forests and provide additional income opportunities for struggling farmers. And when agricultural residues are the source of tree-free fibers, the overall environmental and economic benefits become obvious from a policy-level perspective. That scenario must be kept at the top of the decision-making process, and not buried under arguments about minute variations in the cost/benefit relationship. — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

The environmental problems are similar to those from any pulping process. There are high contents of certain constituents, silica for example. However, the silica issue might just be a technology barrier. With further development, the pulping process can have silica as a byproduct to be sold, rather than a waste material.

Given proper investment, pulping nonwoods might use less energy and resources because they contain less lignin than wood fiber. Generally, nonwood fibers take less water, chemicals, and energy. The nonwood pulping industry needs more experience to definitively qualify that statement, but in our experience it has been true.

To address the technical barriers, there needs to be a combined effort from private industry and public research. When fighting an entrenched industry with significant barriers to entry, public support is critical. — Jeff Mendelsohn, President, New Leaf Paper

Ever since humankind was kicked out of the "Garden of Eden," everything any of us does is detrimental to the environment. Agricultural fibers offer some ways to minimize the devastation, but like any other new technologies there are opportunities with agricultural fibers to do a lot of damage. There is room for improvement in some of the pulping technologies. To make a better copy paper, we need better enzymes for bleaching. We need more research for nonwoods.

The inherently impossible question seems to be: Overall, how do we minimize impact of industries that by existing destroy the earth?

There is a clear role for the public dollar in nonwood research. There is already a ton of federal research money going into tree genetics, lower energy, and water use. We have to tap into this research. Alberta Research Council has done great work and should continue being funded.

For example, the Department of Energy has millions going into research to lower the cost of production. We have to bring all the nonwood proponents out on the fringe together for research that will lower the cost of production. We have to realize that we're all trying to do the same thing: no one wants the landfills filled up. — Peter A. Nelson, President, AgroTech Communications, Inc.

No problems. The Arundo donax processing can recover everything out of the pulp and reuse it. There is an extended value stream off Arundo. If you don't re-burn the black liquor, you can get 52 gallons of ethanol for every ton of pulp you produce. In cases where the cane is harvested from creak beds or other removal location, the free cost of the material offsets the transportation costs. Also, the lower energy and chemical lead to savings of about 35-40%. — Ernett Altherimer, Founder and Chairman, Nile Fiber

Bleaching is a concern. — Russell Clark, Environmentally Preferable Purchasing Program, US EPA

As a purchaser, we need to know about the quality — in particular about the copy paper. We haven't received enough information that can convince us to purchase on a large scale. — Tyson Miller, Program Director, Recycled Products Purchasing Cooperative

It comes down both to the level of effluent treatment and recovery and to the amount and nature of inputs to the process. Pulping nonwoods generally requires fewer chemical inputs. Less in the way of bleaching compounds and sulfur compounds for pulping are needed in general.

While our white paper discussed the challenges associated with the high potassium and silica content of cereal straw residues and the effluents that result from their pulping, we did not find much data on effluent quality resulting from the different composition. In general, there are challenges with recovery due to the higher levels of silica and potassium. Also, there can be some issues if the silica is not removed from the pulp and ends up in the paper – it can be abrasive to the equipment it runs through. — Richard Denison, Ph.D., Senior Scientist, Environmental Defense

Most mills in developing countries use chemical pulping processes and are very small. They produce less than 20,000 tons of pulp per year. Most of these mills do not employ chemical recovery or wastewater treatment. Chemical recovery systems reduce chemical costs and environmental releases. However, conventional recovery systems, such as the one used in the kraft process, have high economies of scale and generally are too expensive to install at these small mills. Lack of wastewater treatment makes the situation more severe. Often, untreated effluent is discharged into the local surface waters. — Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

LISTENING STUDY Question 46: Are tree free fibers appropriate for all types of printing and writing paper?

LISTENING STUDY: Some respondents discussed the question broadly, while others gave examples.

General Comments

It would be difficult to group entire agricultural fibers into one category. Some agricultural fibers do have problems, but the answer is yes. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

They can be, especially when used in combination with other fibers. — Jeff Lindenthal, President, Green Field Paper Company

No. Fiber characteristics such as length and width determine its applicability to various forms of paper. — Tom Rymsza, President, Vision Paper

Yes. Ideally a selected blend of fibers is the best. For example, hemp and flax, which are long fibers, add strength to shorter fibers such as post-consumer waste or straw residue.

Bamboo (Bambusa species) is a grass whose bio-attributes are similar to pine. It is one of the main nonwood fibers used in India. Esparto Grass (Stipa tanacissima) in papermaking is best known for its porosity and strong dimensional stability. Flax straw from the linseed oil industry has been used for the manufacture of cigarette paper and other high quality papers.

Abaca of Manila Hemp is a leaf fiber, a member of the banana family, and makes an extremely strong pulp with high tear and tensile strength. Abaca is used for marine cordage, Japanese shoji screens, abrasive backing papers, and tea bags. — Living Tree Paper Company

There are no fundamental barriers. It is a matter of appropriate choice of agri-fibers, pulping technology and papermaking technologies. Furthermore, the spectrum of agri-fiber is very broad; thus, the range of paper products that could be made is also large. Certain types of paper can not be made with the use of wood pulp only.

See for example, my presentations, "Extension of Canada's Softwood Resources," "Agri-Pulp Newsprint," "Experience in the Technical and Market Development of Agri-Pulp Printing Papers in North America," "Selected Physical Properties of Blends of Wood Pulp and Alkaline Sulphite Flax Straw Pulp," "Alkaline Sulphite Pulping of Hesperaloe, An Arid-Zone Native Fiber Plant from Northern Mexico," and "Alkaline sulphite pulping of abaca (Musa textiles Nee) from the Philippines and Ecuador." — Al Wong, Founder, Arbokem

Kenaf is appropriate for all types of paper. — Tom Rymsza, President, Vision Paper

Ag-residues from cereal crops tend to have shorter fibers that are good for smooth surfaces. Ag-residues from flax, hemp and bagasse tend to have longer fibers for strength. Blending of non-woods with appropriate levels of recycled fibers and FSC virgin wood pulp offers opportunities to meet the needs of practically all paper production. — Jeanne Trombly, Fiber Futures

No, printing and writing papers gain their smooth texture from short fibers derived from hardwood trees, and their strength from long fibers derived from softwood trees. Agricultural fibers come in a variety of lengths and diameters, and other characteristics (toughness, bond strength, etc.) are also variable. Some such fibers can be used successfully in printing and writing papers; others are restricted to packaging uses. Our ability to blend long and short wood fibers, however, enables us to make consistently high quality papers for these applications. — International Paper

Right now, because of cost structures, 100% tree free papers are not practical to replace high-volume, lower-cost papers. It's better to start becoming familiar with tree-free papers in high-visibility, lower-

volume applications. Applications like brochures, envelopes, stationery, and report papers can help overcome the price barrier.

Some barriers are real and some perceived. The perception that recycled papers are dusty and clog up the machines is not necessarily true.

Tree-free papers by themselves are not appropriate for many applications. But these fibers can add significant performance enhancements when they are included as part of the total fiber mix.

This gets back to earlier comments about diversity of fiber supply. I would like to see more mixed fiber papers that have ag residues and post-consumer fiber. We are always going to need trees in paper — they're not going away. I don't have a vision of a paper industry without trees. — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

Nonwoods are just like any other fiber source: you need the right mix of short and long. The nonwood papers can be used in many grades of paper depending on the percentage put into the mix.

The nonwoods might have lower levels of bonding. Some woods are better than nonwoods in their ability to stick to each other in the formation of the sheet. Under a microscope the better bonding fibers have rougher edges – that makes them stick together better. — Jeff Mendelsohn, President, New Leaf Paper

No, not all. Essentially all economically viable nonwood fibers have short average fiber length. This means that they can be substituted for hardwood pulps but not for softwood pulps. Practically all papers are made from a mix of fibers. Some, but very few, are 100% hardwood; normally the maximum hardwood use is 80%. Many papers are 100% softwood, or maximum 20% hardwood (newsprint, magazine printing papers).

Nonwood fibers could be used to replace hardwood in many writing papers and copy paper. They would work in coated white papers such as used in high grade printing for annual reports and high quality catalogs. Eventually a small content in newsprint (10%) might be possible and perhaps 20-30% in light weight coated and SC grades for magazine and catalog printing.

Each fiber type and pulping process has unique characteristics that add or subtract from the quality of the paper. Plant fibers are different than wood fibers in many ways. Many plant fibers form a denser paper sheet than wood fibers; this can be desirable in some papers and undesirable in others. Plant fibers also tend to give paper with poorer opacity than hardwood fibers. While this can be corrected with pigments and fillers, it may affect the economics. — Michael Jackson, Consultant, Tolovana Park, OR

The market and performance will bring this out, but theoretically any agricultural fiber can be made into wood type products. — Peter A. Nelson, President, AgroTech Communications, Inc.

The chemical and physical properties of fibers determine their suitability for use in paper. When the USDA evaluated alternative crops for paper in 1960, they considered performance in three general areas:

- *Chemical composition* including percentage of cellulose in the fiber and solubility in sodium hydroxide. Plants with high solubility in sodium hydroxide (>39%) do not yield acceptable pulp.
- *Dimensions and yield of fibrous consituents*
- *Physical and visual appearance of the plants* which included estimates of the strength and proportion of bast fibers and the texture of the woody portion in each plant.

— Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

It is technically possible to make high quality paper out of almost any kind of fiber. Although virtually all paper in the U.S., as well as most paper worldwide, is made of wood fiber that has not always been the case. For example paper was invented in China in A.D. 105, but it was not until about 1850 that wood began to be used as a principal raw material for papermaking. Today, about 12 percent of paper worldwide is made of nonwood fiber, primarily from wheat straw, bagasse (sugar cane residue) and bamboo.

— Dr. Jim L. Bowyer, et al, Dovetail Partners

Let's start with agricultural residues. Generally, they are analogous in composition and functionality to post consumer recycled content because the fibers are fairly short. The fiber length can compromise

strength but can have the advantage of increased opacity. The greater opacity allows a lower basis weight.

For mechanically-pulped whole stalk kenaf, the fibers are quite analogous to mechanically pulped wood. The former can be a functional equivalent for groundwood fiber, in applications such as newspapers and telephone books.

For chemically pulped fibers, kenaf can offer modest advantages from a functional point of view. The same opacity can be achieved with up to 10% less pulp. — Richard Denison, Ph.D., Senior Scientist, Environmental Defense

The potential of non-wood fibers as a fiber source for paper . . . is both site-specific and grade-specific. — Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

For most of its history, paper was made from non-wood fibers. Traditional fiber sources for paper were old rags and other textile wastes. Wood became the major fiber source for paper in the mid 1800s. — Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

LISTENING STUDY: Some gave examples of specific papers made with nonwood fibers, including other types beyond printing and writing papers.

With the cooperation of seven newspapers, Al Wong of Arbokem developed a test newsprint that was 68 percent de-inked old newspapers, 12 percent thermo-mechanical wood pulp (which is crushed with grinders using steam at high pressures and temperatures), 11 percent ryegrass straw pulp, six percent rice straw pulp and three percent red fescue straw pulp. Some 200 tons of this mixed-origin newsprint were produced and test-printed at such newspapers as the *Los Angeles Times*, the *San Jose Mercury-News* and the *Sacramento Bee*.

The experiment was successful. Sue Dorchak, quality-assurance manager at the *Mercury-News*, says her company had evaluated the agri-fiber's strength, appearance, runability and ability to take ink, and found only a tiny difference. She said the newspaper was both "enthused and optimistic," but the experiment was not repeated (despite projections that the agri-pulp for newsprint would actually be cheaper than wood pulp product at a certain scale).

. . . Kenaf was first used in a print run by the *Peoria Journal Star* in 1977, after the federal Agricultural Research Service (ARS), based in Peoria, laid the groundwork through technological feasibility studies. ARS proclaimed kenaf to be its top alternative fiber candidate for pulp and papermaking. The American newspaper Publishers Association became interested in kenaf and produced a feasibility study in 1981. A joint venture company, Kenaf International, was also formed at that time.

Unfortunately, once the efficacy of kenaf for newsprint was demonstrated in Illinois, ARS effectively moved on to other projects. — Jim Motovalli, "The Paper Chase"

. . . [R]esearch eventually led to a blend of chemical and mechanical bagasse pulp from which a fully acceptable 100 percent bagassse newsprint sheet was produced in Crown Zellerbach tests. Previous failures of other projects, however, had led to an inability to obtain financing for pilot mils, and Crown Zellerbach ultimately never commercialized the process. **—** Maureen Smith, ***The U.S. Paper Industry and Sustainable Production***

A positive example is Living Tree's paper — it's 10% tree- free and the rest is post-consumer. Good for them! They have wonderful environmental papers. The post-consumer content brings price down dramatically and removes the huge barrier to entry. — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

Arundo Donax papers are appropriate for all papers: Xerox-grade on down to corrugated mediums and newsprint. Most people have the most money in wood. — Ernett Altherimer, Founder and Chairman, Nile Fiber

In an informal run, some of the environmental papers did not perform as well with digital printing. We did not do a direct comparison with virgin tree sheets and agricultural papers, only recycled money,

denim, post consumer waste, and kenaf. The digital printing uses toner rather than inks; therefore the results were crisper and less cloudy on the coated papers and those with a low porosity. However, in many cases the recyclers don't prefer the coated papers as they pay by weight and don't want to pay for the extra weight from the clay coating. The clay is a waste product, and quite heavy so the purchaser gets less usable fiber.

The post-consumer waste paper did the best. Digital printing is probably better environmentally, but it might discourage the tree-free paper industry. Purchasers might be misdirected if they hold onto printing on nonwood papers and have to switch back to ink printing. The environmental impacts might actually be worse.

We need to really understand the markets and products. The industry needs to know the performance attributes that must be met for each product. They must understand the cost of competing markets. Models should be run to determine if the tree-free paper can be priced competitively for the same performance. There are not many who will pay a lot more for something that does not perform as well.

Many of the alternative fiber paper sellers seem to understand the niches. If they need more than a niche market, they need in depth cost analyses. First the product must be proven technically. Many producers make it this far, but break down when they need to supply it on market for a competitive price. — Russell Clark, Environmentally Preferable Purchasing Program, US EPA

From Hurter 2001:

The current uses of nonwood pulps include virtually every grade of paper produced including:

- printing and writing papers
- linerboard
- corrugating medium
- newsprint
- tissue
- specialty papers

Typically, common nonwood pulps or hardwood substitutes are produced in integrated pulp and paper mills, and softwood Kraft or sulfite pulp is added to provide the strength requirements to the paper. However, specialty nonwood pulp may be used instead of softwood Kraft or sulfite pulp thus producing a 100% nonwood paper. And, in some cases, wastepaper pulp may be blended in the furnish. The nonwood portion of the furnish typically varies from 20 to 90% and can be even up to 100% depending on the paper grade and required quality. The possible combinations are endless and can be adjusted to meet market requirements.

Furthermore, it is possible to add small quantities (up to 20 - 30%) of common nonwood pulps to primarily woodpulp-based papers without impairing paper properties or paper machine runnability. This provides wood-based mills which are hardwood deficient but located within a region with available nonwood fiber resources such as cereal straw or corn stalks with the option of adding-on a nonwood pulping line to supplement their fiber requirements.

Typically, the specialty nonwoods have physical properties superior to softwoods and can be used in lower amounts in the furnish when used as a softwood substitute. Specialty papers such as currency, cigarette papers, tea bags, dialectric paper etc. may be made from a furnish of 100% nonwood specialty pulps. Specialty pulps also may be used in combination with woodpulp to produce lightweight and ultra-lightweight printing and writing papers.

Combinations of common and specialty nonwood pulps will permit the production of virtually any grade of paper to meet any quality requirements demanded in the global market. Adding possible combinations which include wood pulp, nonwood pulp and recycled wastepaper pulp increases the possibilities for developing paper with specific sheet properties designed to meet specific customers needs.

The following table provides some uses for nonwood pulps in papermaking. It is by no means complete as many nonwood plant raw materials could be added to the table as well as products listed for each of the nonwood plant fiber raw materials identified. Rather this table provides an indication of the many possibilities which are available for the use of nonwood plant fibers in papermaking. When reviewing this table, please note:

The nonwood fiber in the furnish is chemical pulp unless noted otherwise. In all cases for the balance of furnish, "Kraft " or "sulfite" means Kraft or sulfite chemical pulp made from softwoods, and bleached, semi-bleached or unbleached depending on the type of paper or paperboard. The term "woodpulp" is used when either softwood Kraft or softwood sulfite chemical pulp or a mixture of the

two may be used. In some cases, where the nonwood fiber content of the furnish is low or the nonwood fiber is very strong, part of the furnish may be hardwood Kraft together with softwood Kraft and/or softwood sulfite.
— Hurter 2001

Table 7. Potential Uses of Nonwoods in Paper

Nonwood Fiber	Type of Paper / Paperboard	Furnish	
		Named Nonwood Fiber	Balance of Furnish
Abaca	currency	20 - 50%	cotton pulp
	filter paper	10 - 80%	cotton pulp or woodpulp
	high-grade book & writing	10 - 100%	cotton pulp or woodpulp
	high-grade bond & ledger	10 - 100%	cotton pulp or woodpulp
	linerboard	10 - 30%	bagasse or straw pulp
	nonwovens	10 - 50%	synthetic fiber
	sausage skins	90 - 100%	flax or sisal pulp
	security paper	20 - 100%	cotton pulp or woodpulp
	tea bags	90 - 100%	flax pulp
	wrapping & bag	10 - 30%	bagasse or straw pulp
Bagasse	bristol board	60 - 100%	Woodpulp
	corrugating medium	60 - 90%	wastepaper
	duplex & triplex board	50 - 80%	Woodpulp
	glassine & greaseproof	40 - 90%	sulfite pulp
	linerboard	50 - 80%	Kraft pulp
	multiwall sack (requires Clupak)	30 - 80%	Kraft pulp
	newsprint substitute	70 - 90% (chemimechanical)	Kraft pulp
	newsprint substitute	70 - 80% (mechanical)	Kraft pulp
	newsprint substitute	50 - 65% (chemimechanical)	20% woodpulp, balance bleached bagasse
	printing & writing - mechanical	30 - 60% (chemimechanical)	20 - 30% woodpulp, balance groundwood
	printing & writing - woodfree	20 - 100%	Woodpulp
	tissue	60 - 90%	Woodpulp
	wrapping & bag papers	50 - 85%	Kraft pulp
Bamboo	bristol board	50 - 100%	woodpulp and/or bagasse pulp
	duplex & triplex board	30 - 80%	woodpulp and/or straw or bagasse pulp
	linerboard	60 - 100%	Kraft pulp
	multiwall sack	80 - 100%	Kraft pulp
	newsprint substitute	50 - 70%	groundwood pulp
	printing & writing - mechanical	40 - 60%	groundwood
	printing & writing - woodfree	70 - 100%	woodpulp and/or straw or bagasse pulp
	wrapping & bag papers	80 - 100%	Kraft pulp
Cotton	currency & security paper	50 - 100%	Flax
	high-grade book & writing	20 - 100%	Woodpulp
	high-grade bond & ledger	20 - 100%	Woodpulp

Ekara, Knagra & Nal grass mixed	printing & writing - woodfree	50 - 70%	Woodpulp
	wrapping	40 - 60%	Woodpulp
Esparto	blotting paper	50 - 80%	Woodpulp
	cigarette burning tube	20 - 30%	flax pulp or woodpulp
	cigarette filter tip paper	50 - 70%	flaw pulp or Kraft pulp
	lightweight papers	50 - 70%	Woodpulp
	printing & writing - woodfree	30 - 100%	Woodpulp
Flax (bast fiber)	cigarette burning tube	20 - 100%	Woodpulp
	currency	50 - 80%	cotton pulp or woodpulp
	lightweight printing & writing	20 - 80%	cotton pulp or woodpulp
	ultra lightweight paper (bible)	50 - 100%	cotton pulp or woodpulp
	writing & book	20 - 60%	cotton pulp or woodpulp
	security paper	50 - 80%	cotton pulp or woodpulp
Hemp, true (bast fiber)	cigarette paper	50 - 100%	woodpulp, bagasse, straw, kenaf bast or jute bast pulp
	condenser paper	20 - 60%	woodpulp, flax or cotton pulp
	currency	50 - 80%	flax, cotton or woodpulp
	lightweight printing & writing	20 - 80	woodpulp, flax or cotton pulp
	security paper	50 - 80%	flax, cotton or woodpulp
Jute (bast fiber)	cigarette paper	30 - 50%	hemp pulp
	printing & writing - woodfree	20 - 80%	Woodpulp
	tag paper	40 - 80%	Woodpulp or bamboo pulp
	wrapping & bag paper	40 - 80%	Woodpulp or bamboo pulp
Kenaf (bast fiber)	bleached paperboard	50 - 100%	woodpulp, bagasse or straw pulp
	cigarette paper	50 - 100%	woodpulp, flax, hemp or abaca pulp
	lightweight specialty papers	50 - 100%	woodpulp, flax, hemp or abaca pulp
	linerboard	50 - 100%	Kraft, bagasse, straw or wastepaper pulp
	multiwall sack	50 - 100%	Kraft, bagasse or straw pulp
	newsprint	20 - 30%	wood, bagasse or kenaf core mechanical pulp
	printing & writing - mechanical	20 - 50%	20 - 40% woodpulp, balance mechanical pulp
	printing & writing - woodfree	20 - 100%	woodpulp, bagasse, straw, reeds or bamboo pulp
	tissue	60 - 90%	woodpulp, bagasse or straw pulp
Kenaf (whole stalk)	bleached paperboard	40 - 50%	Woodpulp
	corrugating medium	50 - 100%	wastepaper
	linerboard	40 - 50%	Kraft pulp and wastepaper pulp
	multiwall sack	20 - 40%	Kraft pulp
	newsprint	80 - 90% (chemimechanical)	Woodpulp
	printing & writing - mechanical	20 - 50% (chemimechanical)	Woodpulp
	printing & writing - woodfree	20 - 80%	Woodpulp
	tissue	50 - 60%	Woodpulp

Phragmites communis reeds	corrugating medium	60 - 90%	wastepaper
	duplex & triplex board	30 - 80%	Woodpulp
	linerboard	50 - 70%	Kraft pulp
	printing & writing - mechanical	20 - 50%	20 - 40% woodpulp, balance mechanical pulp
	printing & writing - woodfree	20 - 90%	Woodpulp
	wrapping - "B" grade	50 - 60%	Kraft pulp
Sisal	currency	20 - 50%	cotton pulp
	filter paper	10 - 80%	cotton pulp or woodpulp
	high-grade book & writing	20 - 100%	abaca, cotton or woodpulp
	high-grade bond & ledger	20 - 100%	abaca, cotton or woodpulp
	lightweight bond & ledger	10 - 80%	abaca, cotton or woodpulp
	nonwovens	10 - 50%	synthetic fiber
	printing & writing - woodfree	20 - 100%	Woodpulp
	publication grades	15 - 20%	10 - 15% woodpulp, balance groundwood
	sausage skins	90 - 100%	abaca or flax pulp
	security paper	20 - 100%	cotton pulp or woodpulp
	tea bags	50 - 80%	abaca or flax pulp
Straw (cereal & rice)	corrugating medium	60 - 90%	wastepaper
	duplex & triplex board	40 - 80%	Woodpulp
	glassine & greaseproof	40 - 90%	sulfite pulp
	printing & writing - woodfree	20 - 90%	Woodpulp
	printing & writing - mechanical	30 - 50%	15 - 30% woodpulp, balance groundwood
	strawboard	80 - 100%	wastepaper
	wrapping paper - "B" grade	50 - 60%	wastepaper and/or woodpulp
Sources:	Source: Hurter 2001 1. Hurter, Robert W., "Agricultural Residues", TAPPI 1997 Nonwood Fibers Short Course. 2. Hurter, A.M., "Utilization of Annual Plants and Agricultural Residues for the Production of Pulp and Paper", Nonwood Plant Fiber Pulping Progress Report #19, TAPPI Press, pp. 49-70. 3. Rangamannar, Goda, "Conventional Paper Grades & Pulp Properties", TAPPI 1997 Nonwood Fibers Short Course.		

We have been making kenaf pulp and paper for 10 years, and know that high quality paper products can be produced using the whole kenaf stalk, and without using chlorine bleaching. David Brower's last book, "Let the Mountains Talk, Let the Rivers Run," was printed by RR Donnelley using 100% kenaf, totally chlorine free Vision Paper. Also, kenaf is big in Japan, where half the paper companies use kenaf in some of the products they produce. The current issue of E Magazine (May/June 2004) covers paper and the articles (pages 25-40) are printed on a kenaf recycled blend paper that I produced.
— Tom Rymsza, President, Vision Paper

In 2004, according to Conservatree's Environmentally Sound Paper Listings, the following non-wood fibers are used in printing and writing papers available in North America:

- Agricultural residues – domestic cotton linters and flax; imported bagasse, banana stalk, coffee beans, seaweed, and tobacco,
- On-purpose crops – Canadian and imported hemp, domestic kenaf,
- Pre- or postconsumer textiles or products – denim, currency, cotton and linen clothing production scraps (a minute amount from organic cotton).

We believe there is also a minute amount of bagasse in a few tissue products.
— Susan Kinsella, Conservatree

Table 8. Overview of Nonwood Fibers Used for Papermaking

Fiber Type		Example	
1. Agricultural residues		Cereal straws	wheat straw rice straw seed flax straw
		Corn stalks	
		Sorghum stalks	
		Cotton stalks	
		Cotton linters	
		Bagasse (residue from sugar cane)	
		Rye seed grass straw	
Nonwoody fiber crops*	2.1. Bast (stem) fibers	Crotalaria (sunn hemp)	
		Textile flax tow and byproducts	
		Jute	
		Kenaf (Hibiscus cannabinus)	
		Ramie	
		True hemp (Cannabis sativa)	
		Old rope or rags made from bast fibers	
	2.2. Leaf fibers	Abaca (manila hemp)	
		Henequen	
		Maguey	
		Sisal	
	2.3. Seed hair fibers	Cotton fiber	
		Cotton rags and textile waste	
3. Natural-growing plants**		Bamboo	
		Esparto grass	
		Elephant grass	
		Reeds	
		Sabai grass	
		Johnson grass	
		Papyrus	

Note:
* Grown for their fibers for paper and/or other uses
** Wild or uncultivated plants
Source: Joseph Atchison and John McGovern, "History of Paper and the Importance of Nonwood Plant Fibers," Secondary Fibers and Nonwood Pulping, Volume 3: Pulp and Manufacture, Third Edition, (Atlanta: Joint Textbook, Committee of the Paper Industry, 1987), p.3, referenced in Paper Task Force, White Paper 13, Non-Wood Fiber Sources, July 1996

From Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources":

Agricultural Residues: Cereal Straw

Overall Assessment: High potential for papermaking

- Large quantities of this additional source of short fiber are currently available.
- Solutions exist for technical challenges in acquiring and pulping straw.

Advantages:

- Good source of short fiber.
- Readily available in large quantities.
- Beneficial use of waste material.
- Fiber acquisition and pulping costs are similar to those for wood.
- Chemical pulping processes do not require sulfur.

Disadvantages:
- Requires a dedicated pulping process with a digester designed to pulp straw.
- High silica and hemicellulose content of straw makes black liquor difficult to recover.
- Must produce pulp at an integrated paper mill because the properties of the straw pulp deteriorate if the pulp is dried before use.

Kenaf (whole-stalk)

Overall Assessment: High potential for papermaking
- High quality, high brightness mechanical pulp for newsprint and uncoated "groundwood" directory grades.
- Environmental and economic performance is competitive with wood for these uses.

Advantages:
- Pulp yield per acre for kenaf-based mechanical pulp is on average about 60% higher than that for plantation Southern pine-based mechanical pulp.
- Total and purchased energy consumed to pulp whole-stalk kenaf is about 35% lower than that consumed to pulp Southern pine.
- Fiber costs are competitive with softwood.
- Capital and operating costs to build and operate a mill that produces mechanical kenaf pulp should be competitive with costs of a wood-based mill.

Disadvantages:
- On average, kenaf requires more fertilizer per acre than trees do; farmers may have to use irrigation to achieve high yields.
- Opportunity to introduce kenaf as a rotational crop is limited to California and southern states.
- Scale-up of fiber production to commercial scale (e.g., harvesting 40,000 acres of kenaf rather than 4,000) may require changes in harvesting practices or genetic engineering of the kenaf plant to facilitate earlier harvesting.
- Kenaf fields can be expected to provide less water quality protection; plant and animal habitat and overall species diversity; and recreational value than do tree plantations.

Kenaf (separated bast and core fibers)

Overall Assessment: Low potential for papermaking
- Separating kenaf bast and core fibers gives papermakers the most flexibility to produce a range of high quality papers.
- Environmental and economic performance indicate that separated kenaf fibers are more appropriate for products other than paper.

Advantages:
- High opacity and bulk allow reduction of basis weight by about 10% to achieve similar performance as wood-based paper.
- Chemical pulping processes do not require sulfur.
- The total energy consumed to produce a ton of kenaf bleached soda pulp was about 34% *lower* than the energy consumed to produce a ton of wood bleached kraft pulp.

Disadvantages:
- Pulp yield per acre for bast fiber as reinforcing pulp or combinations of bast and core for printing and writing paper are the same or lower than the yield for the equivalent woodbased products.
- Kenaf requires more fertilizer per acre than trees do; farmers may have to use irrigation to achieve high yields.
- Kenaf fields can be expected to provide less water quality protection; plant and animal habitat and overall species diversity; and recreational value than do tree plantations.
- Opportunity to introduce kenaf as a rotational crop is limited to California and southern states.
- The additional cost to separate the kenaf fibers makes them uncompetitive with wood for papermaking.
- Existing information about environmental performance of mills that produce kenaf chemical pulp does not demonstrate improved environmental performance for these mills as compared to wood-based kraft mills.
  - The purchased energy consumed to produce the kenaf pulp is at least 50% *higher* than the energy consumed to produce wood pulp.
  - Effluent flow and quality (BOD, COD and TSS loading in final effluent) are similar for both types of mills.

Hemp (separated bast and core fibers)

Overall Assessment: Low potential for papermaking

- Effective pulping processes are in early stages of development.
- Environmental and economic performance indicate that hemp fibers are more appropriate for products other than paper.

Advantages:

- Hemp bast fibers can add significant tensile and tear strength to paper because of their fiber length.
- Hemp could be grown throughout the United States because it is not a tropical plant; however, under current law it is illegal to hemp in United States.

Disadvantages:

- Pulp yield per acre for bast fiber as reinforcing pulp is lower than the yield for the equivalent wood-based products.
- Hemp requires more fertilizer per acre than trees do; farmers may have to use irrigation to achieve high yields.
- Hemp fields can be expected to provide less water quality protection; plant and animal habitat and overall species diversity; and recreational value than do tree plantations.
- Window to harvest hemp for fiber is very narrow.
  - If harvested too early, plants may be immature and yield will be low.
  - If harvested too late, fibers become too coarse to use in paper products.
- Whole-stalk and bast fiber costs are higher for hemp than for kenaf.
- Hemp bast fibers must be cut before pulping to facilitate processing (long fibers tend to get caught in the digester).
- The lignin in hemp bast fiber is difficult to remove using chemical pulping processes.
- Mechanical pulping processes have not been commercialized – only laboratory-scale testing has been conducted.
  - Performance of hemp bast fiber mechanical pulps are similar to softwood bleached chemithermomechanical pulps (BCTMP); performance of whole-stalk mechanical pulps are similar to those from deinked office waste.
  - Performance-to-cost ratio of hemp mechanical pulps is much lower than that of softwood BCTMP or deinked pulp from office waste.

— Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

LISTENING STUDY Question 47: Are there differences in quality or performance for tree free papers?

In general the agricultural fibers are usually about the same length as deciduous wood fibers, but shorter than coniferous wood fibers. Kenaf grown in tropical area will have fiber length of 7 mm or longer. Agricultural fibers will produce a wide variety of papers such as currency paper and calligraphy paper that require long and thin fibers. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

Yes, there are significant differences. — Living Tree Paper Company

Yes, these differences are dictated by each fiber type. Hemp, for example, has much different characteristics than rice straw. — Jeff Lindenthal, President, Green Field Paper Company

Yes. Quality and performance are factors of the raw material and the manufacturing process. Good and poor qualities of paper can be produced from either wood or agriculturally based papers. — Tom Rymsza, President, Vision Paper

Kenaf and hemp core pulps and rice and wheat straw pulps appear to have the lowest strength characteristics – below that of hardwood pulps and far below that of softwood pulps.
— Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

It depends on the appropriate selection of agri-fibers, pulp technology, and papermaking technology.

See for example, my presentations, "Agri-Pulp Newsprint" and "Experience in the Technical and Market Development of Agri-Pulp Printing Papers in North America." — Al Wong, Founder, Arbokem

Yes, there are wide variations in quality. — Jeanne Trombly, Fiber Futures

There are no quality or performance differences between kenaf and wood. — Tom Rymsza, President, Vision Paper

Yes, there are substantial differences in the quality and performance of paper made from agricultural fibers versus wood fibers. Differences are dependent on the type of agricultural fiber used, the relative amount of each fiber used, the grade of the paper being made, and the application of the paper by the consumer. Consumers have historically chosen wood based paper products because of their high quality and relatively low cost. — International Paper

The market and performance will bring this out, but theoretically any agricultural fiber can be made into wood type products.

Re-Vision paper works better in appearance and machinery. But in real markets, cotton based toilet papers are inherently better. Trying to pound-for-pound replace newsprint with [tree free] newsprint or copy paper isn't an advantageous path. We should be making funky filters for Italian cars and other specialty products. — Peter A. Nelson, President, AgroTech Communications, Inc.

Experiences with a product are highly varied. The quality and performance potential is probably dependent on the experience of those trying to use the products.

Another consideration is that nonwood paper producers often are not coming from multi-generational experience. While a copy paper mill had years to perfect the processes to produce precisely what the consumer wants, new mills have to start from scratch with an extended trial-and-error process. Therefore, if the papers don't initially perform as well, it may be due to lack of expertise rather than fundamental flaws.

An overlying concept with these papers is that before we get into the economics and other challenges, we really need to prove that nonwood papers provide a better environmental profile and outcome. Having not shown that, investment is hard to come by. We're hoping that the Listening Study will point to the best opportunities. From there, there can be many opportunities, whether they are public, private, or partnership-based. Ideally we can lay out the science in a sensible way to find small

gaps and decide if it makes sense to continue promoting tree-free papers. At this point, no one in particular wants to assume that trees are bad, nor should we make such assumptions. It is not clear that agricultural fiber is necessarily better than an equivalent acre of trees. It may not be a "one or another" thing. Trees might be ideal for certain products and places whereas agricultural fibers might be better in other mixes. — Russell Clark, Environmentally Preferable Purchasing Program, US EPA

Clearly there are very significant differences between nonwood fibers that might be used to make paper. But of the nonwood papers that have actually been brought to market in the U.S., including some using agricultural residues and others using on-purpose crop fibers, we have heard of no problems from paper purchasers. By the time they get that far, the producers seem to have worked out enough technical problems that the papers themselves are high quality. — Susan Kinsella, Conservatree

Hemp received a favorable initial rating in the USDA study. Hemp and Kenaf are not related, but they do have similar characteristics. Unfortunately, it is illegal to grow hemp in the US, and the yields per acre indicate a high cost of raw material which is not competitive with wood fiber. Additionally the strong bast fibers are dramatically different than wood fibers, and they require additional processing to prepare a pulp suitable for commercial type papers.

Agricultural residue is a broad term, but in the context of pulp and paper, it usually means corn stalks and various hays, primarily wheat straw and rice straw (but could include other straws from grains). Since pulp and paper making requires homogenous material to produce consistent results the mixing of different types of agricultural residue is not indicated.

Additionally corn stalks and straws contain a high level of silica, which has significantly negative implications for chemical recovery and environmental compliance at a pulp mill. While novel processes have been proposed to alleviate the silica problem, none are commercially proven or in current operation.

Corn stalks are the most abundant agricultural residue material available, and there has been some historic use as a raw material in pulping, albeit, limited. Corn stalks produce a low pulp yield. For every one ton of pulp, you get two tons of waste material which contains a high amount of silica. The short weak fibers will probably be detrimental to recycling.

Straws are another abundantly available raw material, and they have a more extensive history of use in the industry, with the last straw pulp mill in the US ceasing operations in 1960. Wheat or Rice Straws contain short, weak fibers, a high level of silica and, like corn, will not recycle well.

Flax and **cotton** are mature on-purpose crops that have historic use in pulp and paper, especially specialty grades. They both yield long fibers, (much longer than wood fibers) and both carry a very high raw material cost when compared to wood.

Both **bamboo** and **arundo donax** were considered in the USDA study, and both plants have received recent attention in the nonwoods sector. Both plants are perennials (grasses- multi-years to harvest) and not conducive to farming that is based upon annual row crops. They both have a physical structure that is suitable for chipping, which produces a wood-like raw material for the pulp mill in-feed. Both plants produce high yields per acre, and a pulp similar to hardwood pulps.

Bamboo pulp is produced in Asia, and it should be noted that bamboo forests provide the sole food source for the Panda Bear, which is an endangered species.

Arundo Donax grows in the wild in California and can be propagated elsewhere. It is sometimes call "giant reed" and it is used to made reeds for wood-wind instruments. It is considered a highly invasive toxic pest in California, where efforts exist to eradicate it.

Bagasse (sugar cane) fiber is a by-product of sugar production. It is a hardwood-like fiber that has historically and currently been used for common paper products in areas where a sugar cane industry exists. After the sugar is extracted, burning the leftover bagasse fibers for energy value or pulping for paper are two uses for this process residue, and both uses are common. Bagasse has a lower silica content than corn stalks or straws. — Tom Rymsza, President, Vision Paper

Kenaf is one of the best alternatives because it is a "New Crop" and that is really good for sustainable agriculture. The Search for New Fiber Crops program selected it as the most viable plant to replace trees in paper making. That search program also identified crotalaria and roselle as high potential.

Kenaf was chosen because its outer bast fiber was similar to softwoods, and its inner core is similar to hardwoods. The whole kenaf stalk can be used to make high quality paper. Kenaf has a low lignin content, so the chemistry needed to convert it to pulp is less than that used for trees. Kenaf produces a pulping yield of 50% or more, using less energy, making it an efficient raw material. It does

not contain silica, so it is suitable for existing well known and well proven chemical systems, and can be processed without producing additional environmental liability. Kenaf's raw material cost is competitive to wood fiber, and it is a very environmentally sound crop, requiring lower chemical use than most other crops.

It is a fast growing plant, growing from seed, planted in the spring, to a height of 12-18 feet tall in about 5 months. In studies in cooperation with the University of Tennessee using no-till agriculture, we have demonstrated that it can be economically grown using lower chemical inputs than other crops in that region, particularly cotton.

It produces about six tons of fiber in this time period, and that is two or three times the fiber produced by trees in a forest in a twelve month period. That high level of fiber production means it is absorbing CO2 and sequestering the carbon faster than a forest.

— Tom Rymsza, President, Vision Paper

LISTENING STUDY Question 48: What causes the price differences and what could reduce them?

LISTENING STUDY: Respondents understood this question differently, depending on their expertise and place of focus in the production process, which in turn gives us a view from many different points in the system. As Michael Jackson, a noted nonwood fiber expert, points out, there are a number of ways to interpret this question. Some looked at the question overall, others commented on price differences relating to sourcing the fiber, producing the pulp, and buying finished paper.

General Overview

Not sure the exact question here. Price of raw material as delivered to the pulp mill? Price of fiber ready to be made into paper? Price of paper? — Michael Jackson, Consultant, Tolovana Park, OR

Economy of scale, scaling up production and linking it to demand will reduce costs. — Jeff Lindenthal, President, Green Field Paper Company

The most significant factor is the lack of infrastructure for the use of agricultural fibers and the production of agricultural fiber pulps. — Living Tree Paper Company

In a frontier capitalistic society, there is no relationship between cost of production and selling price of paper. Corporations are driven by only one goal: make as much money as possible, by whatever means. There is no common-wealth morality in a free market economy.

See for example, my presentations, "Some problems of technology development for the small innovators," "Saving British Columbia," and "The Cooperative Commonwealth Federation - the time has come again." — Al Wong, Founder, Arbokem

One hundred forty years of practice making paper from trees. Trees have become very efficient sources of papermaking fiber the way the industry is constructed. Tradition is a major holdup. Since just after the Civil War, paper has been made from trees. Every piece of papermaking machinery has been designed for trees. You can't just dump a bale of kenaf into a pulper, because the pulper was designed specifically for trees. The tree paper industry has built economies of scale from research to distribution.

On the other hand, how much is spent on ag-fiber paper research in the last couple of years? Pretty close to $0 has been spent for kenaf, hemp, bagasse, sisal, jute, straw, flax, you name it. Meanwhile, millions are spent each year to develop higher-yielding, shorter-rotation tree-crops. We're really just starting to figure out how to get ag fibers grown and processed efficiently. The holdup is not just lack of sufficient research. Research will help, but there are other critical steps.

The second cause is consumer demand. We've seen this with recycled in our lifetimes. Cost has gone down dramatically since the 70s. They created a system over a period of time that has made these fibers efficient to make into paper. It did not happen all at once or overnight. It was a combination of environmental awareness, government action, landfills closing, deinking technologies — the creation of a new infrastructure and creation of economies of scale over time. The same needs to happen with tree-free fibers.

Consumer demand will be a big driver for this market — if someone can make it at a profit, the industry will go out of their way to make processes more efficient. More folks are working on planting, growing, harvesting, transporting for board products. That's good. If those industries can figure out these issues of efficiency such as bringing the raw materials to a manufacturing process at a profit, then that experience can be translated to other manufacturing processes, such as papermaking.

Other industries are helping do the work — molded car parts, biomass energy, wallboard, they are all working on infrastructure that will help pulp and paper. — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

Sourcing Fiber

Historically, wood fibers were used in the US and Europe and the pulp and paper industry invested so much money in the wood pulping industry. The general consensus is that wood fiber will remain as the main source of paper and the share of nonwood sources will grow gradually. India and China use more nonwood source fibers simply because wood fibers are not available for them.

There remains the three main problems with agricultural fiber pulping in general: (1) agricultural fibers have seasonal supply, (2) the agricultural fibers have low density and transportation cost is high (compacting technology is there but still needs energy to compact them) and need more pulping liquid, (3) agricultural fibers will degrade during storage (wood chips are piled in pulping mills and some will degrade but not as much as agricultural fibers).

A perfect scenario would be establishment of small pulp mills at the heart of the wheat belt, corn belt, etc., compact the straw and send it to the mills, then pulp during the off-season, hiring the farmers. Pulps can then be shipped to the paper mills. Thus, combine farming and pulping. It is no different than sending grains to the mills to be processed as flour. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

Annual agricultural crops are more energy intensive than sustainably managed forests. Much of the additional raw material cost stems from the additional work and energy required to deliver the material. In addition, it is necessary to invest additional money in facilities to convert them to produce paper made from agricultural fibers. Reducing the cost of agricultural fiber crops would not eliminate the fundamental biodiversity and energy use problems associated with these crops. — International Paper

If Arundo donax production is done on a large-scale, the price would be less. We wouldn't want to crash the wood markets. We were at a meeting of wood people and pulp and paper. When we said the price would actually be lower, the industry members told us to be quiet, they'd rather keep the price high. We would need 15-25 thousand acres of the Arundo donax in plantations for the price to even out or become less than wood pulp. With that, we could supply two mills a day with their production requirements of raw material. That's our goal: to plant 100,000 acres by June 2003. This raw material would go to Samoa and others. Some of it would supply the chips required for panel boards. However, the pulp and paper market would be larger.

On the Hellsburg farm, the Arundo donax is like people and animals. We put 4-6 ft rows in one day and 90-120 days later the rows disappear. However, they have never encroached the vineyards. It is harvested with a modified piece of a rice cutter/harvester. The cane is collected with a grapple. With this harvesting method, it costs $9/ton compared to $95/ton for tree harvesting. — Ernett Altherimer, Founder and Chairman, Nile Fiber

From our experience with the recycled paper industry, the price difference is mostly economies of scale. The delivery costs should be highlighted; often these costs make or break the product. Transportation costs can be worked out though; it might make more sense to ship the fiber on a train across the nation rather than shipping it a few states on trucks. — Russell Clark, Environmentally Preferable Purchasing Program, US EPA

The Recycled Products Purchasing Cooperative has only been around three years [in 2002]. We're trying to overcome the price barriers to buying recycled. At this point, we are not purchasing tree-free and alternative fiber papers as the cost isn't competitive. These industries can't get close to virgin fiber prices because the economies of scale aren't there. We do intend to move into the tree-free industry and push suppliers, but it's a bit down the road.

There should be more public funding for R&D to develop new hybrids and varieties that are resistant to pests. Cooperative extensions would be good entities to accomplish such research. Additionally, cooperatives that pool fiber producers together to reduce transportation and production costs would be ideal. There should also be government participation in the fiber production. The government could use public lands to set cheap rates or grow it themselves.

The industry should identify the potential users to determine their price point and what preference they would give to alternative fibers, if any. Then they should balance the demand against the costs of production to see how much the price can be pushed down.

The collection infrastructure should be targeted. The industry could reduce the overall costs of getting pulp to industry by developing regional collection programs to get high volumes shipped. With this model, the pulp purchasers can reduce their fiber unit costs.

Promoters would also need to target producers to show that there would be a demand for tree-free papers. With demand numbers they could get the "big four" to invest in capital equipment and conversion costs. — Tyson Miller, Program Director, Recycled Products Purchasing Cooperative

For kenaf and hemp, the greatest price barrier is the cost for separation of the bast and core fibers. For applications where whole-stalk kenaf can be used, we didn't find significant differences in acquiring the fiber compared to wood. The cost of acquiring separated hemp is even higher than kenaf because hemp has lower bast fiber content and lower quality core fibers, so you have to separate more hemp to get the same quantity of fiber.

The capital costs for a soda process kenaf mill should be on par with a kraft mill for wood. The minimum scale for a kenaf mill, around 300 tons / day is much smaller than a typical kraft mill. A smaller mill has certain advantages; for example, as it wouldn't need to draw on such a large supply area to be economically viable. Kraft mills need to be at least 500 tons / day. If the mill is integrated (using its own pulp to make paper), it will be far more economically efficient.

Operating costs: Our study suggests higher operating costs for chemically separated kenaf than for soft or hardwood. Compared with softwood chemical pulping, kenaf would have 15% higher operating costs. Compared with hardwoods, kenaf would be 50% higher. The cost difference is primarily due to labor and energy for separating the fibers. We would expect the cost for whole-stalk kenaf pulping to be comparable to wood because you wouldn't have to pay labor and energy costs for separation.

For agricultural residues, the overall costs, both capital and operational, would be similar to wood. The limiting factor is the availability of a reliable supply. If the plant is located within a large straw supply area, it is far more economical. — Richard Denison, Ph D, Senior Scientist, Environmental Defense

Price differences are a result of:
1) economies of scale,
2) raw material costs and pulping yield,
3) supply and demand market dynamics.

— Tom Rymsza, President, Vision Paper

Pulping Fibers

The added expense associated with some tree-free pulp and paper is mostly due to small volume production and raw material costs. Large tree-based pulp and paper companies get premium pricing because they are producing large volumes and using an inexpensive raw material. Increases in demand of tree-free papers will allow companies to produce larger volumes at once. The other necessary component is a dedicated pulp mill that can recognize efficiencies through large, consistent volume production. — Tom Rymsza, President, Vision Paper

The price of raw material wood chips is maintained artificially low because of many resource tax breaks and other give-aways of public agencies that own large swaths of forestland, not only in North America but all over the world. Only when wood increases in price do the paper companies get interested in non-woods.

In the mid-1990s Weyerhaeuser built a straw pulping line at its Springfield boxboard plant partly due to the tremendous price spike in 1994 when the cost of wood nearly doubled in one year, erasing their margins. Ditto for the Jefferson Smurfit interest in a test run of non-wood pulp that was arranged with the mill in 1997. But the interest of these companies was not sustained because the cost of wood went back down.

One of the biggest factors in the costs of non-woods is the price of pollution control technologies to recover the pulping chemicals. The wood pulping chemical recovery systems have not worked for non-woods and new inventions have been introduced, but the entrepreneurs providing lab-scale alternatives have not been able to raise the capital needed to get these new technologies into pilot scale.

Yet this may change as one major development is about to break due to the demand for non-wood pulping in China. — Jeanne Trombly, Fiber Futures

Financing was initially a major problem. Nile Fiber had to prove concepts all the way because no one had ever done it before. Investors were hesitant after trying wheat straw, rice straw, and other fibers, which haven't proven to be commercially applicable because they required too many process and equipment changes. After more than 3 years Nile Fiber proved you do not have to do that for Arundo donax. Most of the initial funding has been out of pocket, but now there is a lot of interest.

The first run at Samoa Pacific was about 200 tons of Arundo. Because the beginning and end are mixed with wood, there was probably about 100 tons of pure Arundo. They will run another 40 tons early Sept.

The Arundo donax economics work out very well. Cost that Asian companies are paying for contaminated pulp with silica are very high and these will be much lower with a higher quality product.
— Ernett Altherimer, Founder and Chairman, Nile Fiber

Finished Paper Prices

The current prices for tree free papers may be up to twice the cost of tree based paper. — Green Seal, Choose Green Report: Alternative Fiber Papers

Price differences, in this question, apparently refer to the difference in cost for a nonwood typing paper and a competing tree-based typing paper. The question here seems to be "how do we make sure our typing paper is produced sustainably with minimal impacts?" not what will it be made of.

Kenaf makes a great archive paper — it is long-lasting and has low acidity. Nonwoods are ideal for advanced filters, diapers, bandage products, currency papers, hygiene products, non-wovens — everything from weird composites to feedstocks for cellulose products.

Without higher volume, tree-free papers will naturally be higher priced. Inherently they don't have to be. — Peter A. Nelson, President, AgroTech Communications, Inc.

To date, most of the printing and writing papers in the U.S. and Canada that include nonwood fiber have been text and cover grades. This makes sense, as text and cover papers, despite making up only a very small percentage of the paper market, are produced and priced in a way that allows short production runs, individualized papers, and larger profit margins than in other parts of the industry. Since nonwood papers generally cost quite a bit more than virgin forest fiber papers, often up to 50% more, it makes market sense to place them in competition with the most expensive papers, cotton fiber (which also happen to qualify as nonwood papers).

The nonwood fiber papers that compete in more unforgiving markets, such as coated, copy and offset papers, generally (and ironically) bring their price down by incorporating some recycled content. Almost all nonwood fiber papers usually include recycled content also because they are appealing to environmentally conscious paper consumers, many of whom are looking for recycled paper.

As with recycled papers, which have been significantly reducing or eliminating price differentials by developing larger market shares and more mature production systems, we expect that nonwood papers will improve their pricing as more stable and larger-scale nonwood sourcing and production systems are developed.
— Susan Kinsella, Conservatree

LISTENING STUDY Question 49: Are there limits on making tree free pulps into paper on certain machines?

Yes

We would certainly expect so, depending on the design of the machine and the nature of the agricultural fiber. — International Paper

Yes. Every paper machine has its own specific characteristics. — Living Tree Paper Company

Once again, this is not an issue of replacing wood fiber directly with agricultural fibers. So no, the current wood infrastructure is not suitable (without modifications) for materials that are lower in density, have different structures, etc. There are also some problems (ie: silica in rice straw) that causes problems for machinery.

On a limited scale, some perennials such as Arundo donax and bagasse can run through existing machinery. This proposal is a good ideal. For these fibers, the harvesting is the biggest problem — it's hard to know how much it will cost. — Peter A. Nelson, President, AgroTech Communications, Inc.

No

There are no fundamental barriers. There are numerous ways to make paper, even starting from the selection of a single type of papermaking fiber.

See for example, my article, "Using crop residues to save forests." — Al Wong, Founder, Arbokem

There are differences in moisture level settings that have to occur in high speed papermaking machines – other than this, a pulp is a pulp. **—** Jeanne Trombly, Fiber Futures

We have successfully run various kenaf pulps on many paper machines at seven different mills. Proper pulp preparation is essential to success, and is easy to achieve with experience and appropriate processing equipment. **—** Tom Rymsza, President, Vision Paper

No. — Ernett Altherimer, Founder and Chairman, Nile Fiber

It Is Possible If Adjustments Are Made

Once the fibers turn into pulp, the machines cannot tell the difference between wood pulp and nonwood pulp. Most of the problem is in pulping and not in paper making. One of the general problems with agricultural fibers is high silica content and, according to the pulp and paper industry, the nonwood fibers are hard on machines. However, most of fibers will have impurities and thus undesirable characteristics. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

In a system that works primarily with tree fiber, there are no special considerations if the tree-free fiber has the same technical characteristics as the wood fibers that were being used. All machines do have limits depending on their primary use and product. A machine producing a hardwood (short fiber) specialty sheet may have to use refined bast fiber (long) to perform create the desired characteristics.
— Tom Rymsza, President, Vision Paper

The issue of "sodium chemistry" has already been addressed. The problems of silica in agri-fibers and long-length bast fibers can be overcome by pre-designing the pulping and papermaking facilities appropriately.

See for example, my presentations, "New Direction in Industry Development and Environmental Protection for Nonwood Pulp Mills in Developing Countries," "Agri-Pulp Development in Alberta," and

"Opportunities and limitations of using California rice straw for industrial products." — Al Wong, Founder, Arbokem

Generally plant fibers have lower drainage, water separates more slowly from them than with wood fibers. This can make it necessary to run the paper machine more slowly, reducing the production rate and productivity and increasing costs. Proper design or redesign of the machine can mostly correct this but there is an economic penalty. — Michael Jackson, Consultant, Tolovana Park, OR

For various reasons, wheat straw appears to be most appropriately used in combination with other fibers. Because of its short fibers, wheat straw makes weak paper that drains slowly. However, in combination with long-fiber pulps, these shortcomings can be alleviated.
— Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

For the most part, nonwood raw materials contain higher amounts of silica than wood. During pulping, the silica is dissolved and enters the black liquor. High silica content in the black liquor results in various problems in the chemical recovery loop including:
a) increased black liquor viscosity at high solids concentrations
b) hard scales in the evaporator and hard deposits at various points in the recovery boiler
c) formation of colloidal gels in the recausticizing system that lower the settling rate
d) formation of glassy material in lime kilns
e) reduced slaking rate
With proper design throughout the pulp mill, all of the above problems can be addressed for most nonwood raw materials with the exception of rice straw which has an exceptionally high silica content. — Hurter 1998

LISTENING STUDY Question 50: Are there performance problems with certain equipment?

Only if the fibers are too long or too short. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

Performance problems would be expected. Where such problems arise, equipment modifications or replacements would be required. Confidence in the size and sustainability of market demand for such fiber would be necessary to justify the financial commitment. — International Paper

The performance problems are potentially serious depending on the type of fiber and the degree to which the fiber is refined. — Living Tree Paper Company

On some runs at the Ecusta Mill, there was too much dirt in the kenaf and flax mix. However, newer harvesting and disking methods, similar to corn harvesting, are used that solve this problem. Once the kenaf is past the digester, it runs just like wood pulp. — Tom Rymsza, President, Vision Paper

Again, there is so much variation in the quality of the non-woods, if a poor quality pulp is produced than of course there will be performance problems. If a high quality non-wood pulp is produced, there will not be performance problems. — Jeanne Trombly, Fiber Futures

These have mostly been noted above: Raw material handling equipment needs to be specially designed for plant fibers, pulping digesters also need to be specially designed for plant fibers, all stages where water is drained from the pulp fibers need to be adjusted to the slower drainage. The high speed modern paper machines are probably more difficult to adjust to accept nonwood fibers. — Michael Jackson, Consultant, Tolovana Park, OR

A fiber that has poor papermaking qualities can affect everything from drainage to printability and recyclability. A fiber such as kenaf will have no problems on any equipment. — Tom Rymsza, President, Vision Paper

Arundo donax goes through the machines just like wood. However, it absorbs the chemicals better and faster than wood because of the spores in the end. So, the fibers break down faster, leading to a faster processing time. — Ernett Altherimer, Founder and Chairman, Nile Fiber

We haven't heard any from the printing side. — Tyson Miller, Program Director, Recycled Products Purchasing Cooperative

The whole kenaf stalk has a low lignin content (11-13%) and is easily pulped by either the Kraft process of soda, with or without anthraquinone additive. Good reduction in kappa to bleachable ranges (20-25) was obtained at high yields (48-49%). — Jackson 1997

Both [wheat straw and rice straw] have a high silica content, with that of rice straw being about double that of wheat straw — and so contributing to nonwood chemical recovery problems. Thus, in Canadian wheat straw of 6-11% ash content, at least 60% is silica (distributed in the stem as small bodies called phytoliths), and 10-20% is potassium (another undesirable non-process element). [Watson, P.A. and Bicho, P.A. 1998]

The new Cellpaille mill, in France, is using a Saica digester and soda cook, with spent liquor recovery/treatment by the LPS Process (Granit). The spent black liquor is acidified to pH 2.5-3 to precipitate the lignin, which is then processed, washed, dried and sold for uses similar to those for lignosulfonates (although it is sulfur-free). The resulting filtrate is treated by wet air oxidation (SRS Process; sodium recovery system), with oxgyen being utilized rather than air. Wheat straw has a slower drainage and higher content of nonfibrous cells, which may slow down paper machines and necessitate the use of special washers in the processing lines. Due to high hemicelluloses (aids in swelling of fibers), may aid in water retention. — Jacobs 1997

LISTENING STUDY Question 51: Are there enough tree free fibers to produce adequate amounts of paper?

On Estimating Supply and Overall Quantity

My understanding is that there is plenty of ag fiber to utilize. — Jeff Lindenthal, President, Green Field Paper Company

Using the vast amounts of agricultural residues available in the world today would be a significant step in the right direction toward wood replacement in pulp and paper. **—** Living Tree Paper Company

LISTENING STUDY: Note that no updates have been made to availability estimates since 1998. It is recommended to note the date on the following estimates and use them as relative comparisons, rather than actual quantity estimates.

Table 9. Estimated Global Availability of Nonwood Fibers

Raw material /Bone dry million metric tons	World Availability Estimate 1 (Atchison 1995)	World Availability Estimate 2 (McCloskey 1995)	World Availability (EU Innovation Project)	USA availability (Atchison 1998/paperloop Nonwood Raw Materials)
Wheat straw	600,000	739,700	709,000	76,000
Rice straw	360,000	465,200	673,000	3,000
Barley straw	195,000	218,500		7,000
Oat straw	55,000	50,800		5,000
Rye straw	40,000	41,900		400
Grass seed straw	3,000	-		1,100
Flax (oilseed)	2,000	-		500
Corn stalks	750,000	727,300		150,000
Sorghum stalks	252,000	104,700		28,000
Sugarcane bagasse	102,200	100,200		4,400
Cotton stalks	68,000	35,900		4,600
Leaf fibers (Sisal, Hennequen, Maguay)	500	-		
Reeds	30,000	-		
Bamboo	30,000	-		
Cotton staple	18,300	18,000		3,500
Stem fibers (Kenaf, Jute, etc.)	13,700	-		
Papyrus	5,000	-		
Cotton linters	2,700	2,300		500
Esparto grass	500	-		
Sabai grass	200	-		
Hemp fibers	200	-		
Abaca	80	-		
Cotton mote	-	900		
Total	**2,528,380**	**2,505,400**		**284,000**

In China, some 200 million tons of non-wood fibers are available; globally there are 100 million tons of dry banana stalk available for papermaking; the tonnage of cereal straw ag-residue in Canada and the US is also staggeringly high, as well as sugar cane in Latin America.

Compare this raw material availability to the total global output for pulp / paper, which is in the range of 300 million tons per year.

On simply a per tonnage basis, yes, there are adequate non-woods for papermaking. On a practical basis, it would take an enormous manufacturing shift to incorporate even a 30% blend of non-woods into the global papermaking production stream. — Jeanne Trombly, Fiber Futures

Table 10. Estimated Wheat and Rice Straw Availability (EU Innovation Project)

Continent	Country	Wheat Straw residues (in million metric tons)	Rice Straw residues (in million metric tons)
Europe			
	France	47.8	
	Russia	32.3	
	Germany	23.8	
Asia			
	China	132.0	231.5
	India	79.2	146.6
	Turkey	25.2	55.5
	indonesia		
Africa			
	Egypt	7.4	6.6
America			
	USA	83.3	9.8
	Canada	29.3	
	Argentina	12.1	
Oceania			
	Australia	26.1	1.6
World		709.2	673.3

FF source: EU Innovation Project
Original Source: Mantanis, G. (1999). Worldwide availability of agriwaste. MARLIT Ltd. Greece (unpublished data).
Second FF source: (paperloop Nonwood Raw Materials) Original Source: Atchison, j.e. progress in the global use of nonwood fibers nd prospects for their greater use in the future. Inpaper international, Apr-Jun 1998, pg. 21
Third FF source: Paper Task Force 1996 Nonwood fiber Sources (cites his 1994 estimates)

There are lots of residues out there, but how much is enough? With current demand there are too many residues. If IP wanted to switch today from tree fiber to entirely ag residue, there probably isn't enough. — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

If just 5% of US corn and soy acreage was planted to kenaf, prices for those crops would stabilize, with no net loss to the farmer, since they would be paid a competitive price for the kenaf, without any subsidy. The resulting 7.5 million acres of kenaf could supply more than 1/3 of all U.S. virgin pulp needs. — Tom Rymsza, President, Vision Paper

No, consider the effect on the landscape if all wood fiber was replaced with hemp or kenaf. To grow enough alternative fiber to make up the difference, you would quickly absorb all the remaining available agricultural land in the United States and at least some of what is currently forested. On the other hand, the U.S. forest industry regenerates every acre that it harvests and is adding new forests on land that was once in agriculture. — International Paper

We could figure that out by taking the current acreage of trees and figuring out their yield per acre to get the total yield. Then we could find out how much kenaf is made and see if it is enough. — Russell Clark, Environmentally Preferable Purchasing Program, US EPA

Table 11. Inventory of U.S. Straw

(Fiber Source Potential Quantity, dry tons)

	ILSR[1]	Atchison[2]	USDA, Ag Stat[3]
Wheat	112,700,000	76,000,000	78,900,000
Barley	20,800,000	7,000,000	12,000,000
Sorghum	13,500,000	28,000,000	33,700,000
Oat	10,700,000	5,000,000	6,000,000
Rice	7,400,000	3,000,000	7,500,000
Cotton	5,100,000	4,600,000	7,100,000
Flax (seed)	4,500,000	500,000	700,000
Rye	1,500,000	400,000	400,000
Grass (seed)	1,200,000	1,100,000	900,000
TOTALS	**177,400,000**	**125,600,000**	**147,200,000**

[1] Institute for Local Self-Reliance 1997

[2] Atchison 1994

[3] USDA, Agricultural Statistics 1993 and USDA, Economic Research Service 1997

Three different estimations can be suggested [see Table 9 above]. ranging from 177, 147 and 125 million tons. If we take the smallest number of 125 million tons, a modest 30% yield will give us 38 million tons which is slightly less than 50% of paper and paperboard consumption in 2000 in the US. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

Demand will control supply. If the demand exists, the volume of fiber produced can be increased in one year. Kenaf produces 3-5 times more fiber per acre per year than trees. Bales of kenaf fiber can be held on hand in the field for years until it is needed, allowing any excess demand to be satisfied quickly. — Tom Rymsza, President, Vision Paper

All of the wheat straw in the U.S. would produce about 25 million tonnes of hardwood substitute pulp assuming a 33% yield to account for storage, preparation, pulping and bleaching losses. — Hurter 1998

There may be out-of-date data in the white paper. I expect the supply has changed. — Richard Denison, Ph.D., Senior Scientist, Environmental Defense

Supply for ag residues is a regional issue: A mill in Maine might want to use rice straw. It doesn't matter if there are millions of tons in California, the cost of transportation might mean that there is effectively no supply for that mill in Maine. I don't see any new pulping mills on the horizon, although that certainly could change. What you already have in terms of processing facilities is what you have to work with unless the demand scenario changes. — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

On Estimating Practical Availability for Pulping

In theory yes [there is enough tree free fibers to produce adequate amounts of paper], in practicality no. The fiber supply should be diversified factoring in many sources (trees, herbaceous, annuals, residues, waste and recycled pulp). Computer paper is apparently the high profile target; however there are thousands of other papers in which significant headway is moving towards nonwoods (i.e.: diapers, female products, bandages, advanced filters, currency paper, etc.).

If we add up how much crop residue is grown around the world — of course, there is enough residue. However, it is hard to know when to stop counting — in theory, we could pulp tree clippings from town, but the land management, collection, and transportation is complicated. Pound for pound, hauling trees is generally far more efficient than hauling baled hay. In practicality, all the existing residue cannot and should not be harvested. — Peter A. Nelson, President, AgroTech Communications, Inc.

There certainly is plenty of wheat straw for pulp production in the US and Canada. One problem is that most wheat production areas are remote from existing pulp mills and from good water sources for the pulping operation, especially in Canada.

As you well know, corn stalks have been proposed as a fiber source and there is a huge amount of them available. As to the dedicated crop fibers, there has to be a build up period where the agricultural production is developed. This can take several to many years. There is also a chicken and egg problem. No mill — why grow it? No material growing — why build a mill? The acreage required to supply an economically-sized mill is considerable and has to be part of the overall plan for a new facility.

Just think of all the effort than has gone into developing the collection, processing and use of recycled fibers. A similar effort and capital investment would have to go into systems for agricultural fiber use. — Michael Jackson, Consultant, Tolovana Park, OR

Allocation of sufficient arable land to supply a mega-pulp mill with on-purpose agri-fibers or agri-cropping residues is problematic. A different industry development model is needed. See, for example, my presentations, "The Agri-Pulp Alternative," "Economic and environmental impact of using wheat straw for the co-production of paper and energy in Canada," and "Economic Opportunity in the Use of Wheat Straw in North Dakota for the Co-Manufacture of Paper and Energy."

The societal priority in the use of a large amount of agricultural land is an issue, at a given target scale of operation. See, for example, my presentations, "Technical and Economic Obstacles Affecting the Early Commercialization of Kenaf Pulp Manufacture" and "Socio-Economic and Technical Issues of On-Purpose Fiber Cropping and Food Cropping." — Al Wong, Founder, Arbokem

The only current hold-back is the supply [of Arundo donax]. That's why we're rushing to get plantations in line. This gives farmers a faster return and makes lazy farmers because they don't have to replant every year like with kenaf, sugar cane, and other crops. Currently there is a plantation in Ventura Valley, Hillsburg in Northern CA, a small plantation in Alabama. Beginning in Sept. there will be a small plantation in AZ and one in Lancaster, CA. Arundo donax grows approximately within the 40's (longitude) — in the colder areas: from southern Delaware up to Oregon, and along the South. — Ernett Altherimer, Founder and Chairman, Nile Fiber

We heard that complaint more for post-consumer waste — there is not enough demand or infrastructure yet for tree-free papers to exceed demand. — Tyson Miller, Program Director, Recycled Products Purchasing Cooperative

LISTENING STUDY Question 52: Can tree free papers be recycled?

Yes, agricultural fibers can be recycled. As fibers are recycled the fibers get shorter. One of the advantages in agricultural fibers is that they have various lengths. Jute and Kenaf have lengths as long as 7 mm. The quality of paper can be tailored accordingly by using long or short fibers. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

Yes, agricultural fibers can generally be recycled, but any recycled fiber is subject to degradation after consecutive cycles. The ultimate viability of recycled agricultural fibers will be determined by the products made from these fibers, and the demand for these papers in the market. — International Paper

Any cellulose fiber can be recycled. The shorter the fiber gets, the less value it has in the process. — Jeff Lindenthal, President, Green Field Paper Company

Yes. — Jeanne Trombly, Fiber Futures

Yes. The degree to which they can be recycled depends on the fiber. 100 percent flax or hemp or other long bast fibers can probably be recycled three times as much as wood. Cereal straw residues are short fibers and cannot be recycled as many times. — Living Tree Paper Company

Yes, but even most poor papermaking fibers can make it through the recycling process when the makeup of tree-free fibers is a small percentage of the furnish. If one intends to expand the use of tree-free fibers out of a specialty market, the fiber must efficiently mix with tree-fibers. Fibers that are too long or too short can interfere with draining and may have a short lifespan. A strong papermaking fiber such as kenaf can be recycled at least as well as tree fibers. — Tom Rymsza, President, Vision Paper

Of course, it can be recycled.

See, for example, my presentation, "Experience in the Technical and Market Development of Agri-Pulp Printing Papers in North America." — Al Wong, Founder, Arbokem

Yes, there are no barriers. Ag-fiber papers have longer, stronger, and tougher fibers than most tree fibers, so they generally enhance the recycled fiber supply. — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

Tree-free papers should be able to be recycled several times. Given the current technology, the nonwood fibers would not actually be longer in a real-world setting. Therefore, they don't give any advantage when mixed into the recycled paper slurry.

When processed for specific purposes, the nonwoods can have much longer fibers, which is why they are stronger than comparable wood fibers. Technically, they do well for being thin because of the longer fibers, hence they are used in cigarette filters, tea bags, etc. To say that nonwood fibers add strength to recycled papers is unproven and would require scientific study. — Jeff Mendelson, President, New Leaf Paper

Most nonwood fibers are thinner than wood fibers and more fragile to mechanical treatment. Deinking during recycling involves fairly strong mechanical action. Therefore there is some worry and some evidence that nonwood fibers would break down more than wood fibers during the recycling process.

Yes, they can be recycled but the recovered yield will be lower than for wood fibers. — Michael Jackson, Consultant, Tolovana Park, OR

Yes, agricultural fibers can be recycled. In fact a good market opportunity for long, agricultural fibers is to help extend the amount of times pulp can be recycled, by offering strength.

There should be no problem in recycling nonwoods. All papers have a given life-span, or number of times they can be recycled. The nonwood paper life span should be on par with virgin pulp papers. — Peter A. Nelson, President, AgroTech Communications, Inc.

One of the optimal mixes is a blended recycled paper and Arundo donax. — Ernett Altherimer, Founder and Chairman, Nile Fiber

Preliminary studies have examined the effects of pulping and recycling on kenaf. It has been shown that most nonwoods have a lower lignin content than wood and that it is easier to delignify nonwoods, as they have a lower activation energy. There have also been investigations into the changes suffered by fibers during the recycling of wheat straw pulps. The results of this work implied that wheat straw pulp did not behave differently from wood pulp during recycling. — Pande 1998

The biggest issues might be color — when recyclers want post-consumer waste, they want white paper. They might not want the nonwood papers if they are not as bright. — Russell Clark, Environmentally Preferable Purchasing Program. US EPA

We would like to see more information on this topic. Post consumer waste should be able to be used about 7x before it is not usable. We would like to know the lifetime of the nonwood papers. Also, we'd like to know if alternative fibers can satisfy the requirements for virgin pulp in the recycling industry.
— Tyson Miller, Program Director, Recycled Products Purchasing Cooperative

The industry has very limited experience with this question. Our evaluation found no difference on recyclability. We would expect similar characteristics as with wood fibers — recycling them results in shorter fiber length (the repulping causes breakage and shortening).
— Richard Denison, Ph.D., Senior Scientist, Environmental Defense

Recycling of nonwoods fibers: In considering the impact of alternative fibers on the global fiber supply, at some point the potential for recycling nonwood fibers must be established. Preliminary studies have examined the effects of pulping and recycling of kenaf. It has been shown that most nonwoods have a lower lignin content that wood and that it is easier to delignify nonwoods, as they have a lower activation energy (Pande and Roy, 1996). There have also been investigations into the changes suffered by fibers during the recycling of wheat straw pulps (Xumei and Xiachun, 1996). The results of this work implied that wheat straw pulp did not behave differently from wood pulp during recycling. — Pande 1998, citing Pande, H. & Roy, D.N. 1996 and Xumei, Z. & Xiachun, Y. 1996.

Another question raised about the technical feasibility of using non-wood fibers for papermaking is their recyclability. In general, non-wood fibers are as recyclable as wood fibers and the same issues exist. The strength of pulp made from recovered fibers determines its usefulness. Fiber length as well as fiber bonding ability determine pulp strength. Recovered fibers on average, are shorter than virgin fibers and lose strength with each reuse cycle. For nonwood fibers that are generally shorter than wood fibers (such as wheat straw), issues such as slow drainage and low strength are a problem both in virgin production and recovered fiber paper production.

On the other hand, non-wood fibers with greater fiber length (such as kenaf or hemp bast fibers) can be used to compensate for loss in pulp strength from recycling. Depending on the strength of the non-wood fiber, more or less virgin pulp has to be added to the deinked pulp to produce high quality recycled paper.
— Environmental Defense Fund Paper Task Force, White Paper 13, "Non-Wood Fiber Sources"

We have very successfully recycled kenaf paper to prove its compatibility with existing systems. We have taken tons of kenaf waste paper to commercial scale mills and blended it with wood based waste paper with excellent results. We regularly blend kenaf pulp with recycled pulps.
— Tom Rymsza, President, Vision Paper

We have heard concerns that agricultural residues might create problems with recycling, but we do not know whether these are true or not. The concerns have to do with the short ag res fibers falling out of the system and clogging the machinery. We assume that a clogging problem could be corrected technologically. A problem with the fibers being too short to recycle might be of more concern. We believe that recycling is a fundamental foundation for an environmentally sustainable paper production system. If papers with ag residue fibers were "one-way papers" because they could not be recycled, that would land us back where recycling started. Even though the ag residues would be recycled from a waste

material to begin with, most are combined with other types of fibers to bring in the attributes that they lack. Large fiber losses at the recycling mills could undermine that system. So we believe it is important that this question be answered and any problems resolved early in the development of production systems for agricultural residue papers. — Susan Kinsella, Conservatree

LISTENING STUDY Question 53: Is there an optimal mix of tree free fibers with tree fibers in a paper?

When it comes to the molecular levels of fibers, there is no distinction between the wood fibers and nonwood fibers. Fiber lengths and widths are the only concern and more on the fiber length. — James S Han, Research Chemist, USDA Forest Service Forest Products Laboratory

It depends on the fiber properties. If the fiber characteristics are inappropriate for papermaking, the optimal mix may be less than 10% nonwood. If the fiber resembles wood fiber, such as kenaf, the optimal mix is 100% nonwood. — Tom Rymsza, President, Vision Paper

A 50/50 blend would be ideal, starting with 25% ag fiber would be a great first step. — Jeff Lindenthal, President, Green Field Paper Company

Again, there is so much variation in the quality of the non-woods, if a poor quality pulp is produced than of course there will be performance problems. If a high quality non-wood pulp is produced, there will not be performance problems. Most practicalists now advocating for the use of non-woods in paper want to see a blend of minimum 30% ag-residues, minimum 35% post-consumer recycled and the remaining from a dedicated fiber, whether FSC wood or non-wood, or both. — Jeanne Trombly, Fiber Futures

Yes, but it varies from fiber to fiber and type of tree fiber whether you are using softwood or hardwood and what species of tree. — Living Tree Paper Company

All sorts of blends of woods with non-woods and non-woods with other non-woods have produced viable paper. The ideal mix would depend on the bioregional availability of particular fibers and what type of paper is desired.

It would be interesting to issue a protocol for 33/33/33, calling for 33% ag-residues, 33% post-consumer recycled and 33% ecologic certified "fresh" fiber as it is called in Germany. This could mean virgin wood or a dedicated non-wood crop, such as hemp or kenaf or bamboo or Arundo. All paper would meet this protocol; variations would be issued depending on where one is located, what type of paper is needed and other local conditions. — Jeanne Trombly, Fiber Futures

Depending on the grade of paper desired. The spectrum of agri-fiber is very broad; thus, the range of paper products that could be made is also large.

See, for example, my presentations, "Experience in the Technical and Market Development of Agri-Pulp Printing Papers in North America," "Selected Physical Properties of Blends of Wood Pulp and Alkaline Sulphite Flax Straw Pulp," "Alkaline Sulphite Pulping of Hesperaloe, An Arid-Zone Native Fiber Plant from Northern Mexico," "Alkaline Sulphite Pulping of Red Fescue(Festuca rubra L. var. Boreal) Straw," and "Alkaline Sulphite Pulping of Spartina Grass (Spartina alterniflora Loisel)." — Al Wong, Founder, Arbokem

Different paper grades require different combinations of fiber types and other additives. Depending on the type of paper being produced, there may be no combination of agricultural fibers that produces the desired finished product. — International Paper

What is important in making paper is not the specific source of the fiber so much as its particular attributes. Even papers made entirely of forest fibers generally incorporate several different tree species because each brings different important qualities. So also with nonwood fibers, it is important to mix long fibers (for strength) and short fibers (for flexibility), with the specific proportions dependant on the particular type of paper being produced and the performance requirements it must meet. As we've seen in many of the tables in the Listening Study, nonwood fibers cover a whole range of fiber lengths. Therefore, it is feasible (and actually already occurring) that some papers could include only different types of nonwood fibers, while others might incorporate some forest fibers for different properties. Ultimately, we hope that long nonwood fibers will replace most of the forest fibers in paper (with the shorter fibers being supplied by recycled content) so that the demand for trees is significantly reduced and reoriented towards products in which wood truly is the only and/or best material. (Even the most

ecologically acceptable product uses for trees, however, are likely to produce sawdust, which currently is an important source of virgin forest fiber in papers and may be of acceptable environmental value in paper even in a predominantly nonwood fiber future.) — Susan Kinsella, Conservatree

The appropriate mix depends entirely on the end-use application, and the performance properties each fiber brings to the sheet. — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

The optimal mix would depend on the specific paper grade, as partly discussed above. — Michael Jackson, Consultant, Tolovana Park, OR

It depends on the paper product, the region, etc., as described above. — Peter A. Nelson, President, AgroTech Communications, Inc.

You can mix Arundo donax just like softwoods and hardwoods, where one has short fibers and the other long. Arundo donax, on the other hand has both short and long fibers. — Ernett Altherimer, Founder and Chairman, Nile Fiber

The producers of the range of specialty papers being manufactured today from nonwood fibers may attest to the levels of quality which are possible and when we consider the blending of nonwoods with recycled fibers, wood and other nonwood species. — Hurter 1998

Table 12. Fiber Dimensions of Nonwood Plant Fibers

Nonwood fiber	Average length (mm)	Average diameter (microns)
Abaca (Manila hemp)	6.0	24
Bagasse (depithed)	1.0-1.5	20
Bamboo	2.7-4	15
Com stalk and sorghum (depithed)	1.0-1.5	20
Cotton fiber	25	20
Cotton stalks	0.6-0.8	20-30
Crotalaria sp. (sun hemp)	3.7	25
Esparto	1.5	12
Flax straw	30	20
Hemp	20	22
Jute	2.5	20
Kenaf bast fiber	2.6	20
Kenaf core fiber	0.6	30
Rags	25	20
Reeds	1.0-1.8	10-20
Rice straw	0.5-1.0	8-10
Sisal	3.0	20
Wheat straw	1.5	15
Wood fibers		
Temperate zone coniferous woods	2.7-4.6	32-43
Temperate zone hardwoods	0.7-1.6	20-40
Mixed tropical hardwoods	0.7-3.0	20-40
Eucalyptus sp.	0.7-1.3	20-30

Source: Pande 1998, citing
Original Source: Atchison and McGovern (1993)

LISTENING STUDY Question 54: Is it appropriate to expect tree free fibers to also be organic?

Yes

There are already too much herbicides and pesticides used everywhere. We should all dedicate to promote organic and non-GMO cropping for foods and non-foods.

See, for example, my presentation, "Nutritional Therapeutics as an Effective Strategy for Reducing the Epidemic of Type II Diabetes Mellitus Among Aboriginal People in Canada." — Al Wong, Founder, Arbokem

Yes, but in the short term, it is not a realistic scenario. But the industry should develop a definite time line that includes converting to organic. In some cases, the organic requirement might just be splitting hairs; it would be ideal, but if the industry is already using a waste stream such as straw, then organic would be an unrealistic requirement. — Jeff Mendelson, President, New Leaf Paper

We would be able to put an organic label on Arundo donax. All you have to do is put it in the ground 3 fingers deep and it's amazing what you get in just seven days. — Ernett Altherimer, Founder and Chairman, Nile Fiber

If we did an entire life-cycle analysis of trees, it would be hard to imagine that agricultural fibers have a good chance of competing on an environmental front if you have to dump chemicals on the land annually. Trees may do it after planting or cutting as well, but mainly spray only once every ten years or so. If environmental friendliness is the main thrust for environmental papers, we need to make sure that they really are less harmful. — Russell Clark, Environmentally Preferable Purchasing Program, US EPA

No

To me, it would be impossible to expect agricultural paper fibers to be organic. Most agricultural fibers are annual and most annual plants do need pesticides and herbicides to grow. — James S. Han, Research Chemist, USDA Forest Service Forest Products Laboratory

Probably not given the small but growing niche organic agriculture presently enjoys. Then again, married with steady demand, anything is possible! — Jeff Lindenthal, President, Green Field Paper Company

NO — that requirement would be a huge barrier. Consumers do not require that of almost anything else they purchase. It would ensure the demise of the "tree-free paper industry" to expect that. Does anybody ask why tree papers aren't organic?

We would never be able to have enough fiber to supply the industry. Farmers would have to go through a three-year transitional period, then pay to get a third-party certification. If they had a forward contract, which they would need, and after three years they were unable to meet the contract due to a blight, lack of rain, or too much rain, the paper mill would never come back to that farmer again. Organic is simply a standard we can not expect to impose. — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

No. The value of organic cropland is very high and more appropriate for food crops. Some on-purpose fiber crops, such as kenaf, require very little herbicide because of their rate of growth, and insecticide is not needed because they are harvesting for cellulose fiber rather than grain or fruit. These crops can provide a low input alternative for mainstream farmers. Organic status is awarded after multiple seasons of growing other crops so that the chemicals in the soil are absorbed. Kenaf, as a high yielding and low input option, can be used as one of these transitional crops. — Tom Rymsza, President, Vision Paper

In our opinion, this is a ridiculous question that makes nonwood proponents look like extremists. Agriculture (especially in the US) is becoming more productive, more sustainable, and using much less chemicals and harmful practices. In addition, the chemicals, fuels, etc., used on the farm are quickly being converted to being based on benign, biobased technologies. These agricultural technologies (coupled with robotics and engineering) are creating crop production scenarios that make "certified organic" seem destructive.

Not only would an organic requirement lock farmers into a less sustainable system, but it wouldn't be the most environmentally beneficial. Organic makes sense for foods: they taste better and don't have harmful residues. However, organic growers generally have a lower income, therefore smaller farms and older equipment. They have to make more passes across the field and use more gasoline. We don't view this production practice as sustainable at all. The newer technology uses solar, biotech, and other forward-thinking practices. We used to notice massive dumping of herbicides along the Mississippi delta, where I farm. Now farmers have more options and aren't as dependent on herbicides. Those that they do use are more chemically benign. — Peter A. Nelson, President, AgroTech Communications, Inc.

More Dimensions

Non-woods should adhere to whatever organic labeling standards are currently practiced by the pulp / paper industry.

FSC (Forest Stewardship Council) is dealing with the GMO question – that seems to be of greater concern than organics. — Jeanne Trombly, Fiber Futures

Only as far as mass volume crops can be produced by 'organic' methods, which I think is marginal. — Michael Jackson, Consultant, Tolovana Park, OR

This needs to be addressed by industrial agriculture. Today's agricultural practices do not lend themselves to organic and crop rotation but that is a direction that needs to be developed by that industry. — Living Tree Paper Company

If we want to encourage on-purpose crops to be grown as rotation farming crops rather than in monoculture plantations, then they will only become organic when the food crops grown in other rotations also become organic. I assume that will take a long time and in the meantimewe should not handicap the development of nonwood fibers as rotation crops. The same with agricultural residues – they will become organic only when the food crops they derive from become organic. This is an issue for farm policy experts to work on. I don't think that we can sufficiently influence it from the papermaking side without undermining or even eliminating our ability to develop nonwood fiber options.

Of course, if paper fiber crop plantations are developed – and they do not involve converting forestland, which we along with most others would oppose – it might be feasible to insist that these plantations be organic in order to minimize damage to the land.

Otherwise, however, organic land is so valuable and there is still far too little of it that its healthful value should be dedicated to food crops, not paper fiber.
— Susan Kinsella, Conservatree

Agricultural fibers are environmentally inferior when compared to wood fibers for making most paper grades. Whether the agricultural fiber is grown organically or not does not change the biggest negative environmental problems of using annual agricultural crops for papermaking; biodiversity elimination, massive and sustained land disruption, and high energy use.
— International Paper

There are a lot of variables to weigh. We would expect it would be possible because it is not food, and therefore doesn't have to meet such high cosmetic standards. We would like to see a life cycle analysis of the recyclability and sourcing infrastructure of tree-free fibers to be able to make an assessment.
— Tyson Miller, Program Director, Recycled Products Purchasing Cooperative

This is sort of a philosophical question. From a sustainability perspective, it would be advantageous for agricultural paper fibers to be organic, just as it would be for any other agricultural or silvicultural product. If organic status were easier to achieve for nonwoods than for woods, the organic label would increase their attractiveness. However, I don't know if it is reasonable to expect. I would argue for consumer choice – to let them know what they're purchasing and to develop meaningful standards.
— Richard Denison, Ph.D., Senior Scientist, Environmental Defense

LISTENING STUDY Additional Comments

What Direction Should the Tree-Free Paper Industry Take?

The current discussion of nonwoods as a fiber source for papermaking in the United States and other developed countries has several prominent characteristics. The first is linked to the extreme heterogeneity of the different plants and the ways they might be pulped and used. It is difficult to make an accurate statement about any particular aspect of nonwood use in papermaking without qualifying it by fiber type, farming practice, region, pulp process, production scale, and intended application. The variation in properties and potential application in papermaking appears distinctly greater among candidate nonwood fiber sources than among commonly used wood types. Further, the use of particular nonwood fiber sources in papermaking may sometimes be best conceived in combination with a variety of other industrial applications. . . . [I]n contemplating nonwoods pulping as a commercial enterprise, one must also sometimes contemplate the need to jumpstart a chain of new industrial linkages that may vary widely depending on the fiber.

A second characteristic of the discussion of nonwoods as a fiber source for paper is that although an increasingly vigorous debate is beginning to be waged around a range of potential environmental and economic benefits associated with nonwoods use in papermaking, it is strikingly characterized by the huge vacuum in supporting contemporary technical research.

. . . Perhaps the most interesting aspect of the discussion is the sheer diversity of arguments being put forth in support of nonwoods as a fiber source for papermaking. . . . The web of potential advantages can become even more complex in particular contexts. Because of strengthening prohibitions against burning rice straw in California, for example, finding industrial applications for this material has become linked to the future of the industry in the state. This, in turn, has been linked to preserving the ecological benefits associated with the winter flooding program for the rice fields, which creates critical wetlands habitat for migratory waterfowl.

The arguments for using nonwoods as a fiber source for paper become particularly complex when industrial fiber crops such as kenaf, hemp and others are being considered. They constitute not only an alternative to wood use and timber plantations, but also a potential substitute for heavily subsidized crops such as cotton and tobacco, which invokes further areas of consideration. As alternatives to timber plantations, annual fiber crops are said to be less capital intensive, less risky (because fire or infestations will wipe out only one season's investment rather than years of investment, and more flexible. . . . Yet, for the time being, such arguments remain sparsely documented and contested due to the lack of modern comparative research, and to the need for such analysis to be grounded in the specific soil types, climate, and agricultural practices unique to different regions. Indeed, an appropriate comparative framework that can meaningfully accommodate a broad array of issues has itself yet to be well-articulated. — Maureen Smith, ***The U.S. Paper Industry and Sustainable Production***

There is vast potential for a "green" paper industry, including recycled and natural fibers, that could not only spare trees but also produce paper with minimal environmental impact overall, but it needs an infusion of both public interest and research funding. [Nonwood paper] is presently, at best, a $20 million sales niche in a $230 billion U.S. industry. — Jim Motovalli, "The Paper Chase"

A forward positive step into the marketplace! – Jeanne Trombly, Fiber Futures

Proponents of the tree-free paper industry have been known to target one “bad guy” (ie: commodity printer and copier paper) and run their numbers and anti-marketing campaigns based on a comparison with that “bad guy.” In reality, there are many high volume uses for wood pulp (synthetic fibers, absorbency products, stationery, etc.), in which agricultural fibers already could compete. In general, most industries are headed towards more specialized markets. We should not expect a 24-lb commodity paper to offer a complete replacement. — Peter A. Nelson, President, AgroTech Communications, Inc.

To help develop the marketing end, AgroTech Communications, Inc. is participating with 40+ biobased companies to develop the Biobased Manufacturers Association (BMA) to help in marketing biobased products based on their inherent attributes. Tom Rymsza of Vision Paper Company, KP Products, is representing the pulp and paper industry on the BMA board of directors. One aspect of the program is

setting up cooperative purchasing. Many of the efforts in the past have focused on beating out other crops such as corn or soybean and promoting one specific fiber. A more effective technique is to win the consumer's heart for natural ingredients from the ground as better than synthetics. Then the individual fibers can develop their own niches.

The nonwood industry would be better off to market nonwood fibers as a diversified sustainable opportunity. Particularly after September 11, the industry needs to market to Washington. They also need to heal wounds with the wood industry to come up with the best balance.

The same proponents that scream 'til they're red in the face about one particular fiber are shooting themselves in the foot. — Peter A. Nelson, President, AgroTech Communications, Inc.

Consumers are only becoming more specific about what they want. We're moving away from the commodity-oriented economy as we know it and getting more and more specialized. People want glossy photo paper, different level graded newsprint, etc. Consumers will be pulling paper into the marketplace for use in diverse applications. Therefore, when we look to the future of the pulp and paper fiber supply, the future is not an equivalent switch of all commodity-based virgin pulp copy paper to tree-free paper. Rather, these nonwoods will move into specialized niche markets. We are more likely to see new mills popping up that specialize in specific types of products (e.g. cotton toilet paper, kenaf stationery, etc.) rather than conversion of existing mills, though we might see some conversion for specific reasons. We might see more branding factories. — Peter A. Nelson, President, AgroTech Communications, Inc.

So many of the studies and interest along the way has been focused on getting the industry to change. Industry is not going to change just because we want them to start using ag fibers to make paper. Consumer demand has to change in the absence of other motivating factors for the paper industry.

You can spend all the time you like telling the paper companies how they'll improve the environment, but that's not going to do it. But if there are enough consumers out there saying they won't buy virgin wood paper, the industry will find the economic advantage and take heed. Environmental impacts, aside from complying with regulations, mean little to the paper industry and it's easy to understand why. They are often not held responsible for paying for their impacts on the environment; the public shoulders the burden. What incentive is there for the paper industry to change its raw materials and its processes, if they are not required to by law or are not encouraged to do so by consumer demand?

I interact quite often with the environmental community and am not very happy with how they have chosen to impact the paper industry. Many times they say they are using market-based strategies, but they fail to take real advantage of consumer buying power.

In one current and highly visible case [2002], environmental organizations state they are taking a market-based approach through public pressure, protests, events, earned and paid media, and negotiations to persuade key companies such as Staples to make environmental commitments. But these organizations have taken public issue with Staples for only a portion of its paper purchasing practices, while ignoring the more positive aspects of its business.

Staples is perhaps the largest and one of the longest-standing retailers of tree-free paper in the country. Staples began selling papers from Crane and other manufacturers of tree-free and recycled papers 10 years ago. These papers have been met with excellent response by Staples customers in more than 1,000 of their retail stores. But as protestors take action against Staples for their purchase of virgin-fiber papers and encourage them to take their business elsewhere, they neglect to tell customers that there are excellent alternatives in the same building. Imagine the impact on the business if customers started purchasing more and more tree-free and recycled-fiber papers within Staples itself. The laws of supply and demand would provide very quick evidence that a change in purchasing practices is required.

The environmentalists' ultimate goal of systemic change in the paper industry will require much broader and much more balanced actions than those put forth to date. Greater attention to the end consumer, the product choices available to them, and the places where they can be purchased — even at Staples — will serve that goal equally as well as bringing negative pressure to bear.

I'm completely in favor of tree-free and post-consumer papers. The industry has to make the conversion in a systematic matter. If we advocate changes that are too large, they're not going to happen. A lot of campaigns have started on college campuses, a great forum. However, most have gone about it in the wrong way: they go after copy paper and printer paper. They demand the campus switch immediately and all at once — that's asking too much all at once.

I'd rather see a phased-in approach using high-visibility, lower-volume papers. Start with college letterhead. Who sees copy paper from universities? Compare that with who sees the letterhead: granting authorities, parents, alumni — people with checks! Also, using these papers allows the university to tell a

story that differentiates them from the rest: "Proudly supporting a cleaner environment by using tree-free paper." This first stage creates a favorable and positive environment for the next stage: perhaps an uncoated paper with soy-based ink for the alumni magazine. This kind of campaign takes years and generally the leaders of the campaign are motivated kids who are there for generally only four years. The campaigns have traditionally centered around Earth Day in April, and guess what? Those motivated kids start their finals in a few weeks, and then they're gone. Campaign over. The campaigns need to be spearheaded by faculty and administration, not just students.

The leaders must realize that tree-free papers cost more. If they start pushing high post-consumer content or tree-free copy paper on a large scale with low visibility, it costs a lot more, and gives the administration a very easy reason to say no. — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

When one surveys the breadth of issues and implications associated with the use of nonwoods in papermaking, it becomes clear that one's vantage point matters a great deal. If the question is one of fitting a heterogeneous and disbursed alternative fiber supply into a geographically concentrated, technologically rigid, vertically integrated, capital-intensive industry, one begins to better understand the modern history of nonwood paper commercialization efforts. The question becomes less why the commercialization of nonwood fiber pulping has yet to succeed, than why anyone in his or her right mind would still be trying. . . When one views the issue from a broad perspective of social and environmental opportunity, however, one sees nothing short of abject failure and gross irresponsibility reflected in the modern industrial status quo. One also sees an area of potential remarkable for its reach, its regional variability, and its human and ecological significance. **—** Maureen Smith, ***The U.S. Paper Industry and Sustainable Production***

Additional Observations

One thing I've encountered over years — we argue endlessly about minutia and definitions that people to this day do not understand: "process chlorine-free," "closed loop," "recycled," "recovered," whether tree-free fibers can be recycled, etc. We drive ourselves crazy with minutia. The contamination of bleach in recycled pulp, etc. It's just not a problem, why worry about it? Why argue endlessly about it? The impact is so minuscule — it holds back the transition to mention such minutia as a barrier to recycled paper. In developing the argument we get into too much detail.

We're preaching to ourselves — to the choir. Rather, we need to talk to everyone who is at the Walmart parking lot, corporate boardrooms, and college campuses. We need to express why it is important to buy papers already on the market.

More tree-free advocates need to buy and use tree-free paper. Many fail to use tree-free or use only donated paper. For example, RAN sent out a funding plea that claimed it was printed on tree-free paper when it may not have been. If the advocates can come to grips with why they buy the paper, they can better promote the papers to others.

Second thing the environmental paper industry should do is to take a more positive and market-based approach to promoting these papers. It was fine to discourage Staples from buying from Boise-Cascade, but we also need to talk to the same people about how to change their own habits. — Peter Hopkins, Environmental Papers Consultant for Crane Paper Company, Gargan Communications

The use of agricultural fibers in the manufacture of pulp, paper, and related products is complex. There are virtually unlimited combinations of products and fiber sources that directly affect the sustainability at all levels (earth / sun / water to the end consumer).

There are many products that can be made from natural fibers (trees, ag fibers, etc.). These include nonwovens, specialty pulps, commodity pulps, feedstock for synthetic materials such as rayon, absorbents, industrial packaging, etc. Each of these products uses unique blends of fibers to obtain specific characteristics needed by the end user.

Diversity of fiber supply is key, in both the fiber source and the production / processing. Trees, agricultural residues, annuals, herbaceous crops, and processing residues all have a place in making some of the products listed above. A truly sustainable approach recognizes diversity.

For example, an herbaceous (perennial) crop such as switchgrass may be much better suited to the hills of Illinois than an annual crop such as kenaf, just for the fact that exposing hilly soil to the elements

(between harvesting in the fall and planting in the spring) with kenaf would make the topsoil extremely vulnerable to erosion. However to promote switchgrass as the blanket solution for fiber across the whole United States would be foolhardy, in that a monoculture system using just switchgrass would be susceptible to pests, weeds, etc.

The concept in the above paragraphs is not presented as a whole body of thought on the subject, and is obviously presented from the agriculture/forestry perspective vs. the manufacturer of the actual pulp/paper product. — Peter A. Nelson, President, AgroTech Communications, Inc.

I'm a firm believer that agriculture can supply all the raw materials for industry. A combination of new crops, technology, and biotech are all building blocks for understanding how we can make agriculture work to provide for industry. Non-wood fibers have significant value streams that can and have been developed around them and will only grow to be more integrated. — Peter A. Nelson, President, AgroTech Communications, Inc.

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