Paper Recycling Technology and Science

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Paper Science and Engineering
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Lecture:

Paper recycling and technology course introduction and objectives

Dr. Richard Venditti

- Faculty member in the Paper Science and Engineering Program in the Forest Biomaterials Department at North Carolina State University
- PhD in Chemical Engineering, BS in Pulp and Paper Science and Chemical Engineering
- Research areas:
  - Paper recycling
  - Utilization of forest/agricultural materials for new applications
  - Life cycle analysis
- Named a TAPPI Fellow in 2012
- Relevant research projects:
  - The detection of adhesive contaminants
  - The changes in fibers upon recycling
  - Automatic sorting of recovered papers
  - Flotation deinking surfactants
  - Agglomeration deinking
  - Screening phenomena and pressure sensitive adhesives
  - Deposition of adhesive contaminants
  - Neural networks to control deinking operations
  - Sludge conversion to bio-ethanol and to bio-materials

NC STATE UNIVERSITY

Course Outline

- The US Paper Recycling Industry
- Recovered Paper Grades and Contaminants
- Effect of Recycling on Fibers/Paper
- Unit Operations
  - Pulping, Cleaning, Screening, Washing, Flotation, Dispersion, Bleaching, …..
- Image Analysis, Deinking Chemicals
- System Design
- Advanced/Additional Topics

Course Activities

- Viewing of the Videos of Lectures
  - Base lectures by Venditti
  - Guest lectures from industry leaders
- Homework assignments
- Final Exam

Critical Issues in Recycling:

- **Going deeper into the recovered paper stream => poor quality material**
- **Meeting paper specifications, which are getting more stringent**
- **Increased demands for recovered paper from emerging countries**
- **Requirements for recycling processes to be environmentally friendly**
- **Requirements for recycling processes to compete with virgin pulps from an economic standpoint**
- **Competition from digital communications**

- ***The student after passing this class should be able to address issues in these areas by applying the knowledge developed in this course***

Course Student Outcomes:

- After passing this course, the student should have:
  - A broad understanding of paper recycling technology and science
  - An ability to interpret paper recycling issues correctly.
  - An ability to make decisions based on paper recycling concepts to improve paper recycling operations

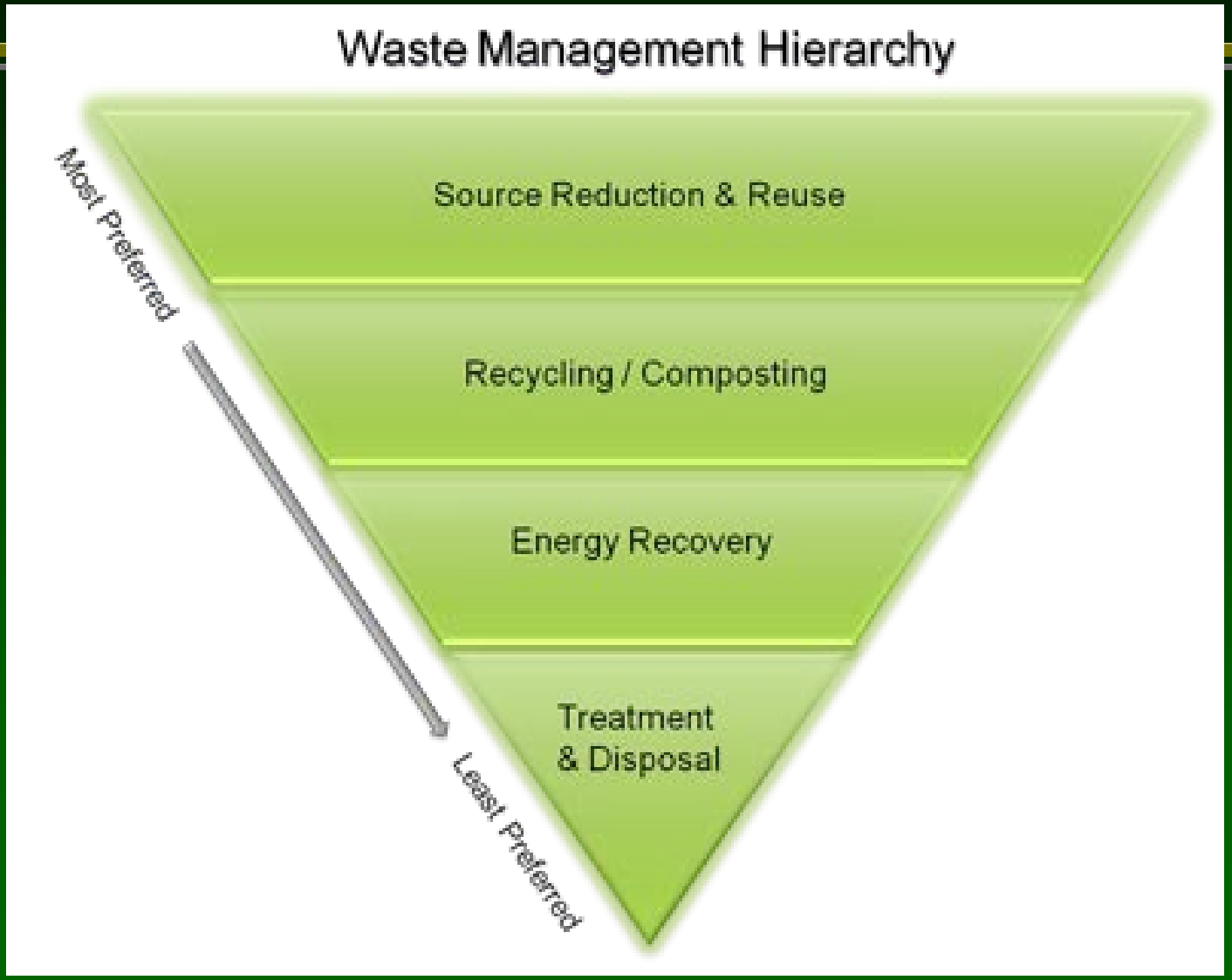
Lecture:

The US Paper Recycling Industry

Recovered Fiber, not “Wastepaper”

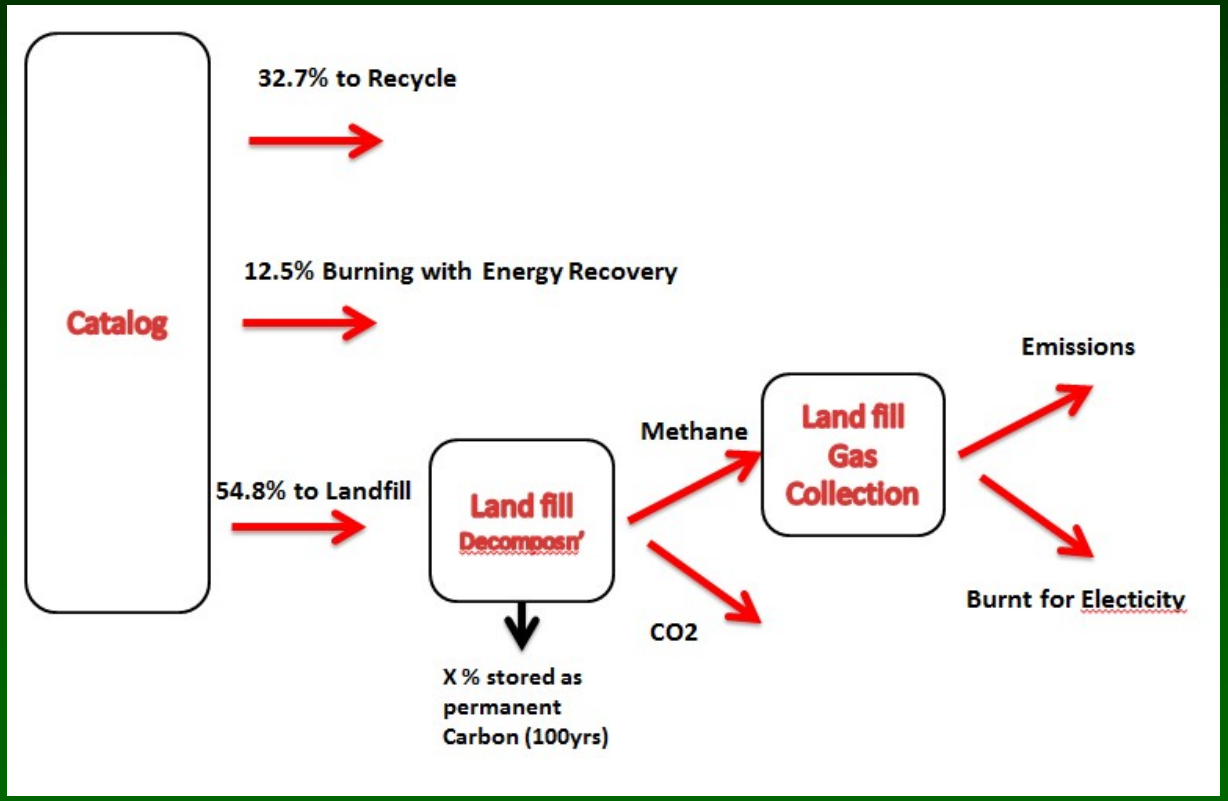
- Learning objectives
  - Understand the trends of paper recycling in the industry
  - Identify the major categories of recovered fiber what is done with them

Waste Hierarchy



http://www.epa.gov/wastes/nonhaz/municipal/hierarchy.htm

Example: What happens to catalogs?



Source: NCASI

Recycled Fiber Definitions

- **Secondary Fiber: fibers that have previously been used in a manufacturing process and have been reclaimed as raw material for another process.**
- **Pre-consumer waste: any waste, printed or unprinted, generated in the fabrication or conversion of finished paper. Before use by a consumer as a final end product.**
- **Post-consumer waste: Paper that has passed through the end usage as a consumer product.**
- **Internal broke: off-specification paper that is repulped and used at the same site, not considered secondary fiber.**

Recycled Fiber Definitions

- **Recovery Rate (RR)**
  - **how much paper is diverted from landfill**

$$RR = 100\% \frac{\text{Tons of Wastepaper Collected}}{\text{Tons of Paper Consumed}}$$

- **Utilization Rate (UR)**
  - **fraction of recycled fibers contained in paper**

$$UR = 100\% \frac{\text{Tons of Wastepaper Consumed at Mills}}{\text{Tons of Paper Produced}}$$

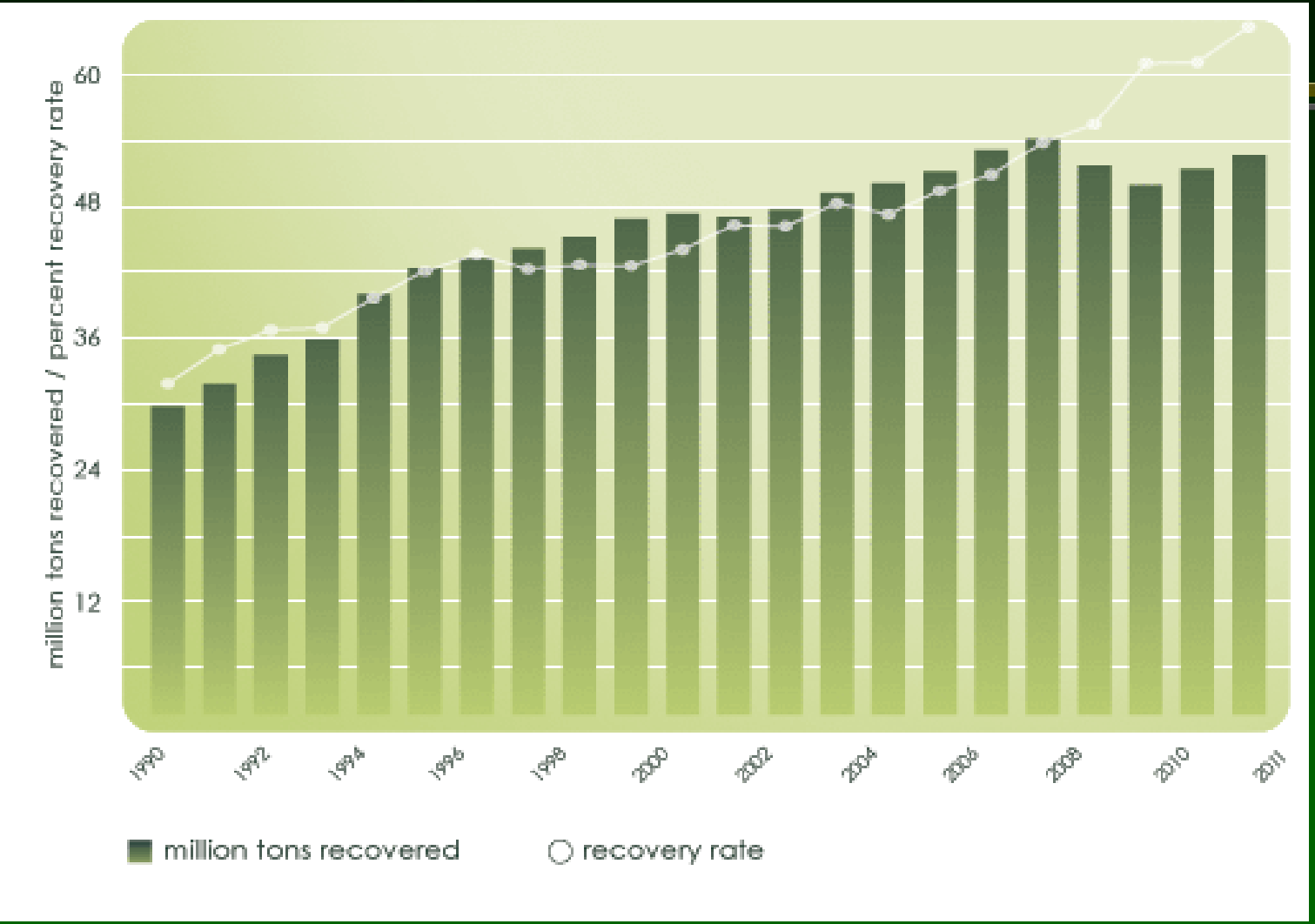
US Paper Recycling Recovery Rate:

- **1999**
  - **Total Paper Consumption: 105 million tons**
  - **Total Paper Recovered: 47 million tons**
  - **Recovery Rate: = 45%**
- **2004**
  - **Total Paper Consumption: 102 million tons**
  - **Total Paper Recovered: 50 million tons**
  - **Recovery Rate: = 49%**
- **2011**
  - **Total Paper Consumption: 79 million tons**
  - **Total Paper Recovered: 53 million tons**
  - **Recovery Rate: = 66.8%**

Source: afandpa.org, 2011

Paper/board Recovery Rate in the US:

53.4%



Record high 66.8% RR.
Paper purchases declined (2.3 million tons) while recovered paper increased 1.3 million tons.
Source: afandpa.org, 2012

Municipal solid waste?

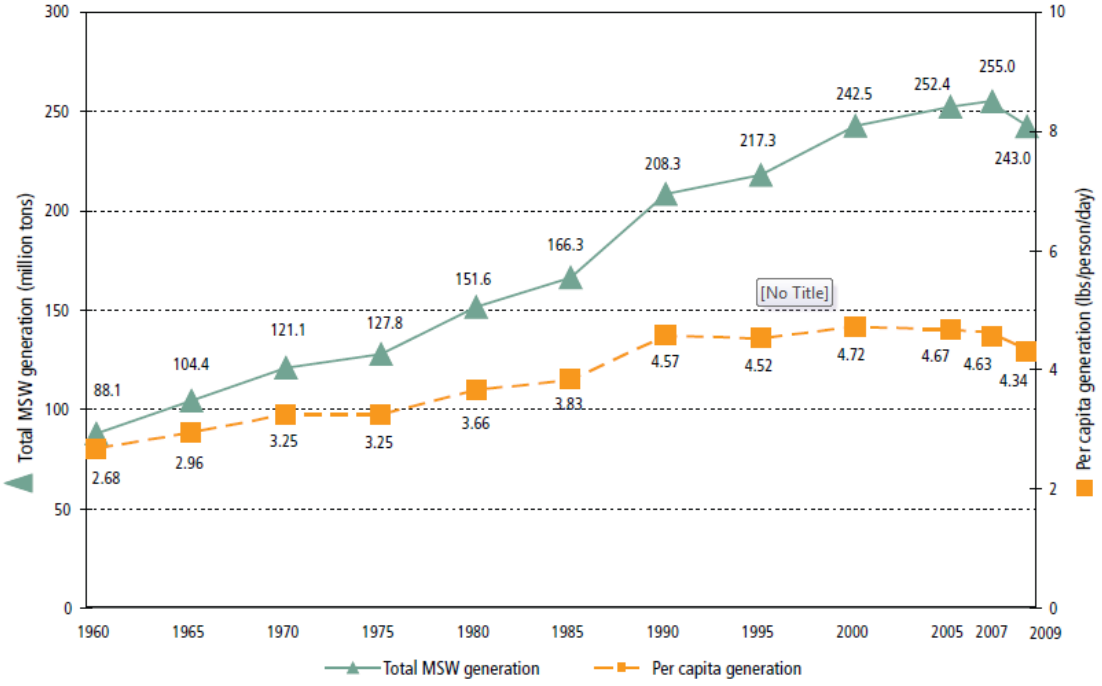
- MSW: everyday items that are discarded by the public
- Also referred to as trash, or rubbish
- Includes packaging, food scraps, grass clippings, sofas, computers, tires and refrigerators, for example.
- Does not include industrial, hazardous, or construction waste.

Source of MSW?

- Residential waste (houses and apartments): 55-65% of total MSW generation
- Commercial and institutional locations (businesses, schools, hospitals..): 35-45%

Municipal Solid Waste Generation (US)

Figure 1. MSW Generation Rates, 1960 to 2009



* The previously published 2008 recycling rate, 33.2 percent, was revised to 33.4 percent in this year's report, based on updated data (see Figure 2).

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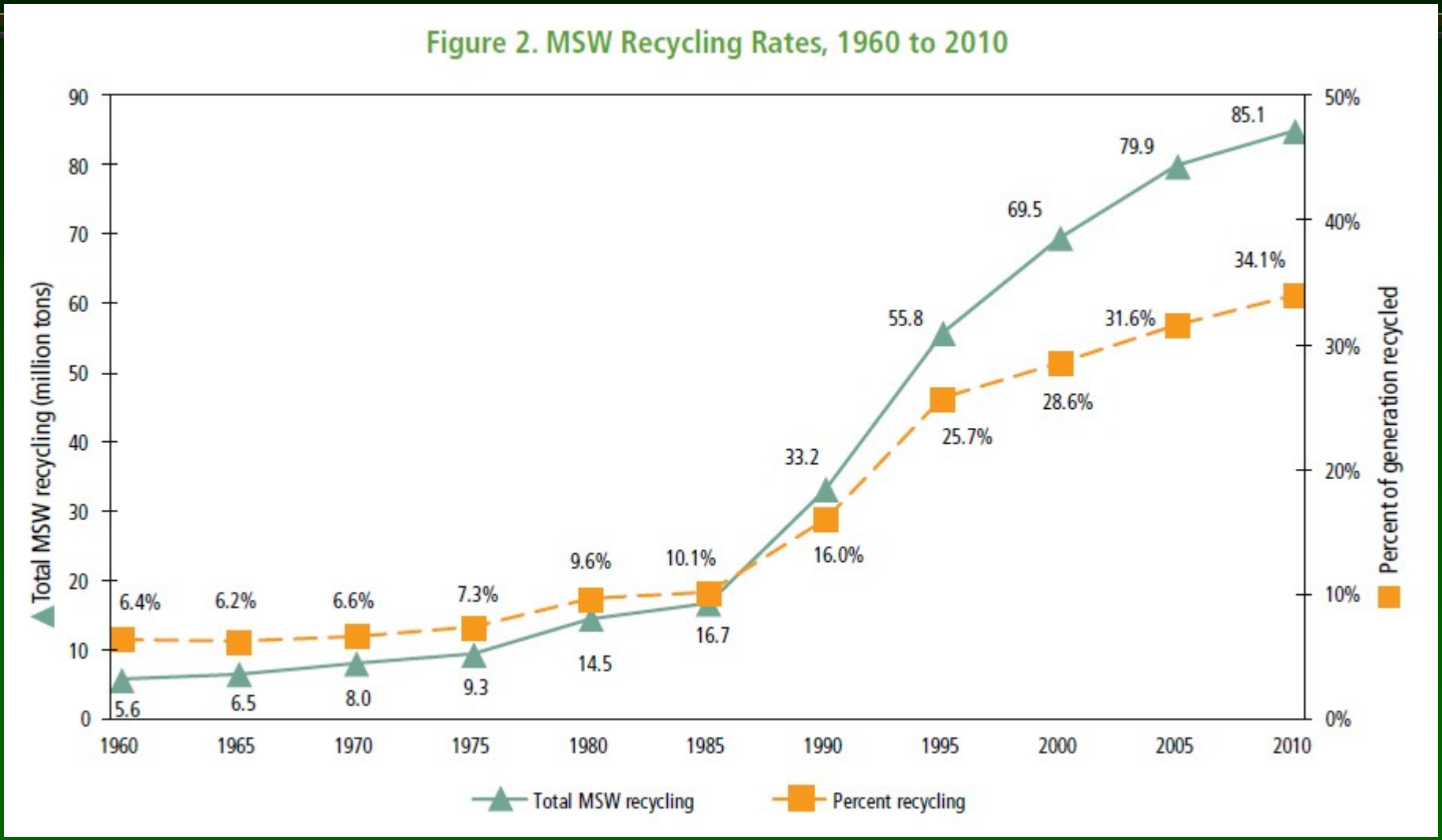
Source: EPA
Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2009

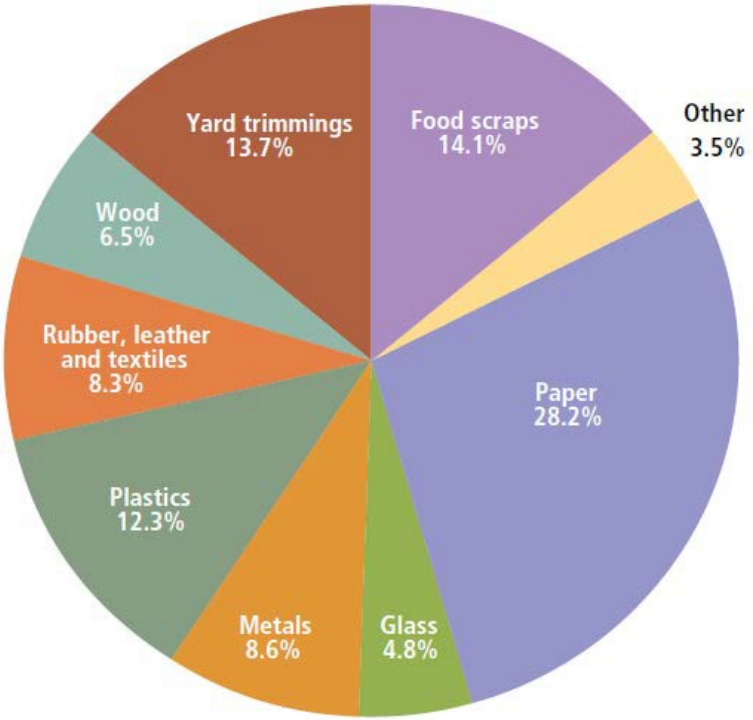
Trends in U.S. Waste Recycling



Adopted from EPA 2011 MSW Facts and Figures

MSW by Material Before Recycling

Figure 5. Total MSW Generation (by material), 2009
243 Million Tons (before recycling)



Source: EPA
Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2009

Table 1. Generation and Recovery of Materials in MSW, 2010'
(in millions of tons and percent ,of generation of each materiaQ

Material	Weight Generated	Weight Recovered	Recovery as Percent of Generation
Paper and paperboard	71.31	44.57	62.5%
Glass	11.53	3.13	27.1%
Metals			
Steel	16.90	5.71	33.8%
Aluminum	3.41	0.68	19.9%
Other nonferrous metalst	2.10	1.48	705%
Total metals	**22.41**	7.87	35.1%
Plastics	31.04	2.55	8.2%
Rubber and leather	7.78	1.17	15.0%
Textlies	13.12	1.97	15.0%
Wood	15.88	2.30	14.5%
Other materials	4.79	1.41	29.4%
Total materials in products	177.86	64.97	36.5%
Other wastes			
food, other!	34.76	0.97	2.8%
Yard trimmings	33.40	19.20	57.5%
Miscellaneous inorganic wastes	3.84	Negligible	Negligible
Total other wastes	**72.00**	20.17	28.0%
Total municipal solid waste	**249.86**	**85.14**	34.1 %

Includeswa efromresideriial commercial.andinstitutionalsoorces.
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Products with highest % recovery.

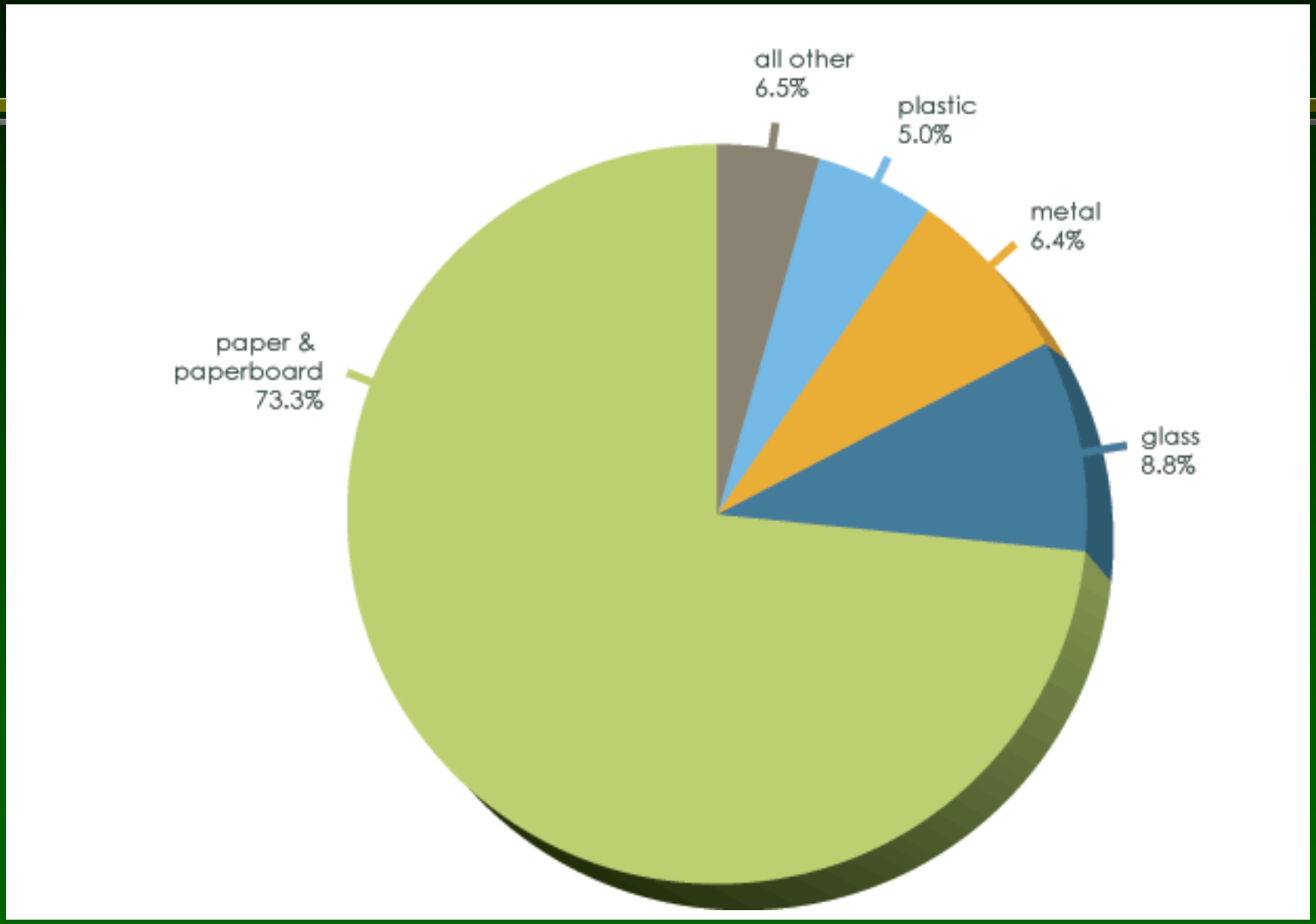
- Lead acid batteries, 96%
- Corrugated boxes, 85%
- Newspapers, 72%
- Steel packaging, 69%
- Major appliances, 65%
- Yard trimmings, 58%
- Aluminum cans, 50%
- Mixed paper, 45%
- *Tires, 35%*
- *Glass Containers, 31%*
- *HDPE, milk containers, 29%*
- *PET Bottles, 28%*

Source: Wikipedia

Source: EPA

Municipal Solid Waste Generation, Recycling, and Disposal in the United States: Facts and Figures for 2009

Paper leads Packaging Recovery

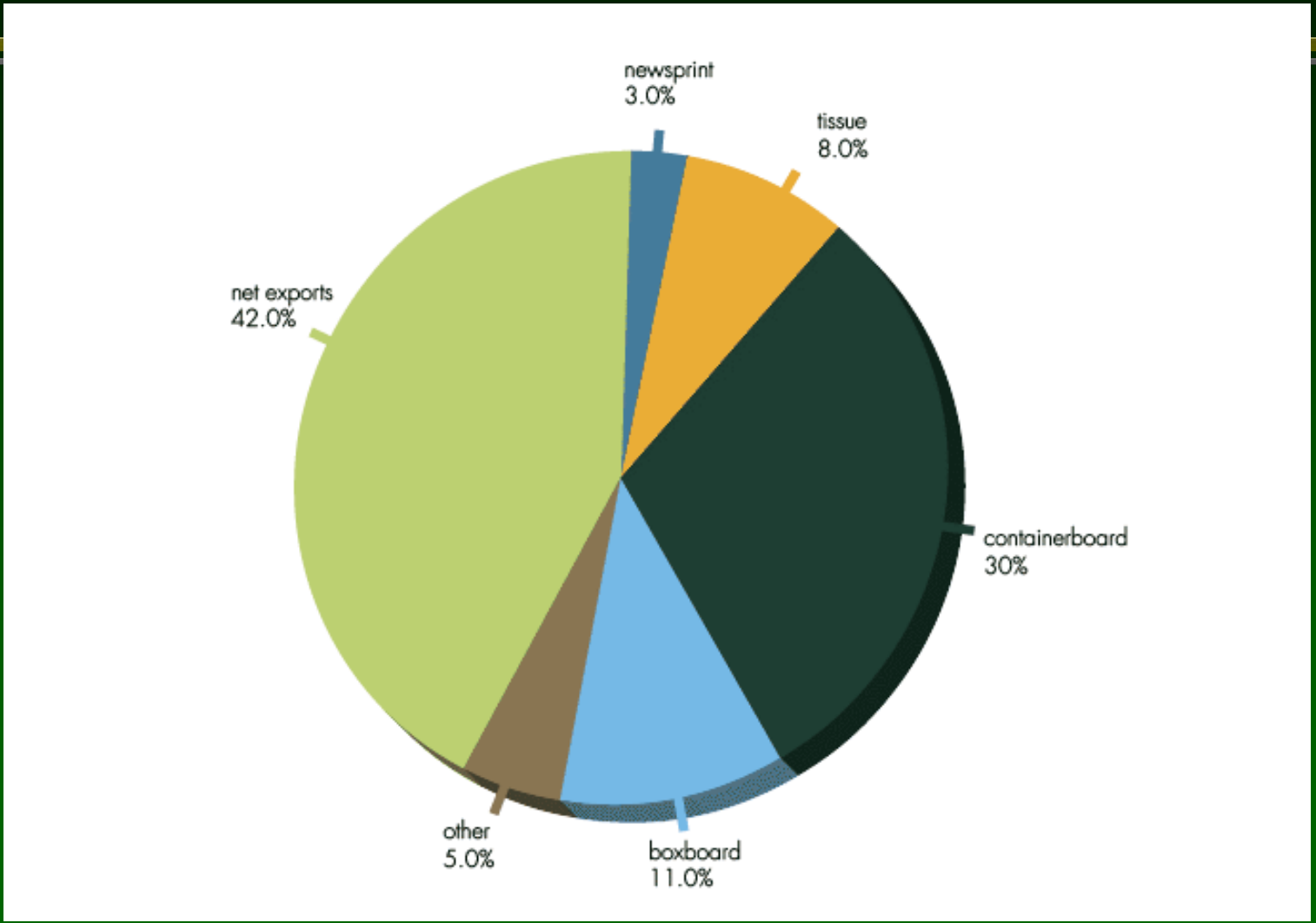


2009 EPA. afandpa.org, 2012

Recovered and Landfilled Paper

Paper purchases declined (2.3 million tons) while recovered paper increased 1.3 million tons.
Source: afandpa.org, 2012

Where Recovered Paper Goes:



Source: afandpa.org, 2012

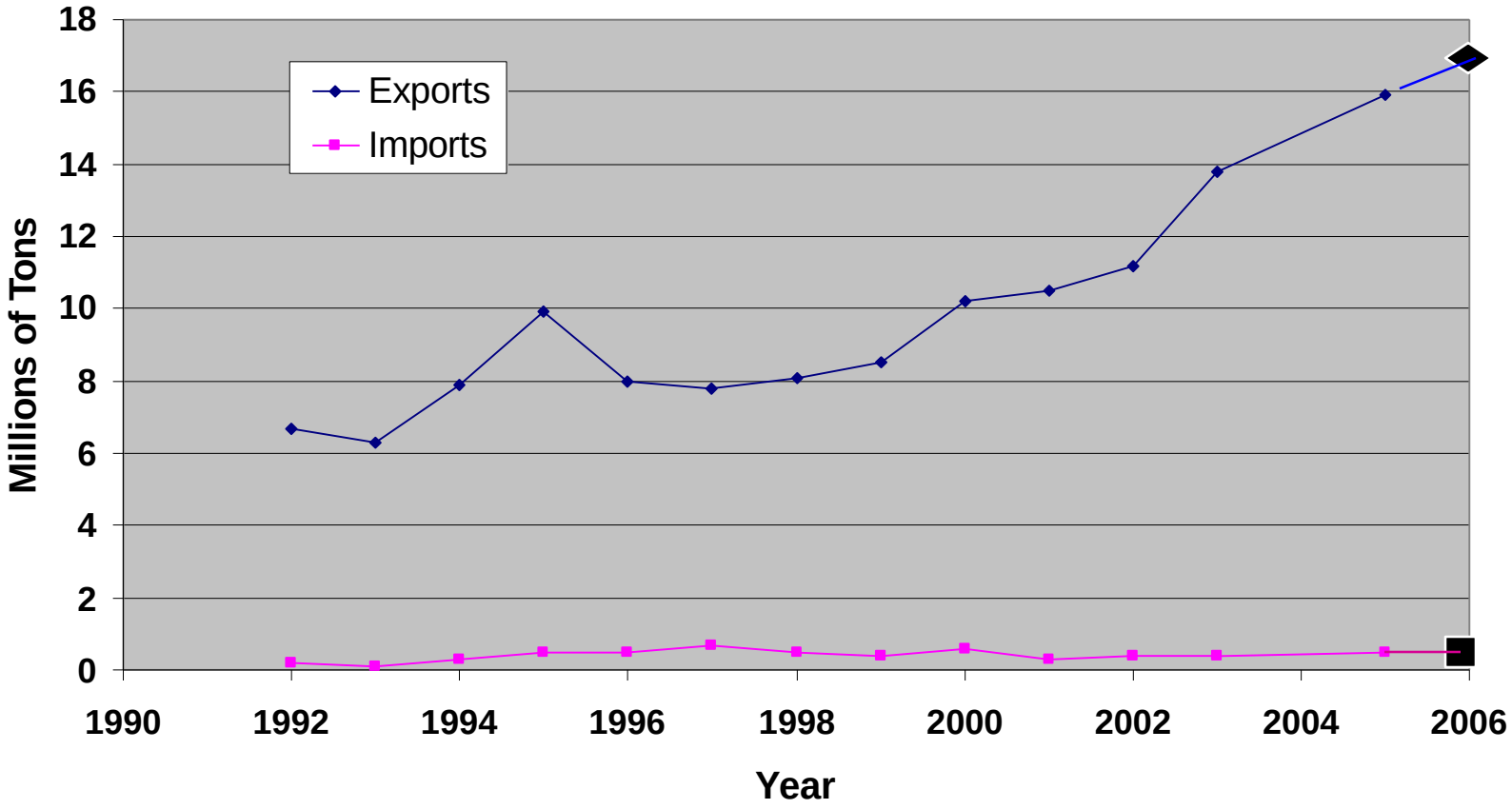
Where Recovered Paper Goes:

Use	Tons Used	Share of Total
Newsprint	1,836	3.0%
Tissue	4,084	8.0%
Containerboard	15,993	30%
Boxboard	6,046	11.0%
Other	2,634	5.0%
Net Exports	22,174	42.0%
Total	52,767	100%

2011 data
Annual AF&PA Fiber Survey/U.S. Bureau of Census

Source: afandpa.org, 2012

Exports and Imports of Recovered Paper



Recovered Paper Statistical Highlights, 2005 Edition, AF&PA

WORLD RECOVERED PAPER STATISTICS BY REGION 2009 - 2010 (1,000 tonnes)						
	Recovery		Imports		Exports	
	2009	2010	2009	2010	2009	2010
Asia	80,381	89,461	35,574	33,201	7,221	6,984
Europe	62,653	63,654	13,469	15,222	24,993	23,442
North America	49,667	51,045	1,615	1,770	20,728	20,593
Latin America	10,264	10,932	2,015	2,169	516	721
Oceania	3,370	3,500	5	3	1,495	1,652
Africa	2,053	2,459	77	30	53	113
Middle East	2,078	2,376	160	172	463	583
Total	210,466	223,426	52,914	52,567	55,468	54,088

Recovered Paper Statistical Highlights, 2005 Edition, AF&PA

Major Recovered Paper Groups

- **Old Corrugated Containers (OCC),** also known as corrugated cardboard: Mills use old corrugated containers to make new recycled-content shipping boxes, as well as recycled paperboard for product packaging (cereal boxes, shoe boxes, etc.). POST-CONSUMER
- **Old Newspapers (ONP):** Mills primarily use old newspapers to make new recycled-content newsprint and in recycled paperboard and tissue, among other paper grades. POST-CONSUMER
- Office Printing and Writing Papers: Printing and writing papers collected from offices, businesses and homes. May be sorted to various extents. POST CONSUMER
- **Mixed paper:** Mixed paper is a broad category that often includes items such as discarded mail, telephone books, paperboard, magazines, and catalogs. Mills use mixed paper to produce paperboard and tissue, as a secondary fiber in the production of new paper, or as a raw material in non-paper product such as gypsum wallboard, chipboard, roofing felt, cellulose insulation, and molded pulp products such as egg cartons. POST-CONSUMER
- **High Grade Deinked Paper:** This grade is made of high grade paper such as letterhead, copier paper, envelopes, and printer and convertor scrap that has gone through the printing process. It must first be deinked before it can be reprocessed into high grade paper products such as printing and writing papers or tissue. PRECONSUMER
- **Pulp substitutes:** A high grade paper, pulp substitutes are often shavings and clippings from converting operations at paper mills and print shops. Mills can use pulp substitutes in place of virgin materials to make back into high grade paper products. PRECONSUMER

http://www.epa.gov/osw/conserve/materials/paper/basics/grade.htm

Grades of Recovered Paper

- Mixed Paper
- Super Mixed Paper
- Boxboard Cuttings
- Mill Wrappers
- News
- Special News
- Special News De-ink Quality
- Over-Issue News]
- Magazines
- Corrugated Containers
- Double Sorted Corrugated
- New Double-Lined Kraft Corrugated Cuttings
- Used Brown Kraft
- Mixed Kraft Cuttings
- Carrier Stock
- New Colored Kraft
- Grocery Bag Scrap
- Kraft Multi-Wall Bag Scrap
- New Brown Kraft Envelope Cuttings
- Mixed Groundwood Shavings
- Telephone Directories
- White Blank News
- Groundwood Computer Printout
- Publication Blanks
- Flyleaf Shavings
- Coated Soft White Shavings
- Hard White Shavings
- Hard White Envelope Cuttings
- New Colored Envelope Cuttings
- Semi Bleached Cuttings
- Manila Tabulating Cards
- Sorted Office Paper
- Sorted Colored Ledger
- Manifold Colored Ledger
- Sorted White Ledger
- Manifold White Ledger
- Computer Printout
- Coated Book Stock
- Coated Groundwood Sections
- Printed Bleached Board Cuttings
- Misprinted Bleached Board
- Unprinted Bleached Board
- #1 Bleached Cup Stock
- #2 Printed Bleached Cup Stock
- Unprinted Bleached Plate Stock
- Printed Bleached Stock

Scrap Specifications Circular, Guidelines for ….Paper Stock…
By: Institute of Scrap Recycling Industries, Inc.

Recovery of OCC

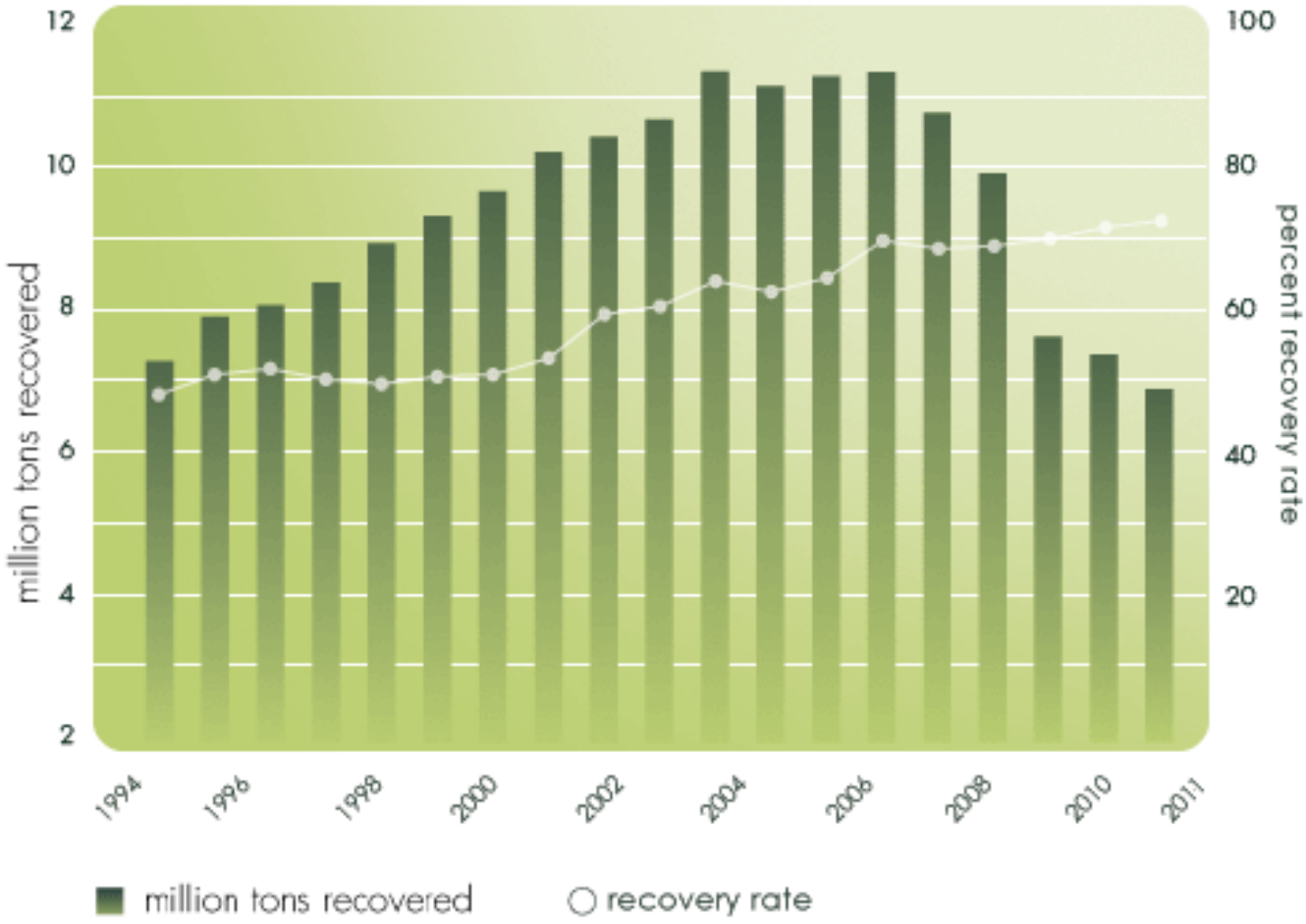
19 MMT used domestically, 8 MMT exported,
Purchases increased 7.2% in 2010, Recovered OCC increased by 11.2%
Source: afandpa.org, 2012

Uses of OCC

	At Paper and Board Mills (000 tons)	Net Exports (000 tons)	Total (000 tons)	Containerboard /Unbleached Kraft Paper Supply (000 tons)	Recovery Rate
1993	13,562	2,338	15,900	29,200	54.5%
2011	19,339	9,778	29,117	31,914	91.2%

19 MMT used domestically, 8 MMT exported,
Purchases increased 7.2% in 2010, Recovered OCC increased by 11.2%
Source: afandpa.org, 2012

Recovery of ONP (mechanical)



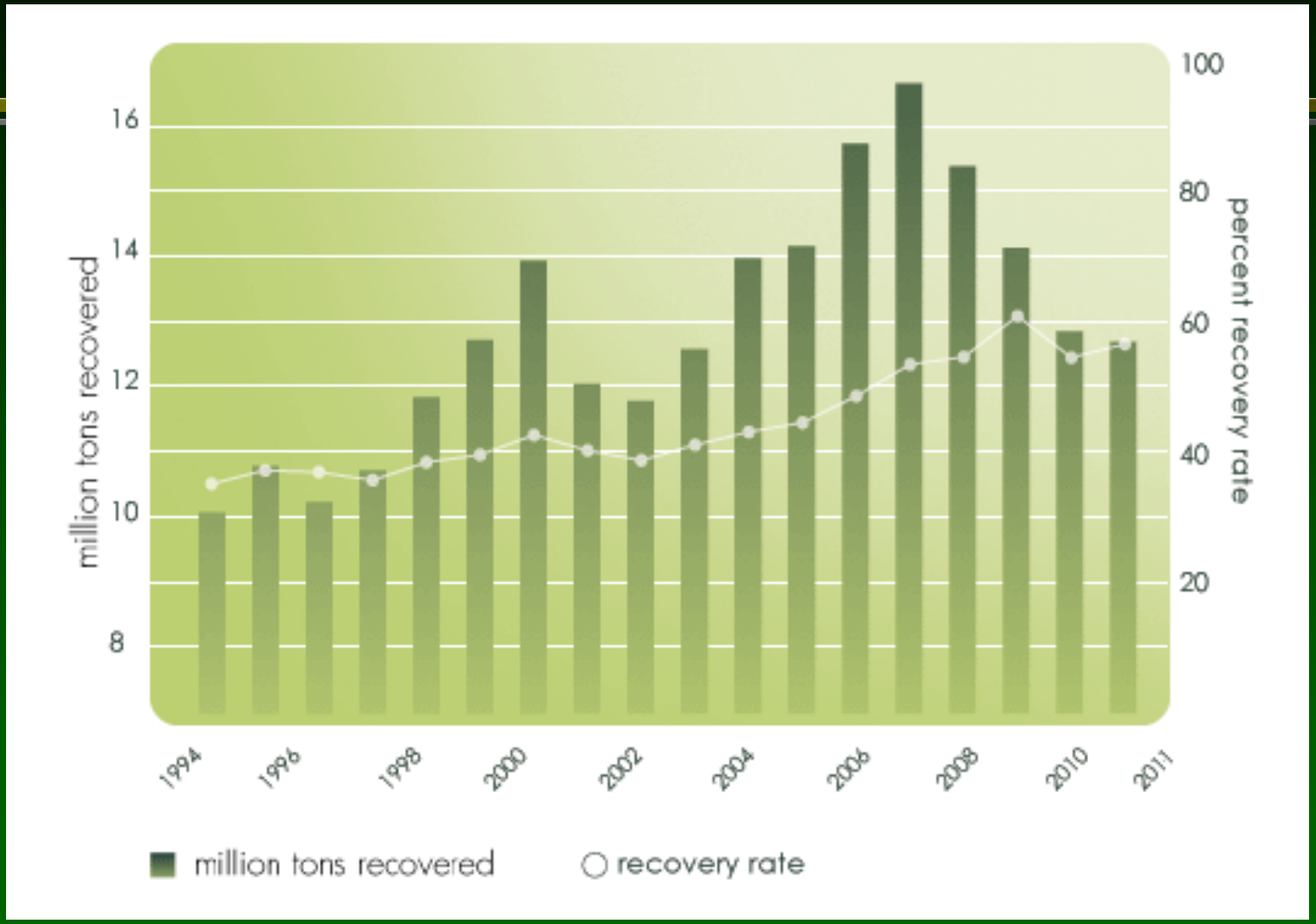
Includes ONP, uncoated mechanical, and coated ONP inserts.
7.5% decrease in consumption of ONP
Source: afandpa.org, 2012

Recovery of ONP (mechanical)

	At Paper and Board Mills (000 tons)	For Molded Pulp and Other Uses (000 tons)	Total Net Exports (000 tons)	Total (000 tons)	Total Newsprint Supply (000 tons)	Recovery Rate
1993	4,670	912	1,706	7,288	15,578	46.8%
1994	5,090	975	1,810	7,875	15,813	49.8%
1995	4,885	1,043	2,096	8,023	15,832	50.7%
1996	4,977	1,115	2,237	8,329	16,971	49.1%
1997	5,273	1,192	2,381	8,847	18,266	48.4%
1998	5,312	1,275	2,624	9,211	18,613	49.5%
1999	5,243	1,500	2,793	9,536	19,152	49.8%
2000	5,512	1,650	2,897	10,059	19,221	52.3%
2001	5,784	1,650	2,827	10,261	17,414	58.9%
2002	5,675	1,650	3,167	10,492	17,464	60.1%
2003	5,474	1,650	4,005	11,129	17,404	63.9%
2004	5,596	1,575	3,764	10,935	17,542	62.3%
2005	5,446	1,500	4,122	11,068	17,175	64.4%
2006	5,552	1,369	4,200	11,121	15,888	70.0%
2007	5,016	964	4,606	10,586	15,397	68.8%
2008	4,593	559	4,623	9,775	14,120	69.2%
2009	3,607	225	3,780	7,612	10,829	70.3%
2010	3,671	225	3,473	7,369	10,235	72.0%
2011	3.226	225	3,458	6,909	9,470	73.0%

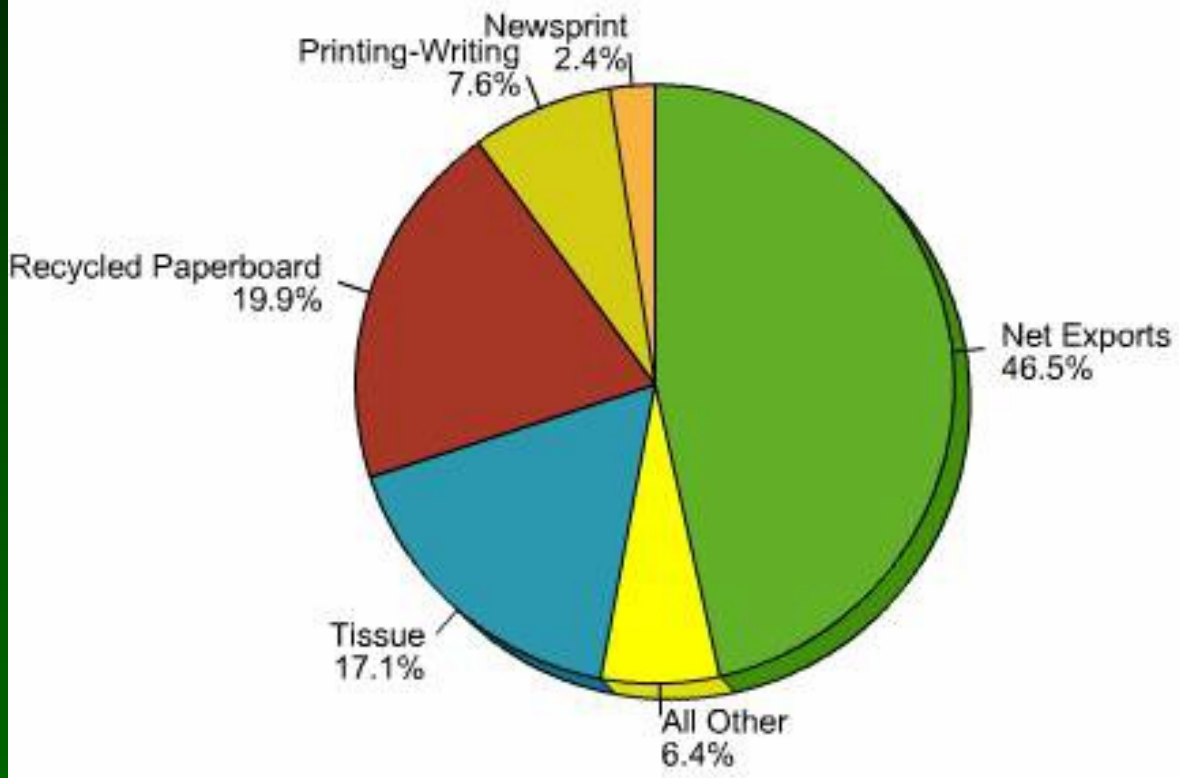
Source: afandpa.org, 2012

Recovery of Printing Writing Papers



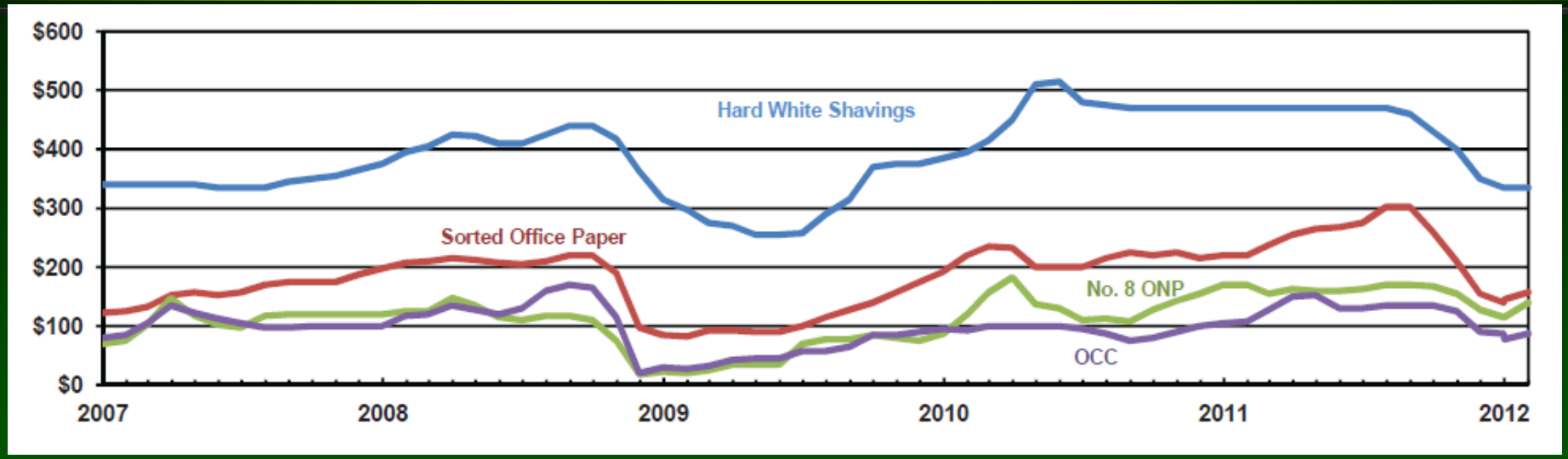
Purchases of PW Papers declined by 5%.
Source: afandpa.org, 2012

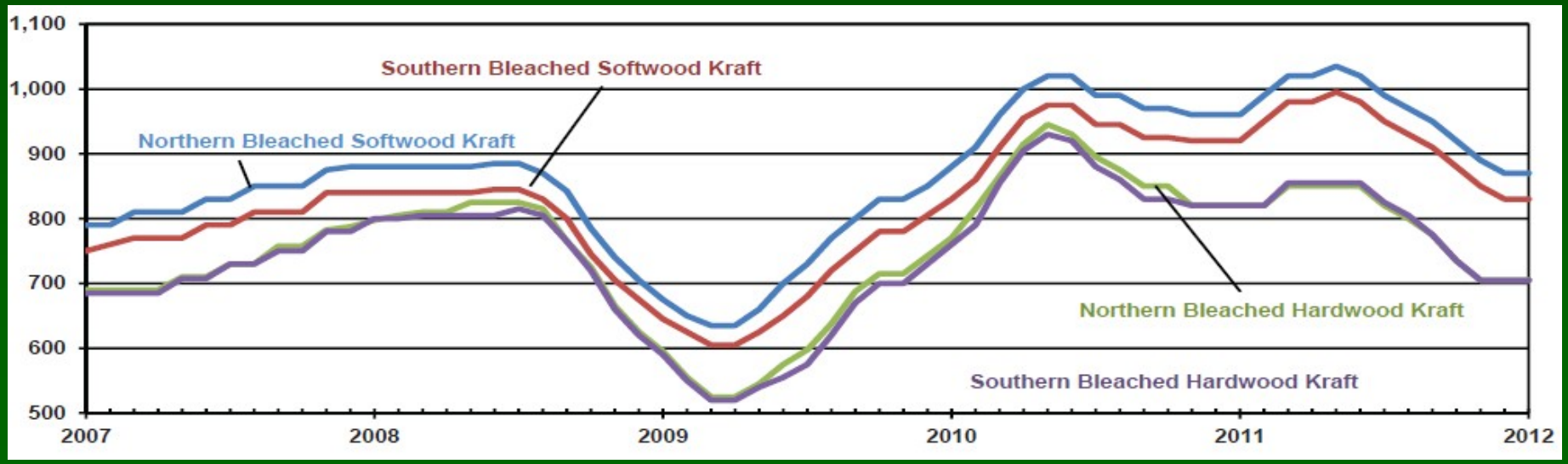
Where Printing-Writing Papers Go



Source: AF&PA, 2006 Recovered Paper Annual Statistics

Recovered Paper Prices, $/short ton, FOB sellers dock





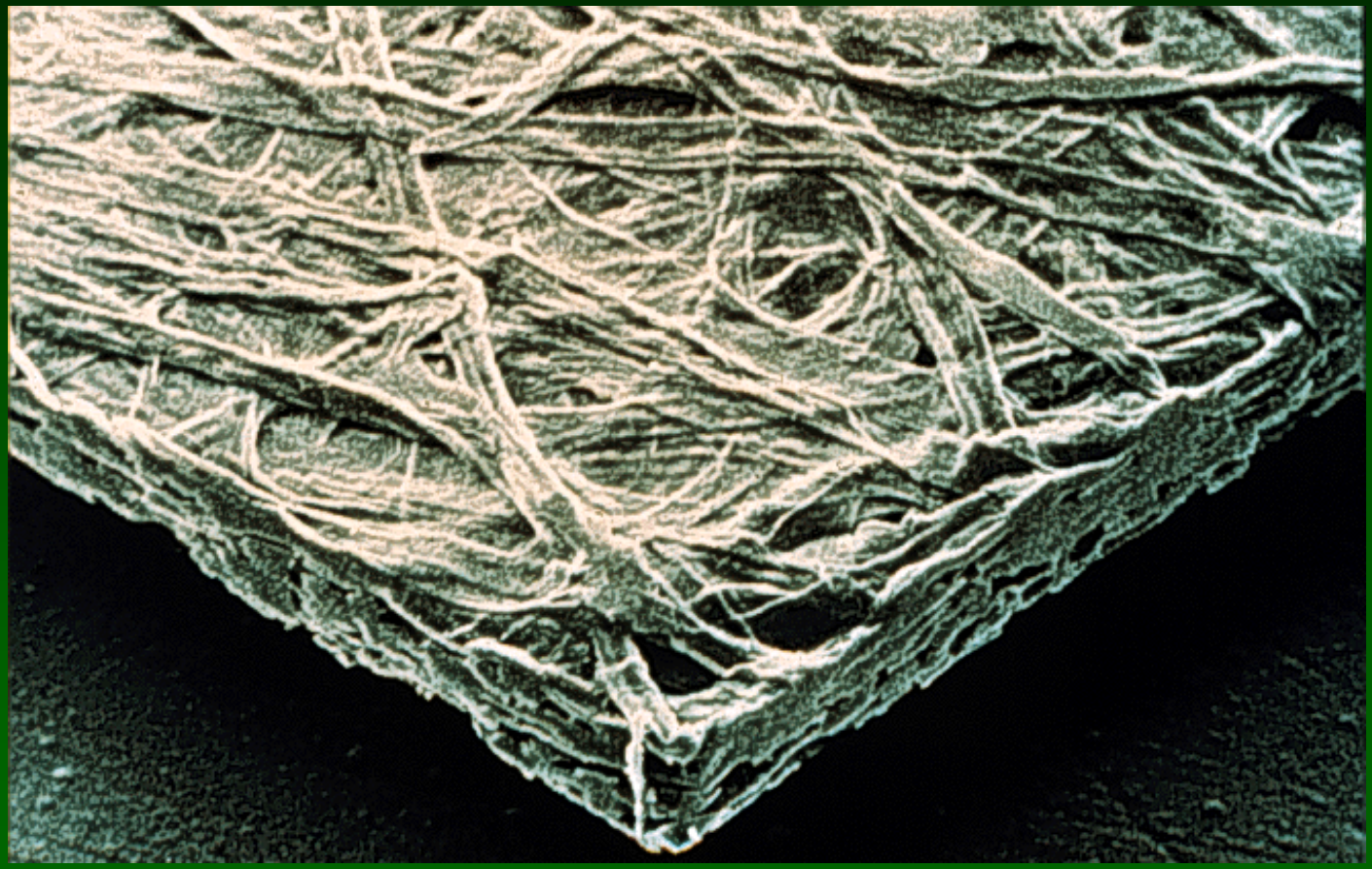
Recovered Paper Prices, $/ton

Grades	LTL 2/08	TL 2/08	LTL 2/09	TL 2/09	TL 1/10
Corrugated Cardboard	48	130	20	55	125
Old Newsprint	36	108	18	54	100
Box Board	33	90	17	45	
Old Magazines	8	24	4	12	
Mixed Paper	9	28	8	25	75
Sorted Office Paper	64	104	57	93	
White Ledger	114	266	102	238	
White Envelope	135	370	121	331	

Lecture:

Introduction to papermaking fibers

The Structure of a Paper Sheet



Slides courtesy of Med Byrd and Mike Kocurek

The Structure of a Paper Sheet

Where do papermaking fibers come from?

- Fibers to make paper are produced in a pulping process.
- Pulping: to liberate fibers for papermaking
- Process depends upon the raw material!

Is paper 100% fibers?

- No, the following are also added to paper depending on the grade:
  - Starch
  - Polymers
  - Inorganic particles: like clay, calcium carbonate, titanium dioxide
  - Waxes
  - Coatings
  - Optical brighteners
  - Dyes
  - More…….

Pulping Processes

- For virgin pulps (produced from wood or other plants)
  - mechanical pulping
  - semi-chemical pulping
  - chemical pulping
- For recycled pulps
  - repulping of paper in water (like a blender)

So if we start with WOOD?

- Wood is a *matrix* or *composite* material, with cellulosic fibers held rigidly in a lignin-hemicellulose matrix
- Since paper is made from individual fibers, they must be liberated from the overall matrix – this is done in the pulping process

What is Pulping ?

Wood – stiff, hard, tough material; useful for building and structures, but useless for papermaking

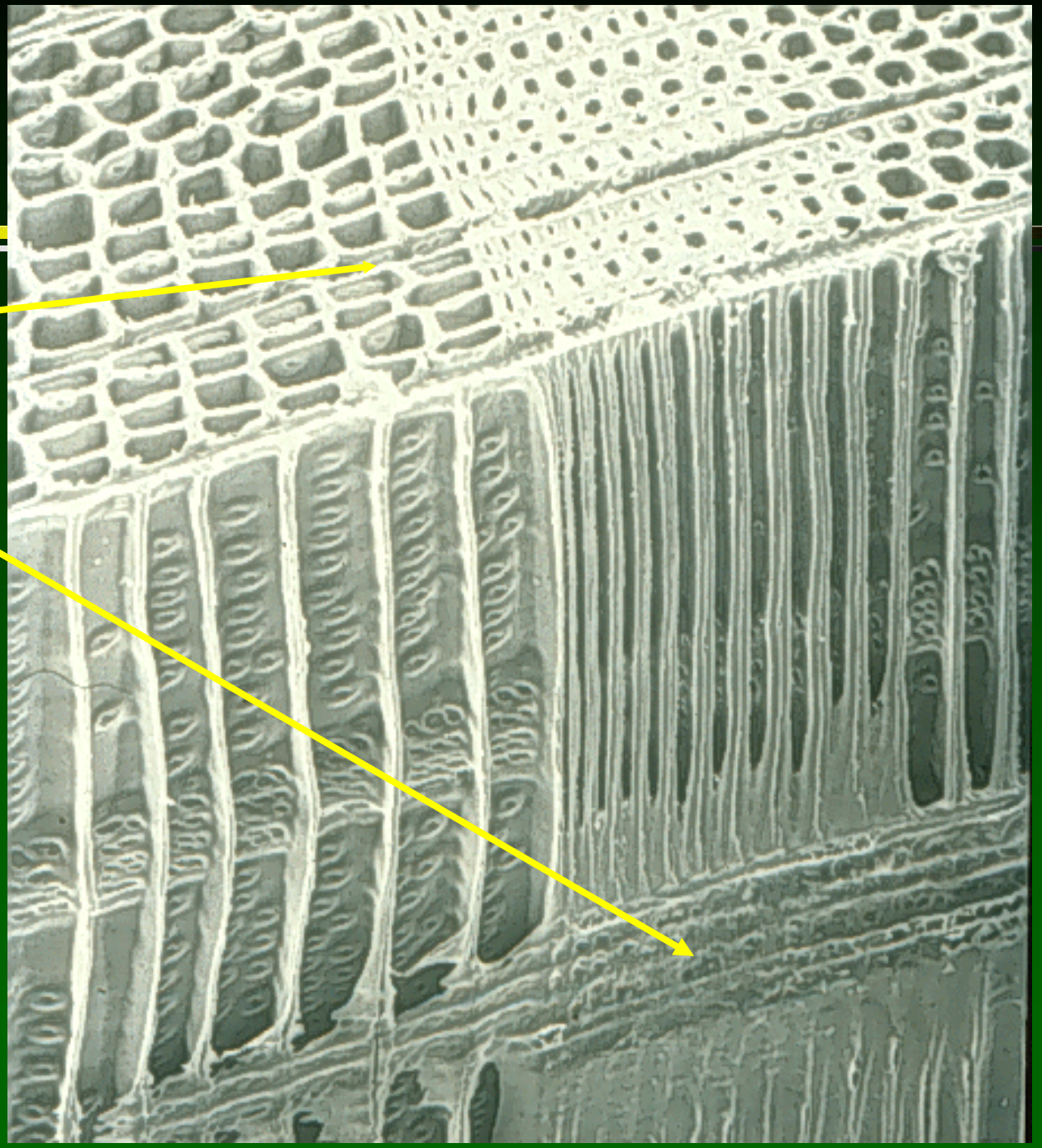
Fibers – thin, long, flexible, collapsible tubes; perfect for suspending in a water slurry and forming a papermaking web

Hardwoods and Softwoods

Softwoods

Longitudinal Cells

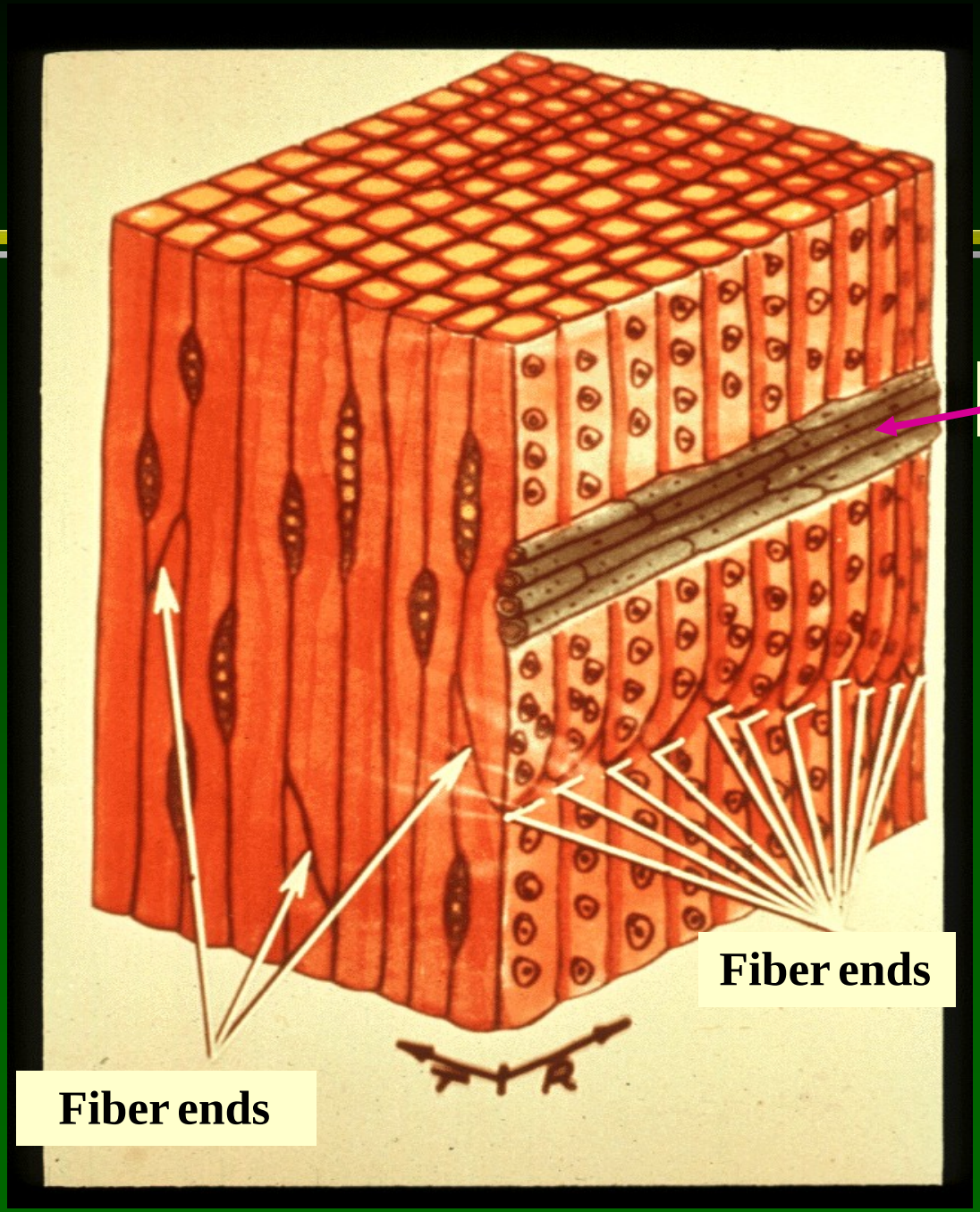
Ray Cells



Longitudinal cells used For transport.

Horizontal fibers used for

- **Storage (Starch, Hemicellulose, Oils, Water)**
- **Transport across the stem**


Ray Cells
Fiber ends
Fiber ends

Volumetric Composition – Soft wood

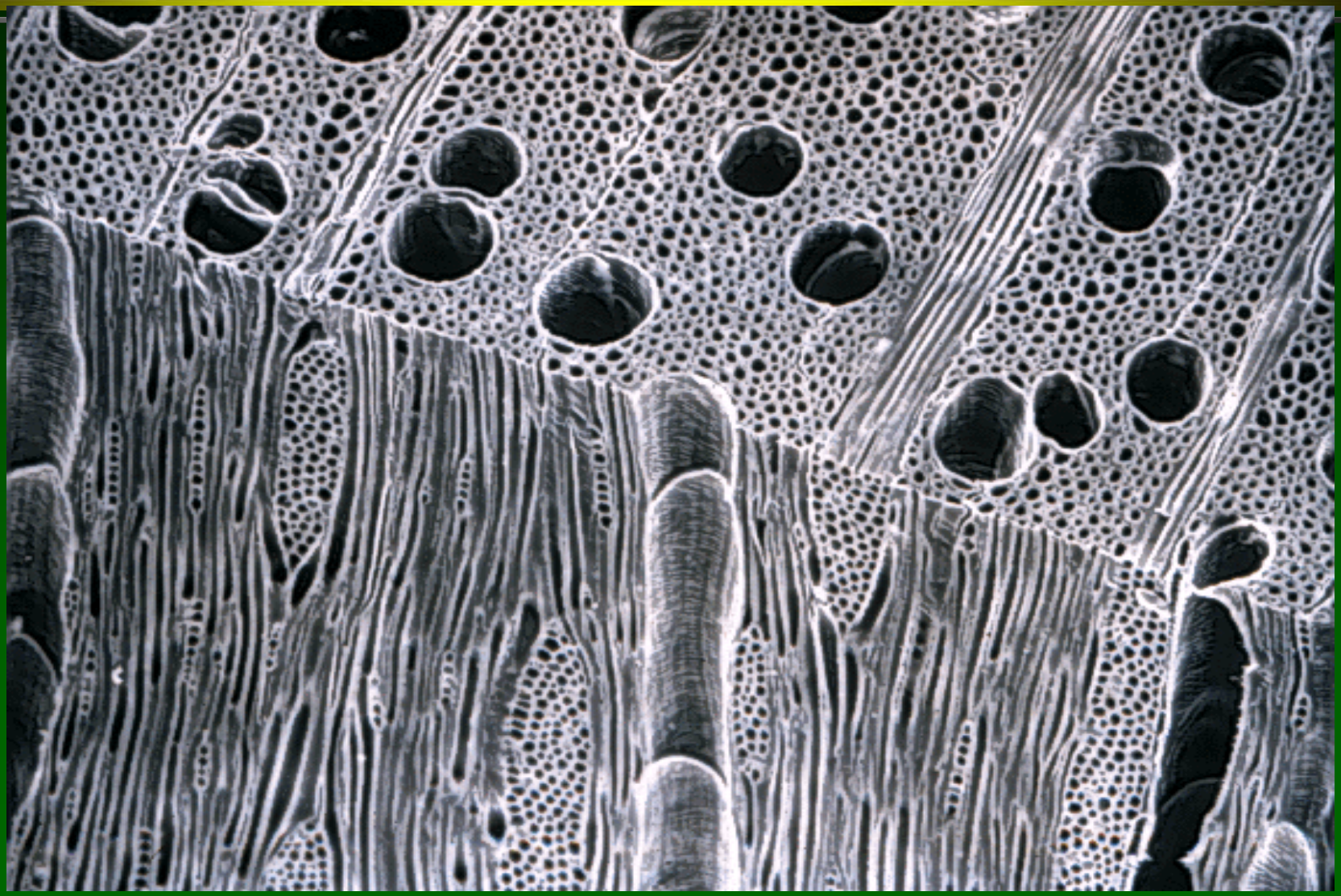
91 - 94%	Longitudinal Fibers
6 - 9%	Ray Cells

Average Fiber Dimensions - SoftWoods

	Region	Length	Diameter
Redwood	**NW**	**6.1**	**.05-.065**
Loblolly Pine	**S**	**3.6**	**.035-.045**
Longleaf Pine	**S**	**4.9**	**.035-.045**
White Spruce	**NE**	**3.3**	**.025-.03**
Red Cedar	**NW**	**3.5**	**.030-.04**

All dimensions in mm

Hardwood



HW and SW Cells

	Softwoods	Hardwoods
Conduction	Springwood	Vessels
Support	Summerwood	Fibers
Storage	Ray Cells	Ray Cells

a **Softwood fiber**

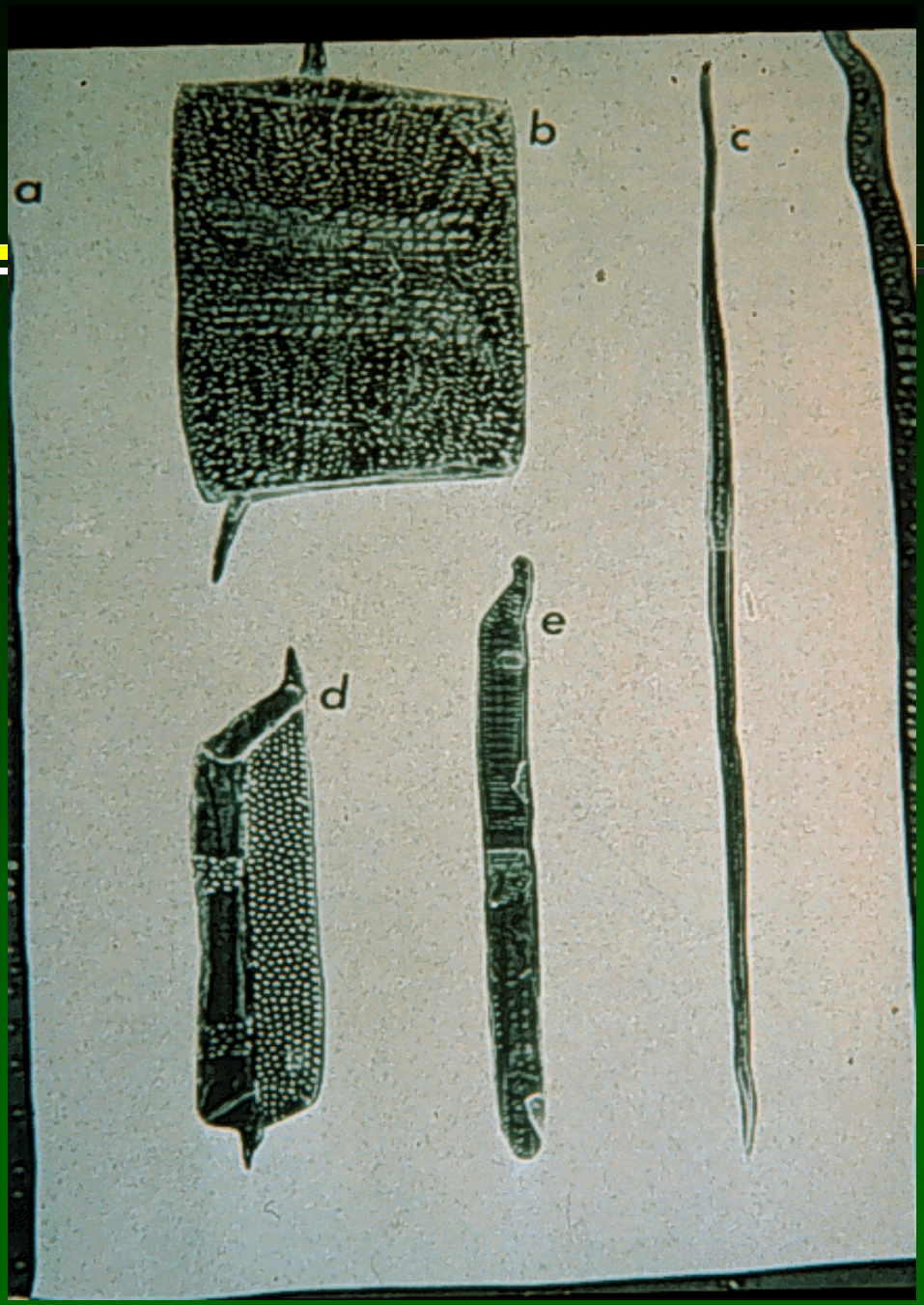
b,d,e **Vessel segments**

c **Hardwood fiber**

Average Cell Diameter:

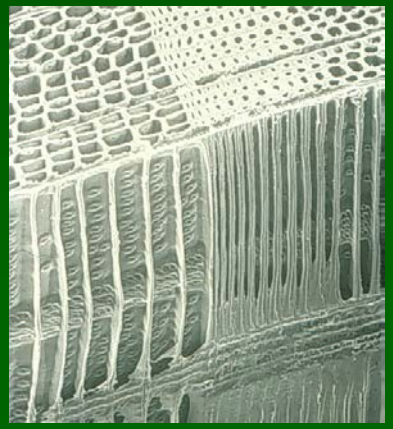
Vessels ***.020 - .500 mm***

Fibers ***< .020 mm***



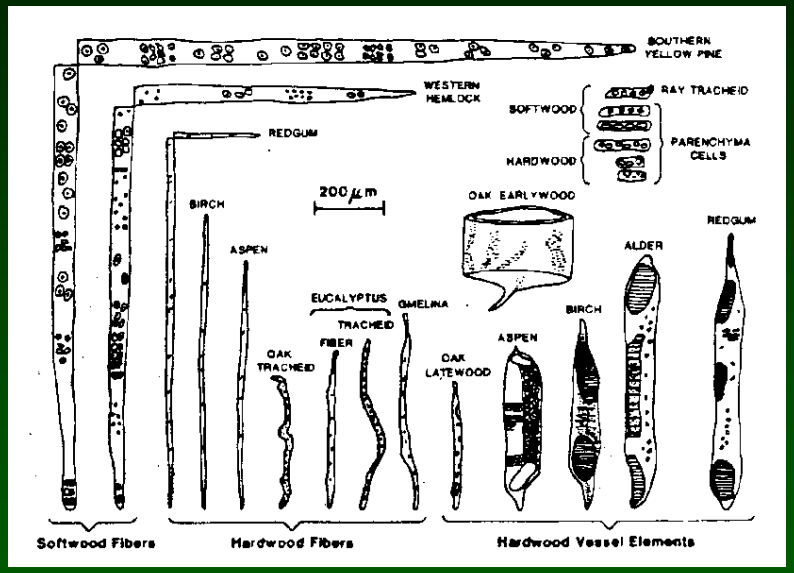
Cellular Composition

	Softwood	*Hardwood*
Fibers	*90%*	*27-76%*
Vessels	*0%*	*7-55%*
Parenchyma	*10%*	*5-25%*



Hardwood vs Softwood

- Softwood and hardwood pulp have different properties and consequently different uses.
- Softwood pulp can be made out of pine and spruce. The long-fibre pulp:
  - reinforcement pulp for improved runnability on the paper machine
  - paper board for strength
- The short-fibred hardwood pulp is made from oak, gum. It is used in the manufacture of printing papers.
  - enhances printability
  - end use properties (smoothness)



Pulping

Here is a micrograph of wood

Here are two individual fibers glued together with lignin

CLEARLY, to get pulp, at the very least these fibers must be separated somehow

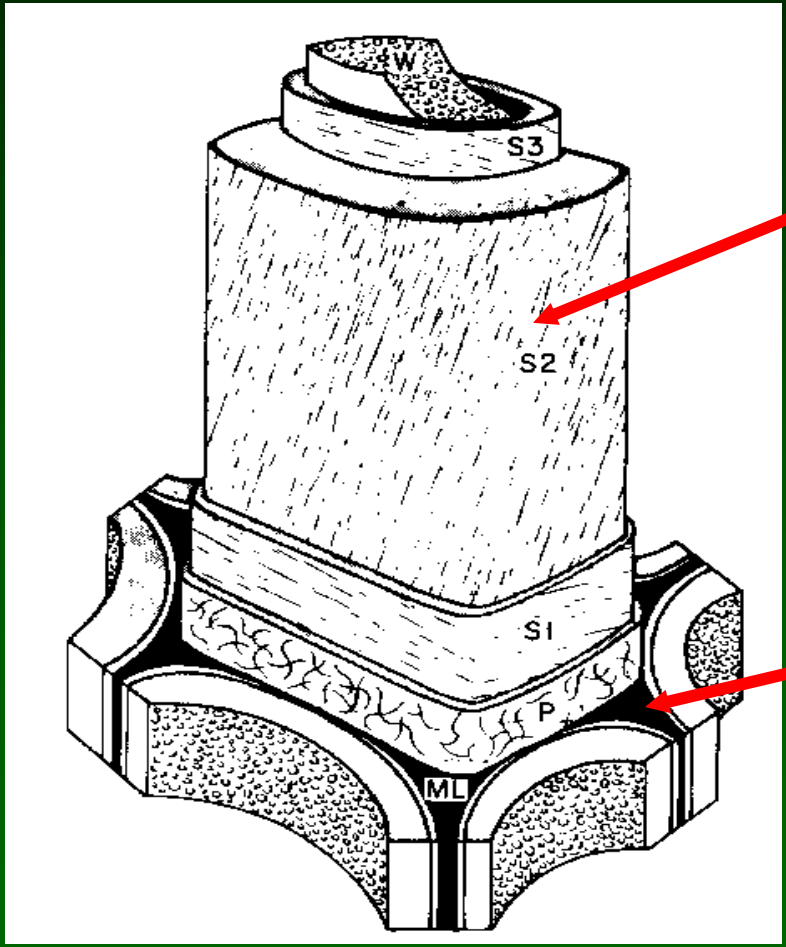
PULP

- This is the industry's term for the mass that results from the conversion of wood (or other plant materials) into its individual unit fibers

Types of Pulping

- There are three basic ways to convert wood into a fibrous pulp mass
- The method to use depends on the final paper product desired and how good the quality has to be…..
- *But what it ultimately depends upon is: how much lignin do we want to remove? None? All? And where from?*

Where's the Lignin?



The cell wall has MOST of the lignin in the fiber… but it is distributed over a lot of volume (low concentration)

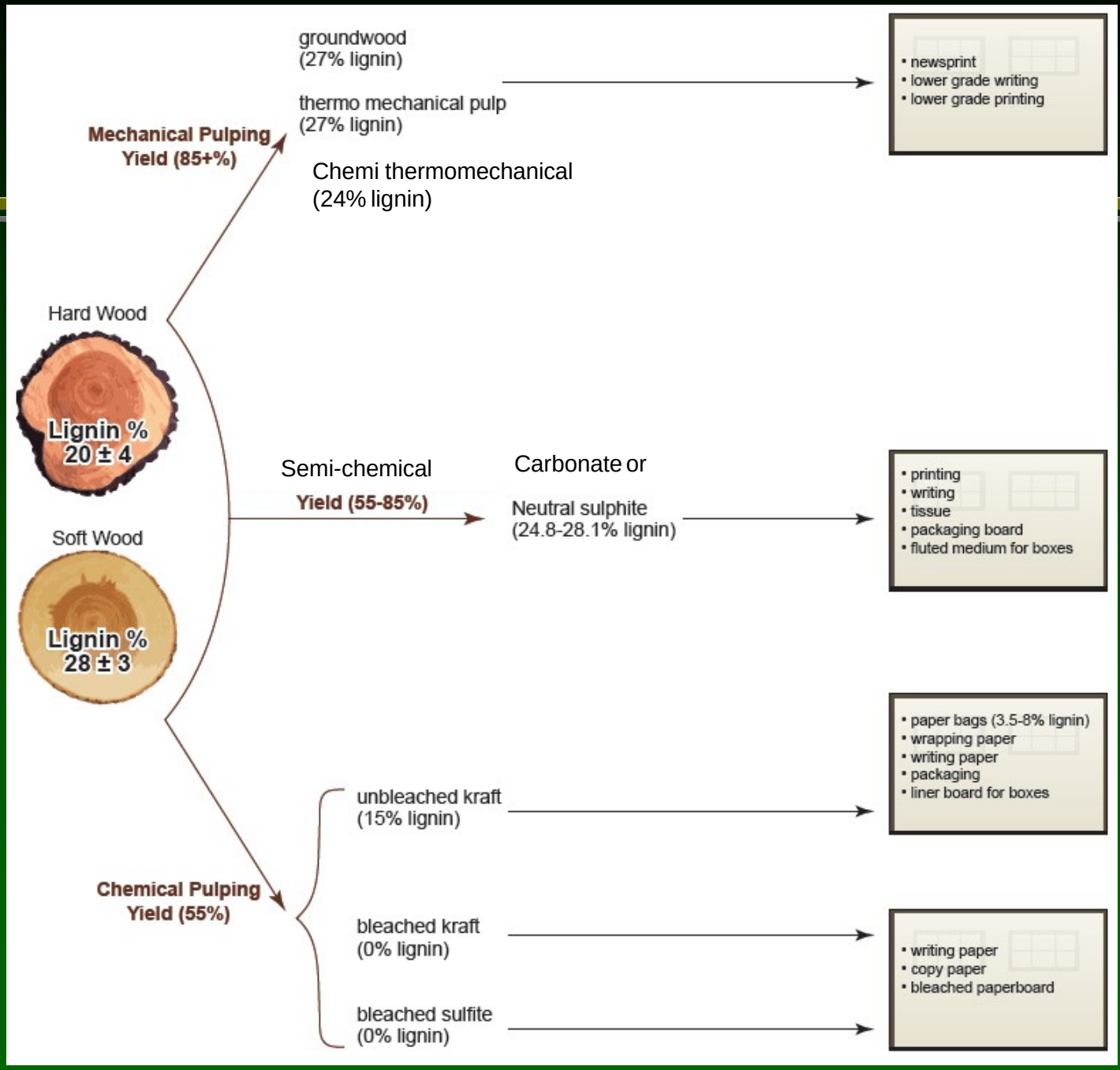
The middle lamella (ML) has a small amount of lignin… but it is in a concentrated form to glue the fibers together

Different Wood Pulping Mechanisms

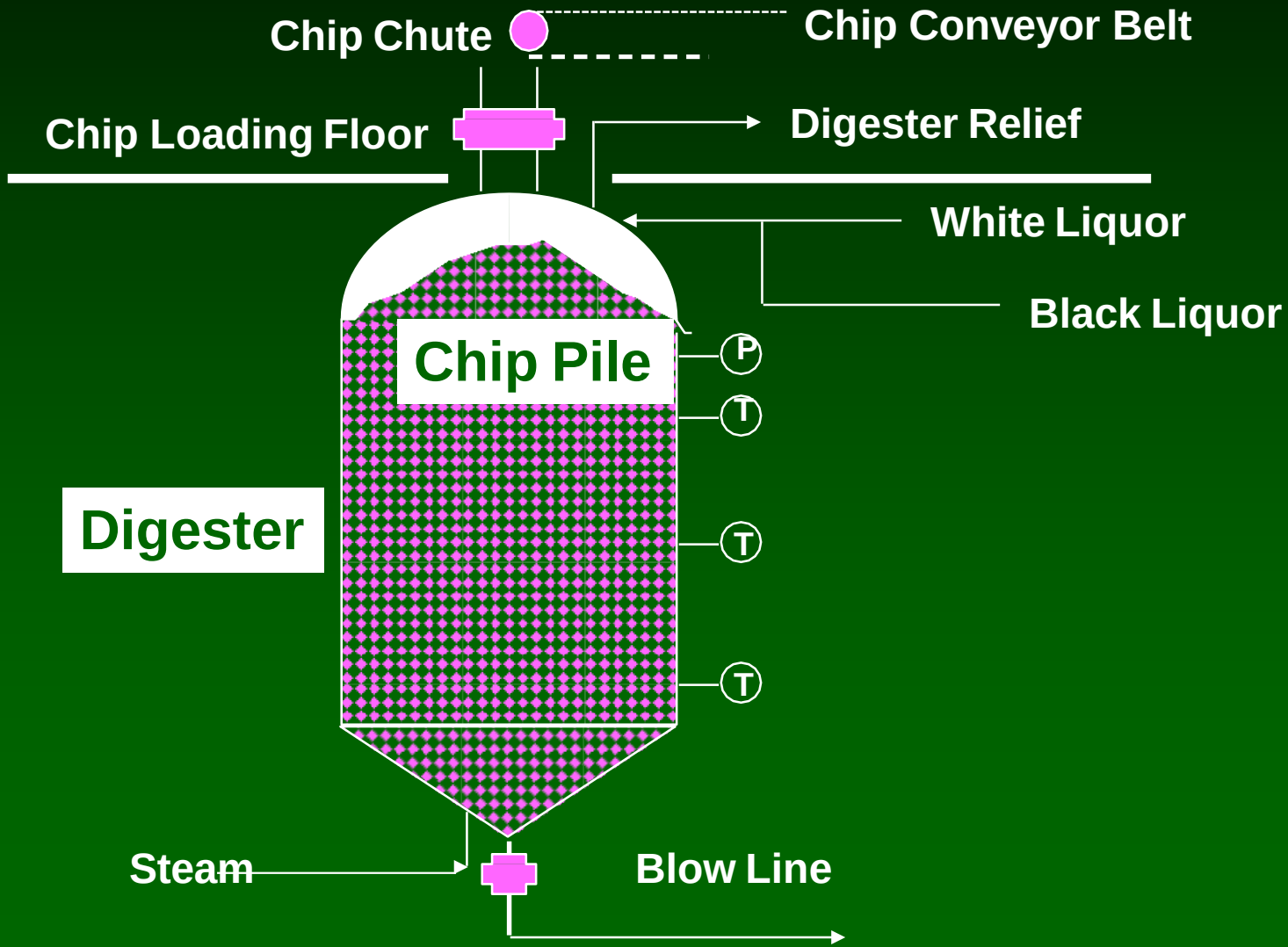
NO LIGNIN REMOVAL → **MECHANICAL PULPING**

SOME LIGNIN REMOVAL → **SEMI-CHEMICAL PULPING**

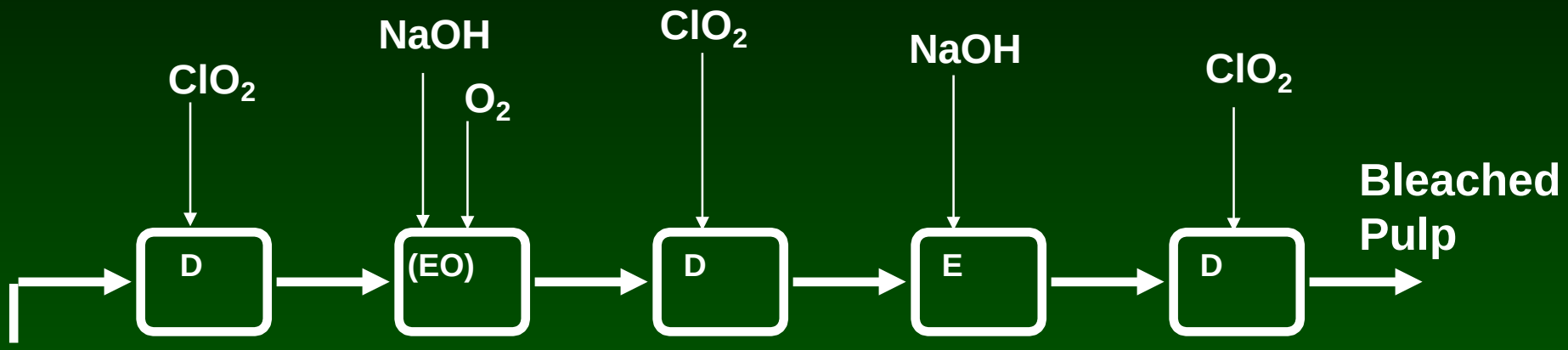
TOTAL LIGNIN REMOVAL → **CHEMICAL PULPING**


groundwood
(27% lignin)
thermo mechanical pulp
(27% lignin)
Mechanical Pulping
Yield (85+%)
Chemi thermomechanical
(24% lignin)
• newsprint
• lower grade writing
• lower grade printing
Hard Wood
Lignin %
20 ± 4
Semi-chemical
Yield (55-85%)
Carbonate or
Neutral sulphite
(24.8-28.1% lignin)
• printing
• writing
• tissue
• packaging board
• fluted medium for boxes
Soft Wood
Lignin %
28 ± 3
• paper bags (3.5-8% lignin)
• wrapping paper
• writing paper
• packaging
• liner board for boxes
unbleached kraft
(15% lignin)
Chemical Pulping
Yield (55%)
bleached kraft
(0% lignin)
• writing paper
• copy paper
• bleached paperboard
bleached sulfite
(0% lignin)

Chemical Pulping
Direct Heated Batch Digester



Bleaching Sequence

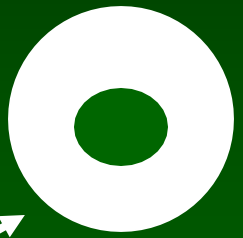


Usually done with multiple stages using different chemicals

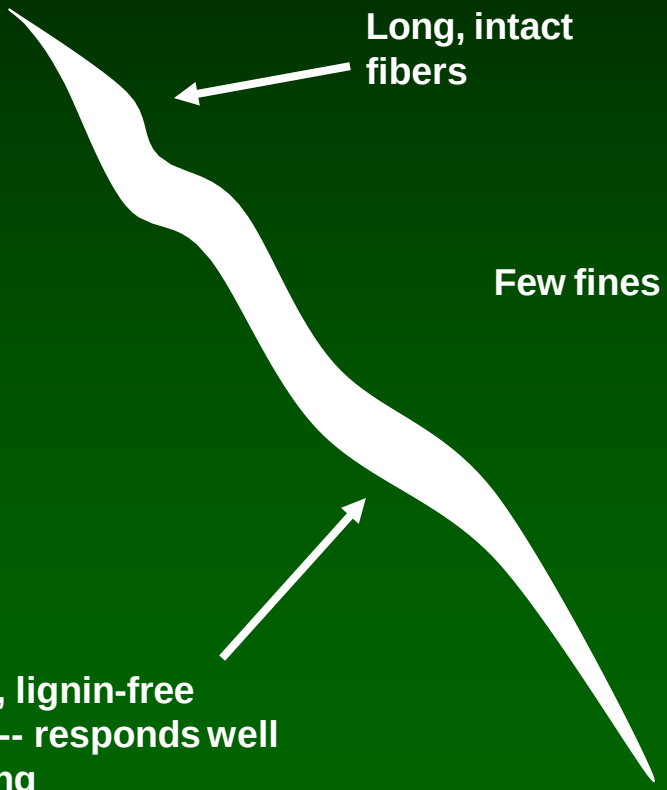
ClO_2 = Chlorine Dioxide (D)
NaOH= Sodium Hydroxide (E)
O_2= Oxygen (O)

Bleach Towers

A Chemical Pulp Fiber



Fiber wall mostly or fully free from lignin; maximum internal bonding possible



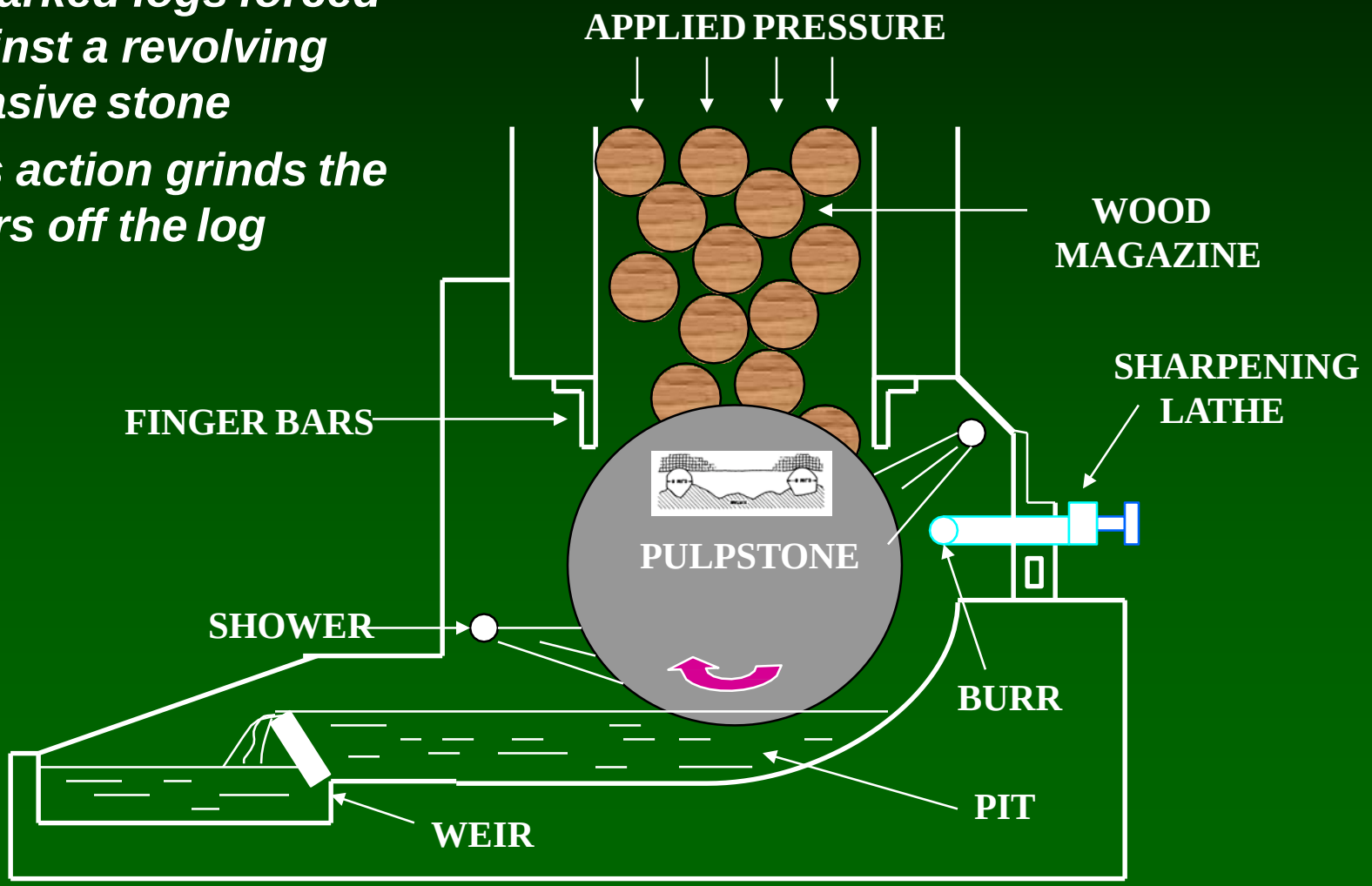
Long, intact fibers

Few fines

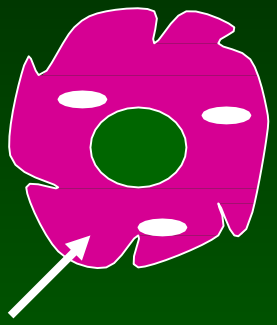
Smooth, lignin-free surface -- responds well to refining

Groundwood Process

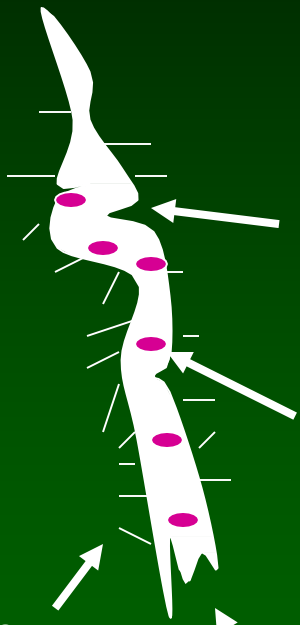
- *Debarked logs forced against a revolving abrasive stone*
- *This action grinds the fibers off the log*



A Mechanical Pulp Fiber



Most or all of lignin still in wall; interferes with internal bonding



Lots of fines & debris

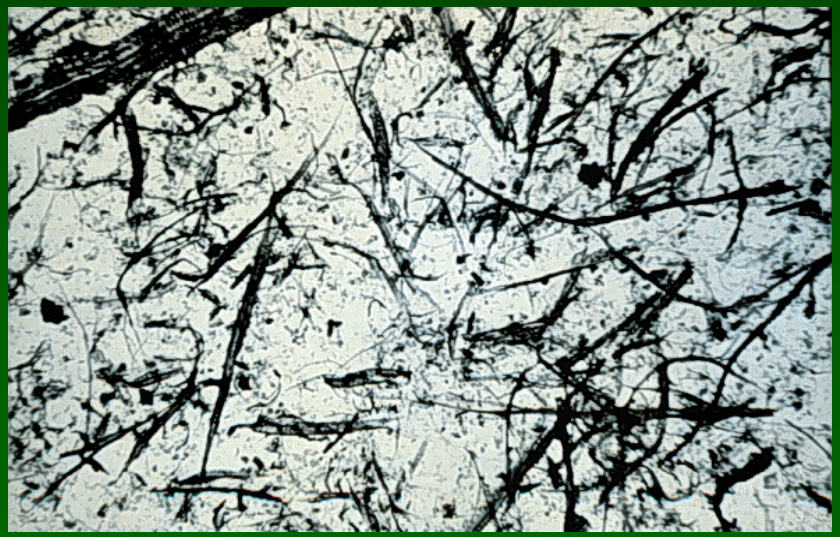
Cracks and tears in wall

Lignin patches on surface

Surface already fibrillated

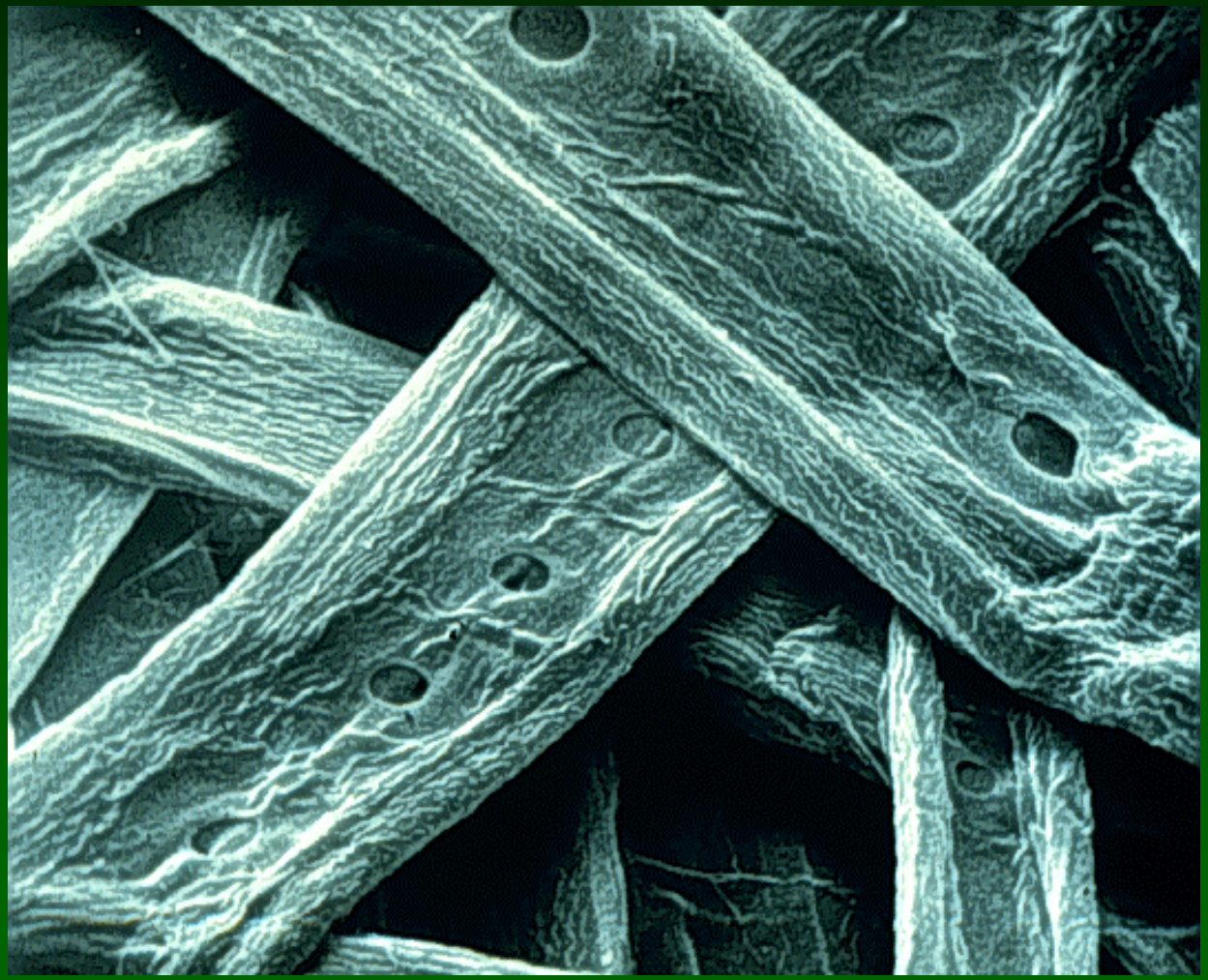
Fiber cut

SOUTHERN PINE
CHEMICAL PULP

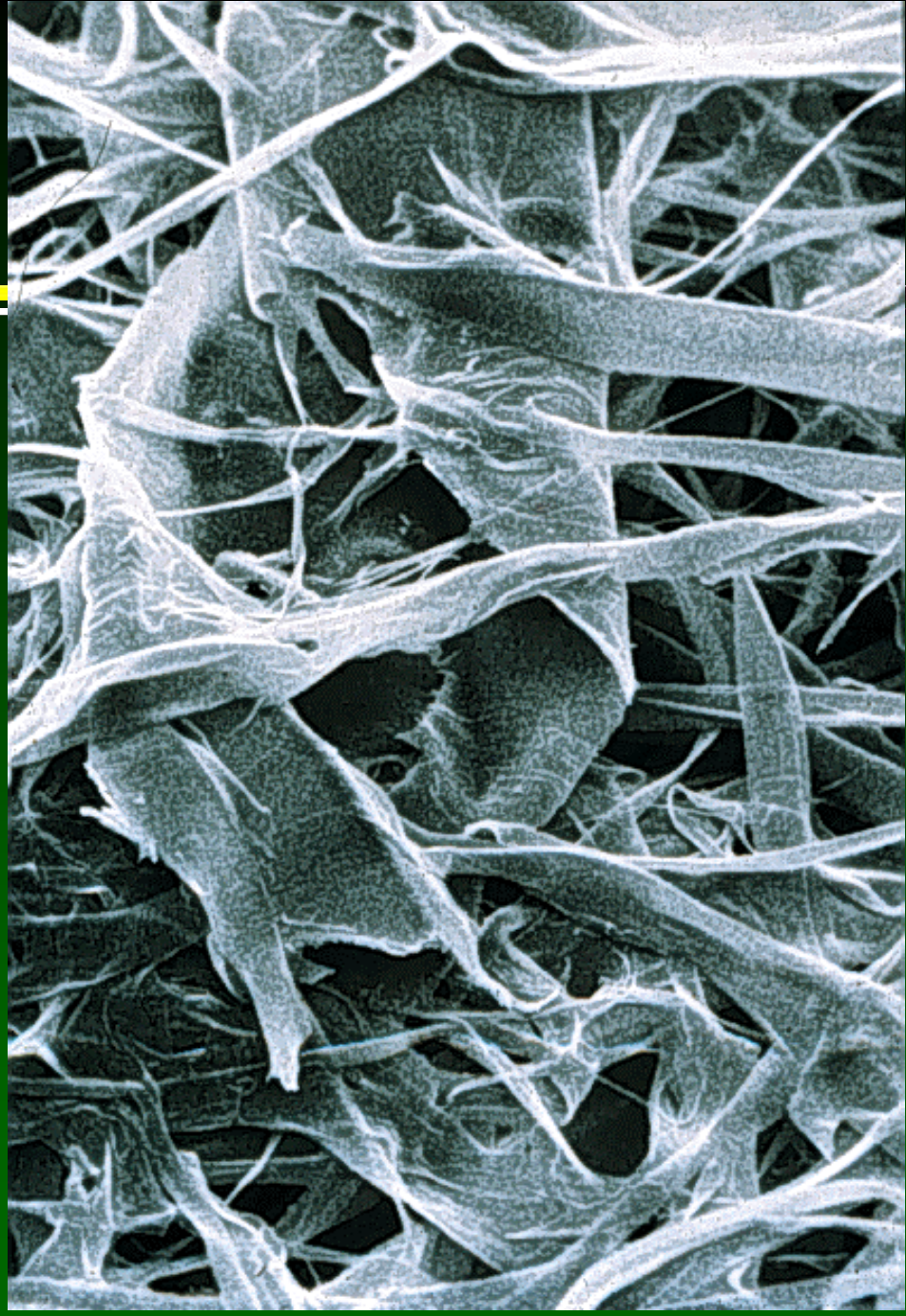


SOUTHERN PINE
MECHANICAL PULP
WITH FINES

Chemical Pulp Sheet



Mechanical Pulp Sheet



What's Good About Leaving Lignin in the Fiber?

- Produces bulky, porous sheets
- Lignin and fines are good light-scatterers; sheets have good opacity
- Lignin permits high filler loading
- Leaving lignin in is good for economics (yield, capital, operating)
- For low value newsprint, leaving lignin in is good!!!

What's Bad About Leaving Lignin in the Fiber?

- Lignin on fiber surface interferes with fiber-fiber bonds
- Lignin inside cell walls inhibits collapsibility and internal bonding
- Lignin makes paper darker, especially degraded lignin like in unbleached kraft
- *Lignin absorbs UV light and produces sheet yellowing and premature degradation, example: newsprint*

Summary: Chemical vs. Mechanical Pulps

- Chemical pulping generally delivers longer, stronger, cleaner, brighter pulps with lower opacity and higher cost (if bleached, brown if not bleached)
- Mechanical pulping generally delivers shorter, weaker, dirtier, lower-brightness pulps with great bulk, opacity, and cost
- The worse characteristic of mechanical pulps is they turn **yellow** with age

Recovered Paper: Virgin Wood Pulping Process Matters

- There are many grades of recovered paper
- However, paper is recycled according to its virgin pulping method
  - Bleached chemical pulps: white (ledgers and others…)
  - Unbleached chemical pulps: brown (corrugated containers and others…..)
  - Mechanical pulps: initially grey and yellows (newsprint and others…..)
- It should be noted that these groups are used ideally by themselves to produce products
- Most grades of paper predominantly consist of one of these fiber types
- Very inexpensive paper products use mixes of these (like shoe boxes)

Summary: Chemical vs. Mechanical Pulps

- Chemical pulps that have been bleached have almost zero lignin, are white and make good printing paper
  - (printing and writing papers such as copy paper)
- Chemical pulps that are not bleached are brown and strong
  - Used mostly for linerboard
- Mechanical pulps are low value, low cost fibers that yellow,
  - reasonable for newsprint and cheap catalogs and directories

Lecture:

Grades of recovered paper

Recycled Fiber Definitions

- **Virgin Fiber: produced directly from wood in a pulping process**
- **Secondary Fiber: fibers that have previously been produced in a manufacturing process and have been reclaimed as raw material for another process.**
- **Pre-consumer waste: any waste, printed or unprinted, generated in the fabrication or conversion of finished paper. Before use by a consumer as a final end product.**
- **Post-consumer waste: Paper that has passed through the end usage as a consumer product.**
- **Internal broke: off-specification paper that is repulped and used at the same site, not considered secondary fiber.**

Recovered Paper

- There are many grades of recovered paper
- They are characterized mainly (from a practical standpoint) by the paper products that they contain
- However, paper is recycled in groups according to its virgin pulping method (scientific)
  - Bleached chemical pulps: white, typically mostly HW (short)
  - Unbleached chemical pulps: brown, typically mostly SW (long)
  - Mechanical pulps: grey and yellows with time
- It should be noted that these groups should optimally be recycled by themselves to produce products
- Most grades of paper predominantly consist of one of these fiber types, but stray amounts of the other types are often present

Recovered paper is recycled into what products?

- Printing and writing recovered paper (bleached chemical) recycled into:
  - Printing and writing
  - Tissue
- Old Corrugated container (unbleached kraft and semi-chemical) recycled into:
  - Linerboard and fluted medium
  - Tube stock
- Old newspapers (mechanical pulps) recycled into:
  - Newspapers
  - Folding cartons
  - Molded pulp products like egg cartons
  - Tissue
- Mixed papers
  - Any low valued product

Why have recovered paper grades?

- **Type, cost and quality of recovered paper are critically important to the design and operation of a paper recycling mill.**
- **The type of fibers existing in the recovered paper have an enormous effect on the resulting recycled paper properties.**

Why have recovered paper grades?

- **Recovered paper grades serve:**
  - **Classify the various types of recovered paper**
  - **Describe the type of paper included in a grade**
  - **Specify general quality requirements in the grade**
  - **Provide a basis for establishing the market value of a recovered paper grade**

The market value of a recovered paper grade depends on:

- Optical properties of the fibers contained (brightness, color..)
- Types of fibers (chemical fibers, mechanical fibers)
- Types of fibers (softwood versus hardwood)
- Types of materials applied to the papers (clay coatings, wax, xerographic inks, wet strength agents……)
- The presence and amounts of various other types of paper present in the grade
- The presence and amount of contaminant s in the grade

Recovered Paper Prices, $/ton

Grades	LTL 2/08	TL 2/08	LTL 2/09	TL 2/09	TL 1/10
Corrugated Cardboard	48	130	20	55	125
Old Newsprint	36	108	18	54	100
Box Board	33	90	17	45	
Old Magazines	8	24	4	12	
Mixed Paper	9	28	8	25	75
Sorted Office Paper	64	104	57	93	
White Ledger	114	266	102	238	
White Envelope	135	370	121	331	

The cost of fiber:

- Paper is bought on a per ton of a recovered paper grade
- However, it is the usable fiber in that grade that is really what is being bought
- The true cost of the fiber in any given grade is actually:

- $$Cost\ for\ fiber\ \left(\frac{\$}{ton\ fiber}\right) = \frac{\$\ cost\ of\ the\ grade}{ton\ of\ the\ grade} \text{x} \frac{1\ ton\ of\ the\ grade}{X\ ton\ of\ fiber}$$

- Where x equals the mass fraction of the grade that is fiber,
- For example if a grade has 80% fiber and 20% other material then x=0.8.

The cost of fiber:

- How much is the cost of fiber using the data on the previous sheet for mixed paper at the date of January 2010 if the mixed paper is known to have 50% fiber content?

- $$Cost\ for\ fiber\ \left(\frac{\$}{ton\ fiber}\right) = \frac{\$75\ \ cost\ of\ the\ grade}{ton\ of\ the\ grade} \text{x} \frac{1\ ton\ of\ the\ grade}{0.5\ ton\ of\ fiber}$$

- Cost for fiber = $150/ton of fiber

Recovered Paper Grades Reference

Scrap Specifications Circular 2013

Guidelines for

Nonferrous Scrap

Ferrous Scrap

Glass Cullet

Paper Stock

Plastic Scrap

Electronics Scrap

Tire Scrap

EFFECTIVE 10/25/2012

ISRI
Voice of the Recycling Industry

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Guidelines for Paper Stock: PS-2013—Domestic Transactions Paper Stock: Domestic Transactions

- **Preamble:** These standards and practices apply to paper stock for repulping only and are for use in the United States, Canada, and Mexico. Transactions may be modified by mutual agreement between Buyer and Seller.

- **Basic to the Success of any Buyer-Seller Relationship is an Atmosphere of "Good Faith."** In keeping with this, the following principles have been established:
  - **Seller must use due diligence to ascertain that shipments consist of properly packed paper stock and that shipments are made during the period specified.**
  - **Arbitrary deductions, cancellations and/or rejections by the Buyer are counter to acceptable good trade practices.**
  - **Seller shall provide the quality of paper stock agreedupon but shall not be responsible for the use of the paper stock or of the manufactured product.**

Scrap Specifications Circular, Guidelines for ….Paper Stock…
By: Institute of Scrap Recycling Industries, Inc.

Guidelines for Paper Stock: The Purchase Agreement

- **Quantity**
  - **Short tons, 2000 lb**
  - **Metric tonnes, 2204.6 lb or 1000 kg**
  - **Order complete when +/- 5% is shipped**
- **Grade Specified as in the Guidelines**
- **Packing type specified**
  - **Bales, skids, rolls, pallets, boxes, secure bundles or loose**
- **Pricing and terms**
- **Shipping terms**
  - "*FOB shipping point*" or "FOB origin" indicates the buyer pays shipping cost and takes responsibility for the goods when the goods leave the seller's premises.
  - **F.O.B. delivered means that the price given to the customer represents all costs needed to delivered the product to the customer's home or business**
- **Shipping instructions**
- **Shipping period**

Scrap Specifications Circular, Guidelines for ….Paper Stock…
By: Institute of Scrap Recycling Industries, Inc.

Definitions

- **Out-throw:**
  - **“all papers that are so manufactured or treated or are in such a form as to be *unsuitable* for consumption as the grade specified”**
- **Prohibitive Material:**
  - **material in excess of specified maximum make the recovered paper *unusable* as the grade specified**
  - **Any materials that may be *damaging* to the equipment**
  - **Sorted material must be free of food, medical, hazardous waste**
  - **Wax, unless agreed to be accepted by the buyer**

Scrap Specifications Circular, Guidelines for ….Paper Stock…
By: Institute of Scrap Recycling Industries, Inc.

Example:

- **News, De-ink Quality #7. Consists of sorted, fresh newspapers, not sunburned, containing not more than the normal amount of rotogravure and colored sections.**
  - **Prohibitive Materials — None Permitted**
  - **Total Outthrows may not exceed — ¼ of 1%**

Scrap Specifications Circular, Guidelines for ….Paper Stock…
By: Institute of Scrap Recycling Industries, Inc.

Grades: Some mixed grades

(1) Residential Mixed Paper

Consists of a mixture of various qualities of paper not limited as to type of fiber content, normally generated from residential, multi-material collection programs.

Prohibitive Materials may not exceed	2%
Outthrows plus prohibitives may not exceed	5%

(2) Soft Mixed Paper

Consists of a clean, sorted mixture of various qualities of paper not limited as to type of fiber content.

Prohibitive Materials may not exceed	1%
Outthrows plus prohibitives may not exceed	5%

(3) Hard Mixed Paper (HMP)

Consists of a clean, sorted mixture of various qualities of paper containing less than 10% groundwood content.

Prohibitive Materials may not exceed	½ of 1%
Outthrows plus prohibitives may not exceed	3%

(36) Unsorted Office Paper (UOP)

Consists of printed or unprinted paper typically generated in an office environment that may include a document destruction process. This grade may contain white, colored, coated and uncoated papers, manila and pastel colored file folders.

Prohibitive Materials may not exceed	2%
Outthrows plus prohibitives may not exceed	10%

(37) Sorted Office Paper (SOP)

Consists of paper, as typically generated by offices, containing primarily white and colored groundwood-free paper, free of unbleached fiber. May include a small percentage of groundwood computer printout and facsimile paper.

Prohibitive Materials may not exceed	1%
Outthrows plus prohibitives may not exceed	5%

Grades: Containing Mechanical Pulps such as ONP

(6) Old Newspaper
Consists of sorted newspapers and other acceptable papers as typically generated by voluntary collection and curbside collection programs.

Prohibitive Materials may not exceed	2%
Outthrows plus prohibitives may not exceed	4%
Other acceptable papers may not exceed	30%

(7) Regular News, De-ink Quality (#7 ONP)
Consists of sorted, fresh newspapers, not sunburned, and other acceptable papers. This grade may contain magazines.

Prohibitive Materials may not exceed	1%
Outthrows plus prohibitives may not exceed	3%
Other acceptable papers may not exceed	20%

(8) Special News, De-ink Quality (#8 ONP)
Consists of sorted, fresh newspapers, not sunburned, and other acceptable papers. This grade is to be relatively free from magazines and contain not more than the normal percentage of rotogravure and colored sections.

Prohibitive Materials may not exceed	1%
Outthrows plus prohibitives may not exceed	2%
Other acceptable papers may not exceed	10%

(9) Over-Issue News (OI or OIN)
Consists of unused, overrun newspapers printed on newsprint, containing not more than the normal percentage of rotogravure and colored sections.

Prohibitive Materials	None permitted
Outthrows plus prohibitives	None permitted

(23) Telephone Directories
Consists of clean telephone directories printed for or by telephone directory publishers.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	½ of 1%

(24) White Blank News (WBN)
Consists of unprinted cuttings and sheets of white newsprint or other uncoated white groundwood paper of similar quality.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	1%

(25) Groundwood Computer Printout (GW CPO)
Consists of groundwood papers which are used in forms manufactured for use in data processing machines. This grade may contain colored stripes and impact or nonimpact (e.g., laser) computer printing.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	2%

Grades: Old Magazines,
typically recycled with ONP into recycled newsprint ,
can be both mechanical and chemical fibers
tend to have a lot of inorganic material in fillers and coatings

(10) Magazines (OMG)

Consists of coated magazines, catalogues, and similar printed materials. May contain a small percentage of uncoated news-type paper.

Prohibitive Materials may not exceed	1%
Outthrows plus prohibitives may not exceed	3%

Grades: Unbleached kraft, such as old corrugated containers

(11) Old Corrugated Containers (OCC)
Consists of corrugated containers having liners of either test liner or kraft.

Prohibitive Materials may not exceed	1%
Outthrows plus prohibitives may not exceed	5%

(12) Double-Sorted Old Corrugated (DS OCC)
Consists of double-sorted corrugated containers, generated from supermarkets and/or industrial or commercial facilities, having liners of test liner or kraft. Material has been specially sorted to be free of boxboard, off-shore corrugated, plastic, and wax.

Prohibitive Materials may not exceed	½ of 1%
Outthrows plus prohibitives may not exceed	2%

(13) New Double-Lined Kraft Corrugated Cuttings (DLK)
Consists of new corrugated cuttings having liners of either test liner or kraft. Treated medium or liners, insoluble adhesives, butt rolls, slabbed or hogged medium, are not acceptable in this grade.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	2%

(19) Kraft Grocery Bag (KGB)
Consists of new brown kraft bag cuttings, sheets and misprint bags.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	1%

(20) New Kraft Multi-Wall Bag
Consists of new brown kraft multi-wall bag cuttings, sheets, and misprint bags, free of stitched papers.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	1%

(21) New Brown Kraft Envelope Cuttings
Consists of new unprinted brown kraft envelopes, cuttings or sheets.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	1%

Grades: Bleached kraft, called High grades or ledger grades, white paper such as copy paper

(30) Hard White Shavings (HWS)
Consists of shavings or sheets of unprinted, untreated white groundwood-free paper.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	½ of 1%

(31) Hard White Envelope Cuttings (HWEC)
Consists of groundwood-free cuttings, shavings, or sheets of unprinted, untreated, and uncoated white envelope paper.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	½ of 1%

(40) Sorted White Ledger (SWL)
Consists of uncoated, printed or unprinted sheets, shavings, guillotined books, and cuttings of white groundwood-free ledger, bond, writing, and other paper which has similar fiber and filler content.

Prohibitive Materials may not exceed	½ of 1%
Outthrows plus prohibitives may not exceed	2%

(41) Manifold White Ledger (MWL)
Consists of sheets, shavings, and cuttings of industrially-generated printed or unprinted white groundwood-free paper. All stock must be uncoated.

Prohibitive Materials may not exceed	½ of 1%
Outthrows plus prohibitives may not exceed	2%

(46) Printed Bleached Board
Consists of groundwood-free misprint sheets, cartons and cuttings of bleached board, free from wax, greaseproof lamination, metallic, and inks, adhesives or coatings that are insoluble.

Prohibitive Materials may not exceed	1%
Outthrows plus prohibitives may not exceed	2%

(47) Unprinted Bleached Board
Consists of groundwood-free unprinted, untreated bleached board cuttings, sheets or rolls, free from wax, greaseproof lamination and adhesives or coatings that are insoluble.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	1%

Grades: Also called ledger, Bleached kraft, but with colored paper

(39) Manifold Colored Ledger (MCL)

Consists of sheets, shavings, and cuttings of industrially-generated printed or unprinted colored or white groundwood-free paper. All stock must be uncoated and free of nonimpact printing. A percentage of carbonless paper is allowable.

Prohibitive Materials may not exceed	½ of 1%
Outthrows plus prohibitives may not exceed	2%

(33) New Colored Envelope Cuttings

Consists of groundwood-free cuttings, shavings, or sheets of untreated, uncoated bleachable colored envelope paper.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	2%

Grades: Food containers

(48) #1 Bleached Cup Stock (#1 Cup)
Consists of untreated cuttings or sheets of coated or uncoated cup base stock. Cuttings with slight bleed may be included. Must be free of wax, poly, and other coatings that are insoluble.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	½ of 1%

(49) #2 Printed Bleached Cup Stock (#2 Cup)
Consists of printed, untreated formed cups, cup die cuts, and misprint sheets of coated or uncoated cup base stock. Glues must be water soluble. Must be free of wax, poly, and other coatings that are insoluble.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	1%

(50) Unprinted Bleached Plate Stock
Consists of groundwood-free bleached coated or uncoated, untreated and unprinted plate cuttings and sheets.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	½ of 1%

(51) Printed Bleached Plate Stock
Consists of groundwood-free bleached coated or uncoated, untreated printed plates and sheets. Must be free of coatings or inks that are insoluble.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	1%

(52) Aseptic Packaging and Gable-Top Cartons
Consists of liquid packaging board containers including empty, used, polyethylene (PE)-coated, printed one-side aseptic and gable-top cartons containing no less than 70% bleached chemical fiber and may contain up to 6% aluminum foil and 24% PE film.

Prohibitive Materials may not exceed	2%
Outthrows plus prohibitives may not exceed	5%

Grades from Food Applications:

(48) #1 Bleached Cup Stock (#1 Cup)
Consists of untreated cuttings or sheets of coated or uncoated cup base stock. Cuttings with slight bleed may be included. Must be free of wax, poly, and other coatings that are insoluble.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	½ of 1%

(49) #2 Printed Bleached Cup Stock (#2 Cup)
Consists of printed, untreated formed cups, cup die cuts, and misprint sheets of coated or uncoated cup base stock. Glues must be water soluble. Must be free of wax, poly, and other coatings that are insoluble.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	1%

(50) Unprinted Bleached Plate Stock
Consists of groundwood-free bleached coated or uncoated, untreated and unprinted plate cuttings and sheets.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	½ of 1%

(51) Printed Bleached Plate Stock
Consists of groundwood-free bleached coated or uncoated, untreated printed plates and sheets. Must be free of coatings or inks that are insoluble.

Prohibitive Materials	None permitted
Outthrows plus prohibitives may not exceed	1%

(52) Aseptic Packaging and Gable-Top Cartons
Consists of liquid packaging board containers including empty, used, polyethylene (PE)-coated, printed one-side aseptic and gable-top cartons containing no less than 70% bleached chemical fiber and may contain up to 6% aluminum foil and 24% PE film.

Prohibitive Materials may not exceed	2%
Outthrows plus prohibitives may not exceed	5%

Glossary

ADHESIVES: Bonding substances that are non-water soluble are considered contaminants in pulp subs, groundwood and deinking grades.

BEATER-DYED: Paper dyed or colored during the paper manufacturing process.

BLEACHED: Paper that has been whitened by chemicals.

BOARDS: Paperboard 0.006 inch or thicker.

BOGUS: Paper of inferior quality to a standard grade.

BOXBOARD: Paperboard made from a variety of recovered fibers having sufficient folding properties and thickness to be used to manufacture folding or set-up boxes.

CHEMICAL WOOD-FIBER PULP: Generic for cellulose fiber isolated and purified by a chemical digestive process.

CHIPBOARD: Uncoated, non-folding paperboard made from a variety of recovered papers, having sufficient strength and structural properties to be used to manufacture game boards, book covers, notebook backing and similar products.

COATINGS: A layer of adhesives, clays, varnish or any barrier applied to paper.

KRAFT: Paper made from sulfate pulp (synonyms: brown and strong).

LAMINATED: Paper manufactured by fusing one or more layers of paper together.

LINERBOARD: Outside layers of a combination board used to manufacture corrugated shipping containers.

MANIFOLD: May denote continuous forms or business forms with several parts (may be interleaved with carbon paper or be carbonless papers).

MEDIUM: The inner corrugated fluted material used to manufacture corrugated shipping containers.

NON-IMPACT: Papers having printing images formed without impact.

OFF-SHORE/ASIAN: Denotes corrugated shipping containers manufactured overseas and containing bogus liners or medium. (Color is somewhat lighter/more yellow than North American produced materials).

PAPERBOARD: Denotes paper products used for packaging (corrugated boxes, folding cartons, set-up boxes, etc.).