MINNESOTA Science
Agricultural Experiment Station
University of Minnesota
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Timberrrr! Will Minnesota Have Enough?

Minnesota's waferboard industry, largest in the world, depends on a continued supply of aspen. Station researchers work with a wide variety of organizations to best manage Minnesota's forest resources.

Minnesota's forest industry is large. In 1988, it will generate about $4 billion in sales, and employ more than 52,000 people (who, in turn, will provide employment for nearly 127,000 more).

The industry is diverse. Pulp and paper account for two-thirds of the receipts from basic forest products, but board, lumber, bolts, logs, fuelwood, specialty products, and Christmas greenery are also important. The economic contribution of secondary manufacturing (producing furniture, fixtures, and paper products) is twice that of all basic forest products combined.

The industry is also growing. During the 10 years before 1987, $911 million was invested for expansion and improvements. Since then, companies have announced plans to invest almost $1.43 billion more.

Much of this expansion will, fortunately, not call for more trees to be harvested. Alan Ek, head of the University of Minnesota's Department of Forest Resources, and Jim Bowyer, head of its Department of Forest Products, point out that processing technology is improving. More species and parts of trees are being used more efficiently.

Experts agree that, except for aspen, supply should meet demand. This is because the acreage of aspen stands near maturity is greater than the acreage in young stands.

"Assuming consumption by present and planned industrial installations, it looks as if there may be a window of time when there will not be enough aspen to maintain favorable pricing—beginning about 2010 to 2020 and continuing for 10 to 15 years," Ek says. Then, industry will have to consider using other species, at least until more of the young aspen trees mature.

The size and type of forest industry that Minnesota can support in the future will be largely determined by actions of land managers now, the researchers say. Harvesting aspen today is the single most effective action to insure supplies in the future, Ek points out. Also, increased harvesting of other species can increase the supply of aspen where it is a minor component of other cover types.

Ek and Bowyer say many factors will influence Minnesota's timber supply.

• Per-acre yields will increase with genetically improved planting stock, and

Timber *continued on back page*

MINNESOTA Science

Summer's Drought Spread the Pain Around

"Sustainable agriculture" methods proved neither better nor worse than traditional farm techniques in this past summer's severe drought.

"This drought was so severe that generally most people felt that relative differences were simply erased. In other words, one of those treatments might have hit the floor sooner than the other one, but by the time we decided to go and look for differences, they'd both been on the floor so long you just couldn't see any difference," says Minnesota Agricultural Experiment Station agronomist Kent Crookston.

But though we also weren't able to learn very much about drought and sustainable ag techniques, says Crookston, who heads up the University's interdisciplinary working group on sustainable agriculture, the drought certainly didn't lessen the interest in sustainability.

"I would say that the interest in working in sustainable agriculture is totally independent of the drought or its effects," he says. "The general reaction we see is an overall increased interest in agriculture whenever there's a drought, but as soon as it rains the interest's gone. But I don't think the momentum that's present in sustainable agriculture research is attributable to the drought."

One surprising finding came from observations of drought stressed crops. Ridge tilling, which has had an overwhelmingly positive record to date, showed a potential problem with potassium deficiency on corn.

"Ridge tillage, a minimum tillage, this year didn't look good, and that was sort of a surprise. Our hypothesis is that with the litter near the surface, the roots of ridge tilled corn proliferated near the surface. When the moisture dropped down below that area, those plants didn't

One effect of last summer's drought was potassium deficiency in some ridge tilled corn, which caused yellow streaks on leaves and added to reduced yield.

prone to remember a disaster. But, in many areas the chemicals also completely failed because of the drought, and people could say that's a testimonial for an alternative approach."

"In terms of sustainable agriculture, there's the hypothesis that a soil which has not been given chemical fertilizers would be better able to withstand a drought. That's the hypothesis that the organic proponents put forth that hasn't been evaluated properly. It's very difficult to evaluate because you need a drought to do it and you can't command droughts, and there's no way you can simulate them in the fields.

"The trouble with the drought, and its effect on research, is droughts are so fickle. We could not have anticipated this drought in time to have done any research on it this year. And by the same token, we can't depend on a drought next year so that we can plan trials to study its effects.

"But we now have a place where good, well designed trials will build a history of non-chemical versus a chemical approach. Then, in another drought year, we'll be able to move in to that site and measure or document the effects."

That site, acquired last year, is the Koch Farm located across the road from the Southwest Experiment Station at Lamberton. That new station property has had few chemical inputs over the past three decades. Soil nutrients are at near-natural levels.

"But either way, I don't see that the drought has altered our thinking or had any appreciable impact on what we'll be doing with our sustainable ag research," he says.

—Larry Etkin

Soil Conservation Pioneer Has

Finding Out What Milk Is Really Worth

Over 30 percent of the milk produced in Minnesota goes into cheese. The price paid dairy producers for that milk is based on long established formulas that consider only the milk's butterfat content. But it would be fairer to account for all the components of milk in setting each producer's price, and experiment station agricultural economists Jerry Hammond and Jay

have many roots down in the subsoil and couldn't get at the potassium that they needed," Crookston said.

"I also know of one quite striking effect of the drought on a field trial by a farmer cooperating with the Land Stewardship Project. They used fall-seeded rye to try and control weeds. Because of the drought the rye became a serious contender for moisture, and this farmer had essentially a complete crop failure.

"One might predict such results would be negative advertisement for sustainable farming," he continued, "because neighbors who were watching, or anyone who knew this, would think 'I saw what happened to that guy when it was dry. I'm not about to try that because it could very well be dry next year or any year,' for example. They are

IN PRINT

A pair of recent Minnesota Agricultural Experiment Station Publications address issues of climate and agriculture, and are now available through the Distribution Center, 3 Coffey Hall, University of Minnesota, St. Paul, MN 55108:

Climate of Minnesota: Part XVI—Incoming and Reflected Solar Radiation at St. Paul (AD-SB-3276) is the latest volume in a 25 year series of technical reports analyzing the nature of climatic conditions in Minnesota. ($4.50+ 6% tax, prepaid)

Environmental Guide to Alfalfa Growth, Water Use, and Yield in Minnesota (AD-SB-3277) discusses the history, growth characteristics and response to environmental conditions of this important Minnesota agricultural crop. ($4.00 + 6% tax, prepaid)

—Larry Etkin

Seen the Horizon Change

Bill Larson and soil conservation grew up together. During his long career as a soils research scientist, Larson saw the zeal for soil conservation grow, diminish and finally rise again. Through it all, he and his colleagues continued the research that's now paying off for the environment.

Larson, head of the University of Minnesota's Department of Soil Science, was a farm boy in eastern Nebraska during the devastating drought years of the 1930's. "Wind and water erosion were rampant," says Larson. "Creeks went dry, ponds went dry; it was really tough. This year (1988) rainfall was as scarce as it was back then but the drought hasn't been as bad."

Working through college helping a soils professor led Larson to specialize in that relatively new field. He worked in Montana and Iowa before landing at the University of Minnesota 22 years ago.

As he was starting his career, President Franklin D. Roosevelt inaugurated the first government set-aside program to encourage soil conservation. Programs of one sort of another have been running ever since. "Most programs weren't very effective," says Larson, "because they let the farmers choose what land they wanted to put in the program. The choice was usually made on economic grounds, not conservation."

Current programs, including the Reinvest in Minnesota (RIM) reserve program that Larson has helped with, use soils research to determine which lands should be enrolled.

World War II forced the emphasis onto production, Larson notes, an orientation continued in the post-war years. Before World War II, an average acre grew 40 bushels of corn. Now 115 bushels per acre is common.

"They kind of forgot about conservation, but we kept on with our research," he said.

Soil scientist Bill Larson has promoted soil conservation during his 22 year association with the University.

Production was increasing, but cropland acreage was decreasing, due in part to erosion caused by weather and to poor management. Since 1980, about 80 million acres have been lost in the U.S.

But even the 420 million current acres may be too much, he notes. "About 10 percent of that total should be taken out of production, either because it's low quality or because it's prone to erosion."

About 2.3 million of Minnesota's 23 million acres of cropland are non-productive and subject to erosion.

Larson praises the RIM program as "an excellent example of how

Pioneer *continued on p. 3*

Coggins have developed a formula to do just that.

Only recently has it become possible to easily test for variations in milk nonfat or protein content. "The problem has been to get a good measure of how that nonfat content changes the yield of cheese," Hammond says.

The traditional formula was developed about 80 years ago. But Hammond and Coggins collected data on cheddar cheese yield from several Minnesota plants over two years and found that it wasn't precisely accurate. "The formulas that have been used are linear, which implies you can substitute fat and protein at a constant rate in producing cheese. In other words, it implies you could produce cheddar cheese with all fat and no protein or vice versa, and of course you can't," he says.

Hammond and Coggins estimated the milk content/cheese yield relationship, and then used that relationship for a pricing scheme more accurately reflecting the economic value of milk components to cheese making. "We produced a table showing how pricing based on those yields would compare with the traditional fat-basis pricing plan. It shows that the traditional plan underprices high fat milk for the producer, and overprices low fat milk."

The new formula benefits both farmers and cheese producers. It pays dairy farmers more for higher quality raw material. It would also accurately predict yield in an individual cheese plant. "Suppose a plant was paying for milk with a certain fat content, but low nonfat solids. It's competing with a plant that buys milk with the same fat content milk, but higher protein. The two cheese plants pay the same price under the old scheme, but the first plant is losing. On the other hand, if they were paying according to what is in the milk, the plant with the lower solids would be paying less."

—Jennifer Obst

MINNESOTA Science

Parsnips and Peat: A Profitable Combo

The unfamiliar parsnip is well suited to Minnesota, particularly to its peat soils. Minnesota growers, with 200 acres planted to parsnip each year, hold their own against other U.S. growers in producing top-quality roots.

University of Minnesota horticultural scientist Dave Davis says parsnips are profitable. "Most of the growers who grow parsnips also grow other root crops, such as carrots, radishes, potatoes and turnips. They've found that wholesale buyers like the convenience of being able to buy all the root vegetables they need from one source."

Parsnip growing is not without its hazards. One is the fungus *Itersonilia perplexans*. Parsnip roots are normally refrigerated for three to five months until marketed. University plant pathologist Frank Pfleger notes that *"I. perplexans* causes a leaf spot disease on plants in the field, and brown canker on roots in the field and in storage. This storage deterioration is particularly damaging economically."

But a new variety, Andover, is less likely to spoil in storage. Andover has

How Sweet It Is—A Potato Processor's Dread

The Red River Valley potato industry is no small potatoes. Each year Minnesota and North Dakota farmers produce 3.2 billion pounds of spuds on 186,000 acres of the valley's fertile soil.

Following a national trend, an ever larger portion—now about 55 percent—of the crop is processed. About one billion pounds are made into chips, nearly 30 percent of all the potatoes chipped in the country.

Joe Sowokinos, a University of Minnesota Department of Horticulture scientist working at the USDA Red River Valley Potato Research Laboratory in East Grand Forks, says the trend has led to new problems in variety development, storage, and product quality that were not critical with fresh markets.

Processing quality is largely a matter of sugars. Sucrose comprises most of the sugar in the developing potato. When the tuber is harvested, an enzyme called invertase converts some of the sucrose to glucose. Glucose is a chipper's nightmare. Chips made from potatoes with high levels of glucose are unacceptably dark.

"Tubers of some varieties, such as Red Pontiac and Norgold Russet, have so much sucrose at harvest that the level of glucose will always be too high to ever be useful for chipping," Sowokinos says.

Each year, since 1976, Sowokinos screens about 550 of their advanced selections to weed out any that have more sucrose than 1.5 milligrams per gram of tuber. This has accelerated their drive for more acceptable chipping varieties. From 1976 to 1983, the percentage of the selections with low harvest sucrose levels increased from 34 to 52 percent.

University of Minnesota potato breeder Florian Lauer says, "Sucrose ratings enable us to make selections more accurately than in the past and to eliminate clones we consider horticulturally sound but which would fail to make it as superior storage and processing potatoes."

However, low sucrose at harvest doesn't guarantee that a selection will chip well when it's pulled from storage later. So, in 1986, Sowokinos began to evaluate advanced selections for the genetic ability to form low levels of reducing sugars in storage.

"Now, we keep only what we call 'safe' selections."

"Now, we keep only what we call 'safe' selections as potential chipping varieties," Sowokinos explains. "These must meet two criteria: a low sucrose rating at harvest and a low glucose-forming potential (GTP) in storage.

Sowokinos is trying to understand

Junior scientist Irene Shea (foreground) and researcher Joe Sowokinos study key enzymes that regulate starch-sugar interconversion in potato tubers.

the biochemical mechanisms that control the conversion of starch to sucrose. "Once we understand the key enzymes which regulate starch-sugar interconversion in potato cells, we'll be able to further fine-tune the selection process," he says.

Chips *continued on p. 4*

Patent Applied for High Protein

We could add lysine and threonine, and look for mutants that would grow in their presence. These mutants might

resulted from cooperative efforts of the University Departments of Horticulture and Plant Pathology as well as growers in Anoka County and the Anoka Extension Office.

Andover resists *I. perplexans* better than Harris Model, the most popular commercial cultivar. It also resists sprouting. Davis says Andover will appeal to retailers. Its long roots allow them to fit nicely, head-to-toe, on a shrink-film tray.

—Sam Brungardt

Pioneer *continued from p. 2*

agricultural and environmental people got together and supported a conservation program."

Larson says Minnesota's rate of cropland loss is declining with the increasing use of conservation tillage, and with growers retiring unsuitable land.

The soil researchers continue to add to their knowledge of their land fertility and productivity. A mammoth project is producing detailed computerized soil maps of all Minnesota counties. This huge task is complicated by the fact that Minnesota has 600 distinct soil types. Mapping has been done in most of the counties and 23 of them have now been computerized.

The maps enable growers to "farm by soil," tailoring fertilizer, pesticide and tillage treatments to their soil types. This custom treatment can cut production costs and minimize leaching.

Larson's research also benefits urban dwellers. Research on sewage sludge and composting have been used by municipalities. Current research also includes measuring how fast biodegradable plastic sacks, made from standard plastics and cornstarch, degrade in the soil.

"We feel we've made some progress," Larson says, "in agriculture, and for the population at large."

—Anne Gillespie Lewis

Corn Regulating Gene

The new high lysine gene is now being introduced into several outstanding corn strains. Station scientist Ron Phillips inspects the results.

Somewhere in the world a corn crop matures every month of the year.

But despite its popularity and many advantages, corn is low in protein quantity and quality. Corn kernels contain, on average, less than 10 percent protein, compared with legumes such as soybeans which contain 38 percent protein. And corn protein is low in two vital amino acids, lysine and tryptophan.

So when University of Minnesota researchers started to investigate the potential of biotechnology for agricultural crops, corn protein improvement was one of the first concerns. Building on that work, begun in the 1970s, experiment station cytogeneticist Ron Phillips and graduate assistant Mike Benner have now discovered a way to increase the lysine content of corn. They have identified a regulatory gene that influences its production in the kernel, and applied for a patent relating to it.

The story began in 1974 when University of Minnesota researchers were the first to grow a corn plant from a tissue culture. That work led to an insight into how production of lysine, threonine and methionine were regulated within the kernel.

Analysis of the biochemistry of production showed the three were mutually dependent. If only lysine and threonine were added to the culture medium, the corn cells didn't grow.

Phillips found the same thing happened to the germinating kernel. "So that suggested to us a selection protocol. represent a change in one of those key enzymes, and a way to get over-production of these products," he says.

They found a promising naturally-resistant line, and then discovered that when they took the endosperm off the kernel, and just germinated the embryo, the embryo would not grow. "So our hypothesis was that the endosperm was furnishing methionine to the embryo," Phillips says.

So far the researchers were tracking down a line that over-produced high methionine, not lysine. Further research showed that this extra methionine resided in a particular protein in the endosperm.

Mapping the genetic structure of this protein, the researchers discovered they were dealing with two different genes. "One produces the protein, and another determines how much protein is produced," Benner says. "To our surprise, we found that in addition to increasing the methionine level, this regulatory gene also apparently elevated the level of other amino acids, most notably lysine."

"The next question was, could we incorporate this regulatory gene into other lines, and promote the same over-production that we saw in this line?" Benner says. The answer so far has been yes. The highest elevation of lysine levels they have induced is 20 percent. Their patent application involves this regulatory gene, and refers to any high lysine corn line that is produced by use of this gene.

Phillips and Benner's discovery comes just when there has been growing interest in the potential of increasing the protein level of corn. Recently, researchers in Mexico introduced an improved type of corn that is nearly twice as nutritious as normal corn. First discovered in 1963, this corn type unfortunately had several undesirable qualities, including reduced yield, and a

Corn *continued on back page*

Chips *continued from p. 3*

"If these genes can be isolated, we may be able to alter them so that less enzyme is produced. Then, we could incorporate the altered genes into otherwise promising selections or existing varieties using recombinant DNA techniques."

This could result in the development of superior chipping varieties, Sowokinos says. "What if we could take a variety that's a bit higher in sugars allowable for its market, but has disease resistance, uniformity in size and shape, good color, and resistance to bruising, and genetically engineer it so that it could undergo cold stress for six to eight months and still chip well? That would turn the whole industry around!"

—Sam Brungardt

IN PRINT

A Minnesota Agricultural Experiment Station publication, *Maintenance of Potato Processing Quality by Chemical Maturity Monitoring (CMM)* (AD-SB-3441) provides a technical explanation for using CMM to gauge the suitability of stored potatoes for processing into potato chips. It also describes how to adjust storage conditions to improve their acceptability for chipping. ($3.50+ 6% tax, prepaid. Contact Distribution Center, 3 Coffey Hall, University of Minnesota, St. Paul, MN 55108)

—Larry Etkin

"Fused Chromosome" Causes Reduced Fertility in Beef Cattle

The fused chromosome condition now being detected in Charolais cattle first happened to continental European cattle in the Middle Ages.

A cellular glitch centuries old has been found in some Minnesota cattle. It's an errant chromosome and it kills some early embryos. A University of Minnesota researcher discovered its presence while doing a routine lab test. He's now helping breeders detect and eliminate it from their herds.

Veterinary biologist Lance Buoen found the condition while testing for infertility in female calves of male-female twins. In 9 out of 10 such cases, the female will be infertile, and a chromosome test is routinely done.

While checking for these cells, he found evidence of "1/29 Robertsonian translocation," caused by fused chromosomes. It's thought that the fusion happened to European cattle in the Middle Ages.

"Because this chromosome does not split apart as it should, there are four of six potential combinations of sperm and egg that are lethal. One-too-few chromosomes or one-too-many will create a genetically unbalanced embryo which will die a few weeks after im-

fields, as they would from an infectious agent," Buoen says.

Buoen was the first to spot the condition in the Charolais breed in the United States.

"The main reservoir of the condition now is European cattle," says experiment station veterinary biologist Alvin Weber. "The problem is well known there in a score of different breeds. But Europe has almost eradicated the problem over the last 20 years by testing and culling."

In North America, there is a growing concern among cattle researchers. One affected prize bull can cause major problems.

"Norway had 10 percent of the animals of one of its breeds with the 1/29 condition, and all the cases came from the semen of one bull," Buoen says. He has found the condition unevenly distributed, but in about 20 percent of the Charolais bulls tested.

This has not been good news to some breeders. "The problem is how to get the testing program generally accepted, and not hurt the animal breeders and producers economically," he says.

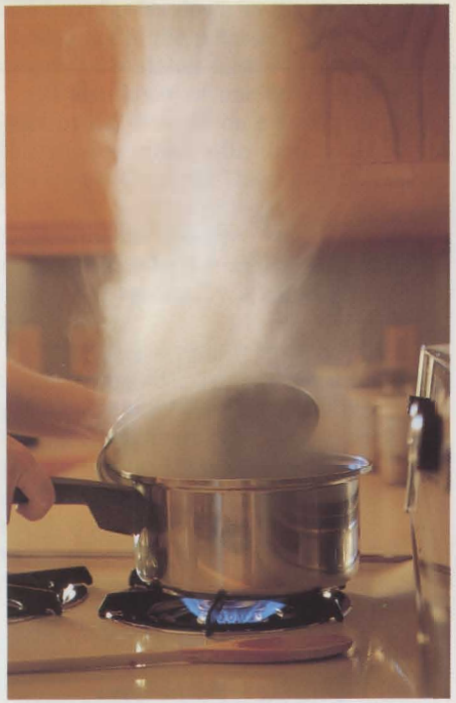
"There is a practical solution," Weber says. "A producer could have all the offspring from a carrier bull checked as soon as they are born. If they test negative for the condition, the producer knows the bull can be used."

"A few producers have already done this. They don't want to lose the genetic qualities that have been bred for generations into a prize bull, so they check all their animals," Buoen says.

The condition has now been found in Charolais from five other states and Canada. As a consequence, more and more producers are now testing their cattle.

"We're working with a university agricultural economist to get the figures

The Wrong Kitchen Exhaust Can Cost



Cooking steam (here simulated in a time-lapse photo) can create moisture problems in the house.

If you can't take the heat, get out of the kitchen. . .or, get a good kitchen exhaust system.

That's what Wanda Olson, an experiment station housing design researcher, says. A kitchen range exhaust system eliminates excessive cooking moisture that encourages mold and mildew in the home. And, kitchen range exhausts remove cooking contaminants from the air and greatly improve air quality. But some exhaust systems work better than others, and some require more energy for the same effect, she says.

Popular down draft units make a cooking island possible without an overhead hood. But they are not as effective as overhead hood units for all types of cooking. They usually require a higher air flow rate, and therefore use more energy, says Olson.

Olson recently collaborated on a video illustrating tests of several types of kitchen range exhausts. The testing was done by Jim Ramsey and Tom Kuehn, researchers from the Department of Mechanical Engineering.

They tested several wall-mounted overhead hoods, a microwave hood, island hood, and three types of down draft units with different locations of exhaust grill.

Olson looks at kitchen ventilation as part of a whole house system. She points out that exhaust fans put stress on that system. In older, leaky homes, enough fresh air circulates to compensate for air exhaust. "But in new more tightly built homes, these large kitchen fans can be the largest exhaust fans in the house, and create the need for more fresh air. You need to have a special duct to bring in outdoor air, and you may have to heat that air. So we need to look at capturing the contaminants with the lowest air flow," she says.

Down draft units are pretty good for eliminating cooking steam and other contaminants when cooking in low pans when grilling and frying, but are not as effective with high pan cooking. Island hoods need a higher air flow rate due to crossdrafts. Down draft units need a higher flow rate to overcome the natural force of hot gases rising, and take more energy.

"The range exhaust system that seemed to work the best was the standard overhead wall-mounted hood that extends over most of the cooking surface. The choice will be a trade-off between aesthetic appeal and performance," Kuehn says.

The best system takes into account the air quality needs of the whole house, Olson says. "If for whatever reason you don't want to choose the lowest air flow, then you have to make sure you are matching outdoor air with your range exhaust system to have a safe system," she says.

—Jennifer Obst

plantation, the condition causes a 5 to 10 percent reduction in herd fertility. "Over the years, that adds up. But the problem can go undetected because the animals are not dropping dead in the

on what a carrier bull could cost a producer in lost fertility over the years. Without testing, the problem is not going to go away, it's going to get worse."

—Jennifer Obst

Service Sector Wage Gap Widens

The next banker you see ordering a hamburger may be giving you a nutshell view of the future of the U.S. economy.

The people involved in that routine transaction are both members of an increasingly significant part of our society: the service sector. More striking than this characteristic in common, is the difference between the two. The financier may be pulling a six-figure income. The burger flipper is probably plugging along at minimum wage.

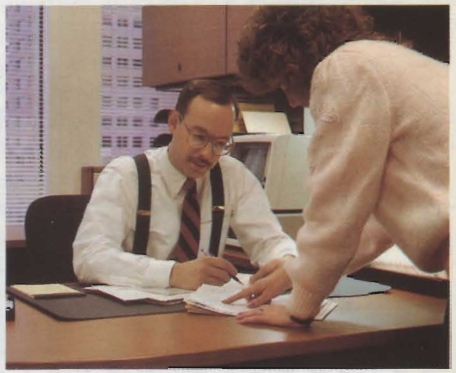
This marked diversity is the subject of extensive research for University of Minnesota sociologist Joel Nelson, who has conducted experiment station studies of the burgeoning service sector.

Some sociologists have predicted that as services become a greater part of the economy, society will become more equal, comprised largely of low-paying jobs. But recent research by Nelson and others suggests that extremely high-paying service jobs are proliferating as well, resulting in an increasing disparity between top and bottom earners.

Nelson and University of Houston researcher Jon Lorence found this in a study of the 130 largest U.S. metropolitan areas. Of the occupational groups listed in the U.S. Census, both the highest and the lowest paying are in the service sector.

The trend appears to foreshadow increasing disparity between the earnings of men and women, too. More than half of all service sector workers are women, and Nelson's research shows women hold a disproportionate share of jobs at the low end of the wage spectrum.

Nelson notes also that many of the low-paying jobs are part time. "Services by their nature are abstract; you can't store a ride on a bus. So employers adjust by making jobs part time, and this creates a problem for structuring the work force." This tendency toward part-time employment is another contributing factor in the predominance of women on the bottom end of the service sector



Service sector jobs show a wide gap between high salaried predominantly male positions and lower-paid clerical jobs.

wage scale because the limited hours and lack of benefits made them viable options only for the "second" wage-earner in the traditional family.

Nelson predicts an increase in efforts to mechanize low-paying services as one means of mitigating the trend. In fact, he notes, we've already started in that direction with developments such as self-service elevators and automatic teller machines. However, he suggests, perhaps the most critical thing we as a society can do at this point is become aware of the directions in which the service sector is tending to pull us.

—Mary Hoff

Corn *continued from p. 3*

floury, soft kernel which did not store well. However, it has recently been sufficiently improved to offer great potential benefit to third world countries, Phillips says. These kinds of improved varieties are not of the hybrid type and therefore are not likely to be used directly in developed countries.

"The difficulty of this corn type is it is a complex genetic system, rather than one gene that gives high lysine. So you can't just take and transfer it into other lines easily," Phillips says. "Our material is a much simpler genetic system. As far as we can tell, it brings with it no undesirable effects. The fertility and quality of corn with it is completely normal."

For the researchers, the discovery has been an illuminating example of the biotechnology process. "It's an example of laboratory screening techniques, biochemistry, classical molecular genetics and plant breeding, all coming together. That's what we've always said, that we have to get all these disciplines together to make progress in biotechnology," Phillips says.

"Everything we see at this point looks very positive."

—Jennifer Obst

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Timber *continued from front page*

improved site preparations and weed control practices.

• The public will continue to value abundant wildlife, and water resources and forests will have to be managed with sensitivity to this.

• New technologies will allow fuller use of raw material or of species not being used now. "For example," Bowyer says, "we've worked out a way here to substitute birch for 15 percent of the aspen in waferboard and other composite panels. And this is one way that the projected aspen shortfall will be avoided."

• New technologies will create new markets. "Engineered" products, such as parallel strand lumber, laminated veneer lumber, and wooden I-beams, will compete increasingly with solid wood and even steel building materials. These products are stronger than solid-wood products, can be made in large cross-sectional dimensions from small diameter trees, can be made in any length, and do not vary in their strength and other properties.

"The United States is on the verge of a major wood chemical industry—plastics, resins, all kinds of things made from wood," Bowyer predicts. "One firm in Michigan, for example, is experimenting with wood/nonwood composites to use in external and internal auto parts," Bowyer says.

• New technologies will also address environmental concerns, using lignin to make plastics; using biodeterioration to pulp wood; using fungi to bleach pulp. And letting forests vigorously grow may moderate atmospheric carbon dioxide increases.

The extent to which Minnesota's forest industry remains competitive depends largely on the industry's willingness to continue to invest in new technology and on the state's dedication to a strong forest management program.

"There is also a real need for public education," Bowyer says. "People need to learn that commercial forestry and tourism can be very compatible activities and land uses."

"Realistically, some lands will be reserved mainly for single uses; however, much of our land base can be managed for timber and still provide for other uses and benefits, especially wildlife and recreation. In many cases, the areas that were hunting, picnic and hiking grounds of yesterday can be the timber harvest zones of today, and recreational areas again in a few decades."

—Sam Brungardt

IN PRINT

A number of new Minnesota Agricultural Experiment Station forestry publications are available:

Factors Affecting the Regeneration of Quaking Aspen (AD-SB-3610) summarizes our knowledge of forest regeneration for this fast growing, commercially valuable and most widely distributed North American forest tree species. ($1.00 + 6% tax, prepaid. Contact Distribution Center, 3 Coffey Hall, University of Minnesota, St. Paul, MN 55108)

Cloquet Forestry Center Research Papers and Reports comprehensively lists publications resulting from 75 years of research at the Center. (Contact Alvin Alm, Cloquet Forestry Center, 175 University Road, Cloquet, MN 55720)

Urban Forestry: A Bibliography (second supplement) identifies material published on Urban Forestry since the first supplement was produced in 1982. (Contact the University of Minnesota Forestry Library, 203 Green Hall, 1530 Cleveland Avenue, St. Paul, MN 55108)

—Larry Etkin

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