This annual report summarizes the results obtained by a few of the more than 130 ongoing research projects supported by the Agricultural Experiment Station at Colorado State University. The Agricultural Experiment Station is an integral component of Colorado State University, your land-grant university, and it is committed to conducting research on the agricultural and natural resource needs of the people of Colorado, the region, and the nation. Our mission is to support research leading to an agriculture that is economically viable, environmentally sustainable, and socially acceptable. The Agricultural Experiment Station research efforts extend across the entire campus involving faculty and staff from more than 25 academic departments in 7 colleges. We also have a network of off-campus research centers conducting research to meet agricultural production needs in different regions of the state. To address the complex problems facing agriculture, it is essential that academic departments work in concert with each other to solve problems through interdisciplinary efforts.

An initiative was funded by the Colorado legislature for the current fiscal year to enhance funding for programs in the Agricultural Experiment Station, Colorado State University Cooperative Extension, and the Colorado State Forest Service. The rationale for seeking additional funding was based on the following: 1) the dramatic growth in population and the diversification of Colorado's economy have increased demand for research and outreach information; 2) structural changes in agriculture and shifting demographics pose new challenges to food and fiber production and management of natural resources; 3) and these units are funded based on consumer price index and increased demand for programs is not a factor in the current funding formula. The identification of programs targeted for enhancement was based on stakeholders identifying research and outreach program needs in agriculture and natural resources. We are extremely pleased that the Colorado legislature funded the first year of this three-year initiative, which will provide base funding support to address issues facing Colorado agriculture.

The areas receiving enhanced funding this fiscal year are forest health and interface, invasive plant species on public and private land, and increased Colorado Extension staffing in selected counties. A request is pending for legislative support of three additional program areas: mitigating wildfires, policy analysis for agriculture and natural resource issues, and safe food for Coloradans. The base funding increase received by the Agricultural Experiment Station for invasive plant research will significantly enhance our efforts to address the economic and productivity impacts of weeds. Appreciation is extended to all who supported our efforts to obtain additional funds for program enhancement.

I hope you enjoy this report. Please contact me if you have any questions concerning our research programs at Colorado State University

Lee E. Sommers
Director
Colorado Agricultural Experiment Station at
Colorado State University

PINTO BEANS . . . *JUST RIGHT*

Research leads to new disease-resistant varieties

Bean processors are picky people. Ask the farmers who manage Colorado's 150,000 acres of dry beans. To be successful in the market, a bean must be the right color, the right size, the right shape. Not too big. Not too small. Not too round. Not too flat. Each bean must be, as Goldilocks would say, "Just right."

So for plant breeder Mark Brick, whose number one goal is to provide farmers with high-yielding, disease-resistant, excellent bean varieties with good seed quality and profit-making potential, he also must ensure that any new variety will pass muster with bean processors and educated consumers. Take pinto beans, which make up about 95 percent of Colorado's dry bean crops. They have to have a bright cream background color with distinctive cocoa-colored markings. Informed consumers won't accept beans that appear dirty brown.

Since becoming Colorado State's dry bean breeder in 1986, Brick has been working to develop pinto bean varieties that will resist rust, root rot, blights, and other prevalent diseases. Pinto plants grow as a mass of vines that retain humidity and create an inviting environment for disease, so Brick also is breeding for upright architecture, which is easier to cultivate, irrigate, and harvest. "If you have upright plants in rows, and the space between the rows is open," Brick explains, "the plants stay dry and aren't conducive to disease."

In 1994, Brick released Arapahoe, a pinto bean variety that resists white mold and grows semi-upright. Now he's breeding for resistance to rust, which occurs in Colorado every year. "Some years rust is all over, damaging 30 to 40 percent of the crops," Brick says. "In an average year, it might cause a loss of 5 to 8 percent, and it can be devastating to producers who do not apply fungicides to control the disease."

Developing a new variety and making it widely available takes a decade or longer. In the first year, Brick may cross one parent, which resists rust, with another parent that has good qualities except for its susceptibility to rust. The offspring will contain traits from both parents. He then selects progeny for both rust resistance and the good traits needed for a new variety. Year after year, Brick chooses the best plants from each new generation to produce more of the desired traits. It may be five to seven years before he gets what he's looking for. Then he tests the plants at locations throughout Colorado and the United States.

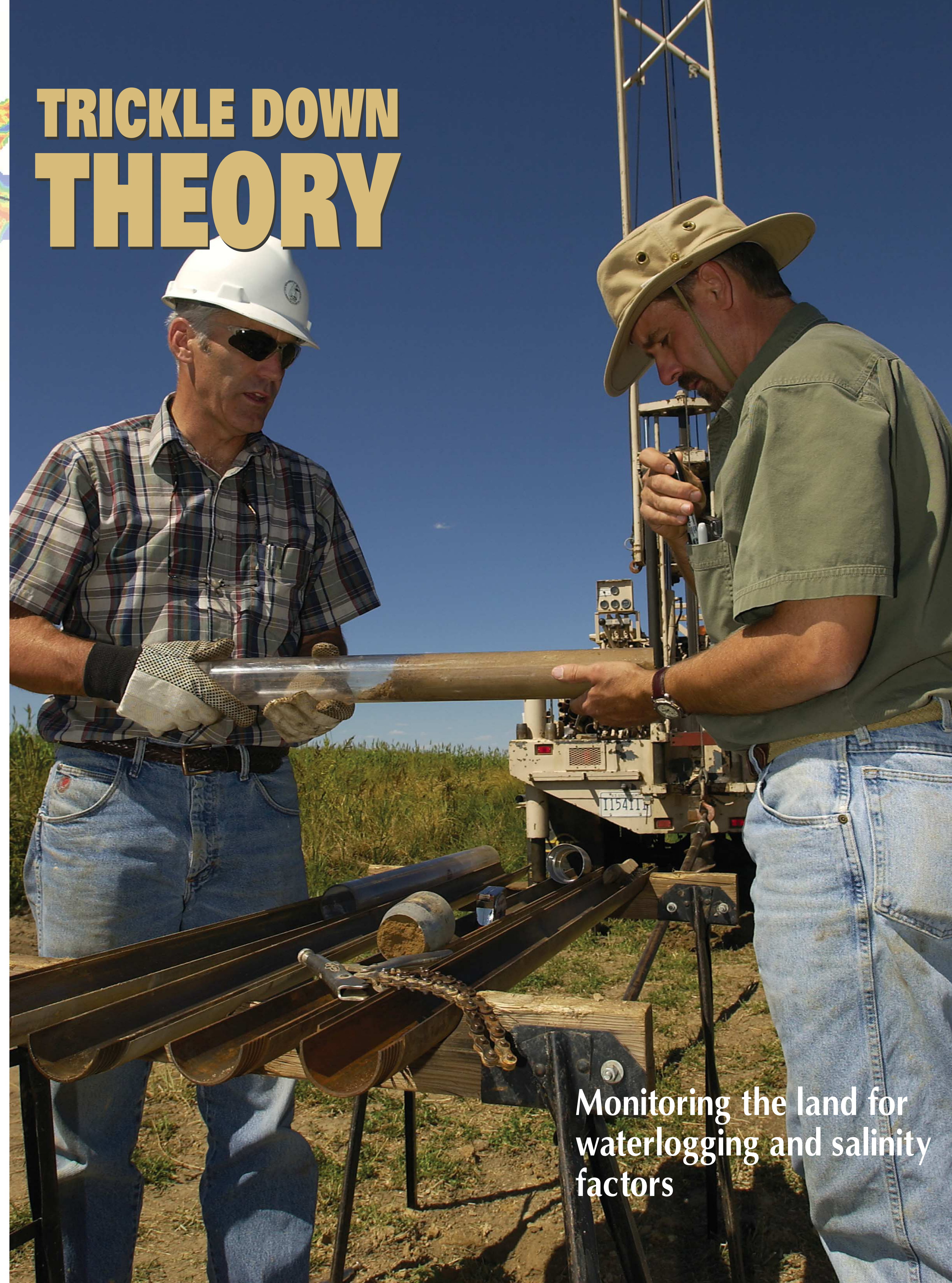
Brick's network of colleagues include plant breeders like himself in North Dakota, Idaho, Michigan, Nebraska, Washington, and other parts of Colorado. "My colleagues test these plants in environments other than Colorado, so I can see whether they're going to make it in the real world," says Brick. "The plants have to perform well in a broad range of environments. North Dakota offers a different spectrum of diseases than Colorado, and Idaho is a different environment altogether – no bacterial diseases but serious viral diseases. In eastern Colorado, I see heat stress, common blight, white mold, and rust. Only by testing the new lines in all these environments do I get to see what these plants are made of."

When he finds a plant that grows well at most or all of the sites, he tests the variety again through cooperating nurseries located throughout the U.S. and Canada. "Now I'm looking at seed quality, disease resistance, all sorts of things." When the variety meets the criteria, he releases it. The plants go to Fruita, Colo., where the line is increased for certified seed production. Fruita, like most regions on the Western Slope, does not have common bacterial diseases, says Brick, which is the reason that the certified bean seed industry is there.

Brick attributes the success of Colorado State's plant breeding program to its numerous partners – research associate Barry Ogg, plant pathologist Howard Schwartz, extension crop testing specialist Jerry Johnson, foundation seed manager Fred Judson, and extension agents, research associates, and nurseries across the state and country. "If you didn't have all these resources, you couldn't be successful," says Brick. "It's a real team approach to developing a new bean variety that farmers can profit from."

TRICKLE DOWN THEORY

Monitoring the land for waterlogging and salinity factors



Colorado State University civil engineering Professor Timothy Gates, is standing in the middle of an irrigated field in Colorado's lower Arkansas River Valley. Off in the distance, he sees the classic lush and verdant landscape that for more than a century has defined this valley's rich agricultural heritage. But Gates knows this picturesque scene is deceiving. The salt-encrusted, waterlogged field in which he is standing, surrounded by stunted and wilted yellowish corn, could be the future of agriculture in this once productive river valley.

Irrigated since the 1870s, agricultural fields in portions of the Arkansas River Valley began showing signs of increased salinity and waterlogging as early as the 1920s. Irrigation-induced salinization is very common to intensively irrigated areas throughout the world. About 20 to 25 percent of the world's irrigated land, including up to 27 percent in the United States, is affected by saline high water tables. The threat to global crops is serious, with some scientists estimating worldwide productivity loss valued at $10 billion per year.

Salinity and waterlogging are coupled problems that typically show up within a few decades to a century after intensive irrigation begins in a river valley. When irrigation occurs at a rate that exceeds the natural capacity of the soil and the aquifer to drain the excess water back out toward the river, the water table starts rising. If it rises too close to the surface, the crops do not have adequate aeration to grow properly. Additionally, this water contains dissolved chemicals, some of which are salts. When evaporation drives the water up out of the water table into the atmosphere, high concentrations of the salts are left behind in the soil.

Another complicating factor is that some salts also are naturally inherent to layers in the subsurface profile. These salts are dissolved by excess irrigation flows, make their way to the river, and increase salinity concentrations in waters diverted for irrigation and other purposes further downstream.

Today, farmers in the Arkansas River Valley are seeing crop yield reductions that average about 10 percent, and in some areas are as high as 70 percent. Even those areas that on the surface seem unaffected are showing signs of increased salinity in the underlying soils and aquifer.

Gates believes the solution to the Arkansas River Valley's salinity problem can be found by documenting and studying the complex interaction of groundwater flow with salt transport, irrigation and drainage systems, and the flow of the river. He is joined in this current research effort by co-principal investigator Dr. John Labadie and Ph.D. student Phil Burkhalter in civil engineering and by other students and colleagues at Colorado State University.

Over the past three years, Gates has overseen the most intensive field data collection effort ever undertaken in the Arkansas River Valley or anywhere else. His research team has installed more than 100 monitoring wells, made thousands of groundwater and surface water measurements, conducted numerous tests of aquifer flow properties, and taken thousands of soil samples from about 100 agricultural fields in the lower valley.

This data is driving the development of computer models that will allow farmers and water and land managers to better understand the cascading network of interactions that lie at the heart of the salinity problem.

"The computer modeling allows us to use the local data to take a broad perspective and look at the multiple scales at work," says Gates. "We can see the interaction between processes that occur when a farmer irrigates his individual field, how that affects other fields in the subregion, and how that in turn affects what goes on in the entire river valley."

As Gates and his colleagues enter the next phase of the research, that of finding viable solutions, economists, agronomists, soil scientists, sociologists, and perhaps even lawyers will play more of a key role on their team. Among the engineering interventions being considered are improvements to irrigation systems to boost efficiency and reduce recharge to the water table, lining of canals to reduce seepage, installation of horizontal subsurface drains and systems for managing drainage effluent, and alteration of river operations to lower the water level in the river. Because of the legal complexities involved with changing how water is moved, drained, and supplied in a river valley, Gates expects they will need someone very familiar with water law and appropriation issues.

Since the conditions in the Arkansas River Valley are broadly similar to those in irrigated alluvial valleys elsewhere, the U.S. Bureau of Reclamation, U.S. Geological Survey, USDA Natural Resources Conservation Service, USDA Farm Service Agency, Colorado Water Resources Research Institute, Bent County Soil Conservation District, and local irrigation canal companies are all working with Gates and his colleagues to learn more about salinity and its complex web of technical, legal, and social issues.

"It's formidable work, but it's also stimulating," says Gates. "We want to see a rural lifestyle continue to be built upon productive agriculture. We also want the overall environmental health of the Arkansas River to be enhanced. Hopefully, we can give insight and guidance that will help solve similar problems throughout the western United States and the world."

How instrument grading technology has turned the beef industry around

MAKING THE GRADE

This is the story of how Colorado State helped U.S. beef producers reverse a 23-year trend of declining market share. Certainly, a paradigm shift toward satisfying consumer demand helped. And so did a new strategic focus on increased spending in instrument grading technology research. But the catalyst, says animal sciences Associate Professor Keith Belk, was the rather serendipitous partnerships and chain of events that led to a better way to evaluate beef carcasses.

One of the biggest challenges for beef producers and processors is accurately predicting the yield of individual carcasses. Knowing the cutability – how many high-value and low-value cuts a carcass contains – is essential to determining value and pricing. In 1995, when Belk joined Colorado State's Meat Science Program, he became aware of VIAscan™, a beef-carcass scanning system under development in Australia. A noninvasive instrument that could precisely measure cutability could be a tremendous asset to beef packers.

Belk approached the beef industry, which also became excited about the possibilities of VIAscan™ and provided funding for Colorado State to evaluate the Australian technology for use in U.S. carcass evaluation.

Around the same time, a Canadian group had developed a similar technology called CVS. Belk and his colleagues, animal sciences Professors Gary Smith and Daryl Tatum, researched and tested both systems with successful results.

"Now we had two technologies that worked," says Belk. Both could quickly and accurately evaluate the cutability of a carcass.

In February 2001, the USDA Agricultural Marketing Service approved the instruments for USDA graders to use in applying official U.S. Yield Grades to beef carcasses. Beef graders, who on average grade 450 carcasses an hour, now have, for the first time, technology to assist them in determining yield.

But there's another feature that determines the value of a carcass, Belk continues, and that is how well the consumer will like the beef. How tender will it be? How flavorful? How juicy? Beef producers refer to these qualities as palatability. By the end of 1999, no system existed that could predict how good the beef would taste.

Around that time, says Belk, the concept of quality management became prevalent, and beef producers realized they could improve sales if they catered to consumers' preferences, rather than producing various beef products and hoping someone would buy them. The grading technology Colordo State University was working on was instrumental to everything the industry was trying to do to improve its market share.

Duane Wulf, a graduate student in the Meat Science Program, who had been measuring carcasses using a hand-held color meter, had found correlations between color measurements and the eating quality of beef. Armed with this knowledge, Belk contacted Hunter Labs, a video-imaging company in Virginia, to see if they could build a prototype instrument that could identify individual carcasses and capture quality measures, such as lean meat, fat, and marbling. Again the beef industry funded the research. Again the instrument produced the desired results.

Now it was time to make a product that would work commercially. Colorado State University's Research Foundation initiated the patent process and gave exclusive rights to a Hunter Labs subsidiary called SmartMV. A new branded-beef start-up company in Texas – Nolan Ryan's Tender Aged Beef – helped fund and served as the testing site for developing a commercial model. "There's a big difference between a prototype and a machine that's operating accurately at high speed in a beef-packing plant day in and day out," says Belk.

In early 2001, after a year of testing and tweaking, the BeefCam Tenderness Evaluation System was born. It was the first commercially available machine anywhere in the world that could evaluate the eating quality of beef. Belk attributes BeefCam's development to a whole host of people, including graduate students Rob Cannell, Aaron Wyle, and Derek Vote.

Now instruments that measure cutability can be interfaced with BeefCam and other tools to produce customized equipment for specific needs. The technology provides cattle producers with detailed information on carcasses. Producers then can look at their feedlot operations and adjust management practices to optimize yield and quality.

"For the last 2 ½ years, as the result of things we've been doing in the beef industry for 10 years, beef demand is back up," says Belk. "There are a lot of reasons for that, but a big part is that these technologies have helped to improve the eating quality of beef."

DETECTING
SOIL CONTAMINANTS

Imagine you are sitting in a room by a window on a sunny afternoon in September. You start to feel warm and you want to know the temperature in the room, so you bottle a sample of the air and mail it to a laboratory in another part of the country. Several weeks later, on a snowy October morning, you receive a report telling you what the temperature in the room was on that warm September afternoon. Sound absurd? Sure it does. But this is actually the way most environmental chemical analysis is conducted, bringing the researcher a single, time-delayed measurement that may not accurately reflect the current situation.

Colorado State University chemical engineering Professor Ken Reardon thinks there is a better way. He puts it like this: If you want to know the temperature in the room, you look at a thermometer on the wall – so why not something similar for analysis of groundwater?

Reardon is applying this concept of in situ (in place) continuous measurement to his work in monitoring groundwater for agricultural pesticides. Currently, the primary method for measuring pesticide contamination is to remove a groundwater sample from a well, package it in several sample vials, ship it to a lab to be analyzed by gas or liquid chromatography, and receive the analysis weeks later. Reardon would like to replace laboratory analysis of groundwater with reliable, easy-to-use field sampling methods that produce real-time results.

Reardon and his research team - graduate students Neema Das and Brinson Willis and collaborators Linda Henk, research assistant professor of chemical engineering, and Reagan Waskom, Colorado Extension specialist in soil and crop sciences – are developing unique biosensors to detect the presence of agricultural pesticides in groundwater. In a biosensor, a biological component, such as enzymes or whole cells, is fused to the end of a transducer, such as an electrode or optical fiber. When a contaminant is detected by the biosensor, the transducer takes the chemical signal from the biological component and turns it into an electronic signal that can be continuously monitored.

"Continuous groundwater monitoring at the site of pesticide production and use is important for detecting spills and tracking the effectiveness of clean up efforts," Reardon explains. "It's also important from the application end in helping farmers to apply just the amount of pesticide they need and to know where it is going after they put it on their fields."

So far, Reardon and his colleagues have developed fiber optic biosensors capable of detecting certain chlorinated organic compounds, such as atrazine, at levels as low as one part per billion. No other similar device for inexpensive, continuous, compound-specific sensing has ever been developed, and Reardon has been issued a provisional patent for his sensor design.

While the developments on this project are very promising, Reardon says the next challenge is to discover appropriate detection systems for additional chemical contaminants.

"What we've got is a start," he says. "What we've found out about pesticides and atrazine we hope to apply to any form of groundwater contamination. The goal of our current research is to make our instruments more effective in analyzing different classes of chemicals. Right now we are working on developing sensors for two other chemicals - alachlor and metalochlor - but obviously there are hundreds more."

The ultimate goal of Reardon's research is to enable greater agricultural productivity with less environmental impact. While his biosensors may not help us replace the use of pesticides in agriculture, they will ensure that pesticides are used more safely and responsibly. And as companies develop new pesticides that are more environmentally friendly, Reardon and his team will continue to develop more sensors to detect them.

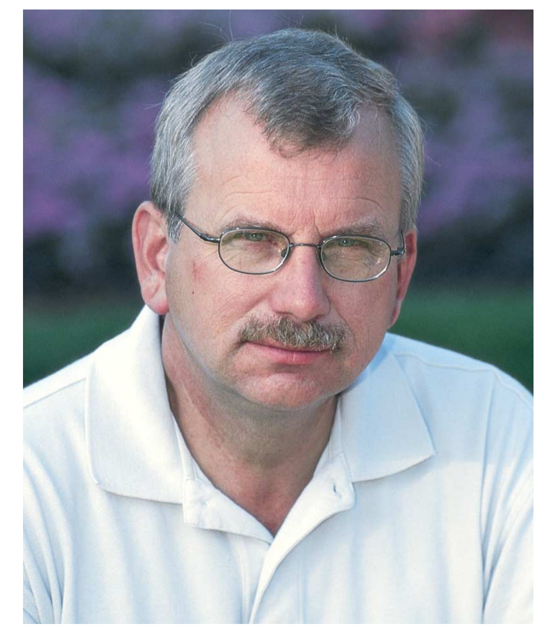
OVER TWENTY YEARS OF BLOOMING SUCCESS

Experimental garden proves which flowering plants will thrive

Gardening in Colorado can be a real challenge. The region's high altitude, intense light, clay soils, and aridity cause problems that multiply when bizarre weather events, such as summer hailstorms, occur. A typical June may bring temperatures ranging from 34 to 97 degrees and less than an inch of moisture. It's enough to try the patience of even the most dedicated grower.

Enter landscape horticulture Professor Jim Klett and his ongoing research into landscape plants for the Rocky Mountain/High Plains region. Klett evaluates annuals, herbaceous perennials, and woody plants and the best ways to grow them. Then he lets growers and retailers know which plants have proven successful.

A large part of his work is managing Colorado State's Annual Trial Garden, an outdoor laboratory that tests more than 1,100 annual varieties each year.



"Several of the major seed companies have breeders who want to see how the new plants they're breeding will do in our climate," explains Klett. "We have high light intensity and low humidity, but we don't get a lot of the disease and insect problems you often see in Pennsylvania, Michigan, or Georgia, where some of the other big trials are set."

Klett cooperates with about 25 different companies that provide seeds and cuttings for testing, some coming from as far as Costa Rica and Israel. Each March, Klett begins receiving vegetative varieties, which then are grown in the University's greenhouse until late May. The seed varieties come as an in-kind donation. Partners at Denver's Welby Gardens germinate the seed varieties and then supply the seedlings to the University for planting in the outdoor beds.

The trial garden is an official All-American Selection test garden, which tests new seed plants next to one or two comparison varieties. If the new plant proves exceptional, plant breeders will spend several years producing seed so the plant can be introduced to the public. "The test gardens are a way for plant breeders to get useful information about how a new variety will grow in lots of different settings," says Klett.

In early August, a 30 to 35 member team, comprised of greenhouse growers, faculty, students, public horticulturists, seed company representatives, and Master Gardeners, spends a day evaluating the varieties. They evaluate three different things, says Klett: "the plant, the flower, and an overall evaluation, plus additional comments." Students then input that information into a database, so that "best-of" varieties can be identified. Those and other results are published in the *Annual Trial Garden Performance Report*.

"This is what the growers really like, because they can go through the report before the next growing season and see what looks good, then decide what seeds and cuttings to order," says Klett. The report tells when each variety was planted and provides other cultural information so growers can replicate an ideal growth environment. All green-industry personnel also receive the information after the growing season is over, and consumers learn about the "best-of" varieties at planting time through articles published in Colorado newspapers and magazines.

The Annual Trial Garden began at Colorado State in the late 1970s, when 250 varieties were tested. Today it's recognized as one of the country's leading annual trial gardens. This is Klett's 11th year running the garden, and each year brings something new. Now most varieties arrive as cuttings rather than as seeds. "Some plants are difficult to grow from seed, and it's easier and quicker to grow them from cuttings," says Klett.

Sometimes the results can be surprising, as in the case of New Guinea impatiens. "People didn't think they would do well in Colorado, because of our high light intensity," Klett explains. "But we grew them under about 60 to 70 percent shade cloth, and they've been just beautiful all year round. Now, as a result of these trials, we're seeing more and more New Guinea impatiens being sold throughout this whole region."

Testing new varieties allows companies to diversify and provide an increasingly sophisticated gardening public with more of the unusual things they're demanding, Klett adds. Perhaps gardeners will be intrigued with the 2001 Best of Show, "Magical Michael", a fragrant, purple basil plant boasting lavender-white flowers.

Klett views the flowering outdoor laboratory as a statewide garden – a resource and a showplace not only for the University, but for the community and the green -industry as well.

THE IMMIGRATION DEBATE

Are immigrants a boon or a threat to Colorado's rural communities?

Since the Census Bureau released its most recent findings, the immigration debate has been reignited. Census 2000 data revealed pockets of Hispanics throughout the country, with some areas seeing as much as a 500 percent increase in their ethnic populations. In Colorado, immigration – particularly from Mexico – is predicted to continue at a high rate, says Dawn Thilmany, associate professor of agriculture business management. Whether that Hispanic influx is positive or negative depends on how you look at it. One perspective, says Thilmany, is to view immigration as a labor-market resource.

For more than a decade, Thilmany's research has focused on labor-market dynamics and the impacts of immigration and immigration policy on agriculture. She studies Hispanic populations in states that historically have depended most heavily on seasonal workers: Washington, California, Colorado, Texas, Utah, and other Intermountain states. If we prohibit people from crossing the border, she asks, will we have an adequate labor supply to sustain our communities and the economic prosperity to which we've become accustomed? "The choices we make about immigration policy affect the ability for a lot of ag producers to operate effectively, and that affects the health of rural communities," she points out.

Many Hispanics, Thilmany says, meet the demand for seasonal work. Recently, they've begun to work in food-processing plants too, which often are located in and near agricultural areas. Sometimes the jobs complement one another. "Once you get to harvesting, the next step is processing," Thilmany explains. Staying employed in one area benefits workers who previously pieced together jobs by moving from state to state. This trend also helps stabilize communities and ensure that farmers will have the laborers they need during the most critical times in the growing season.

The trend toward less migration solves some problems and raises others. "Some people aren't concerned about immigrants being here, because they feel these new employees accept jobs that other people wouldn't find attractive," says Thilmany. But others argue that the immigrants' use of government programs may cost more than the immigrants' contribution to the economy.

Are Hispanics likely to use welfare programs? According to Thilmany, the evidence suggests they're not. "Some research shows that communities that have higher Hispanic ratios actually tend to have lower rates of poverty." She attributes that tendency to an ingrained work ethic. "Mexican communities actually send their most ambitious young people to the United States – those with the highest earning potential and strongest work ethic. So when they come here, they're usually here with true purpose."

It's difficult for immigrants to use our welfare programs. She adds "That would suggest that when they're here, they're making money. It may not be much above the poverty level, but they're far more willing to work at that borderline of the poverty level than most Americans are. That sounds controversial, but it also suggests there are some nice gains to be made from integrating Hispanics into rural communities where, typically, costs of living are low and unskilled jobs go unfilled."

The services that Hispanics are most likely to use, Temporary Aid for Needy Families, Women-Infant-Children, and schools – are those designed to help families assimilate and support the human capital they bring to the community, says Thilmany. "My research suggests that Hispanics have been a net benefit to the economy rather than a net cost."

In fact, Hispanics may be the lifeblood that will allow dying rural communities to survive. To stay employed year-round, many Hispanics are transitioning into resort-industry jobs during the cooler months. "They're staying within the state, but moving into different sectors, such as hotel and restaurant work," says Thilmany. Since many can't afford to live in resort towns, they're settling out in rural areas and commuting to their jobs.

"Depending on where you fall in the debate, it may be more attractive to have Hispanics buying houses and settling out, because it would suggest their potential to become long-term, community citizens who may invest more in the capital of their community, rather than being transitory. There's also evidence that this is one way that rural communities that were disappearing can now sustain themselves," Thilmany adds.

"It's labor-market dynamics. We're not stopping immigration, and we never will. So the most effective integration of Hispanics into our economies and communities is probably in our long-term best interest."

BEEF SAFETY . . .

Research and public education go hand-in-hand

Animal sciences Professor John Sofos was addressing food safety issues in his laboratory long before *Escherichia coli* O157:H7 outbreaks raised public concern. After the 1993 Jack-in-the-Box incident, in which undercooked hamburgers were found to carry the pathogen, *E. coli* O157:H7, Sofos's research received more attention. Producers, processors, government agencies, and the food service industry all needed to know how they could ensure the safety of Colorado's main agricultural product – beef.

Among other things, steam-vacuum the carcass, Sofos suggested. His research had revealed that thorough washing and decontamination procedures can reduce incidence of pathogens like *E. coli* O157:H7, which may be introduced on the surface of carcasses from the environment and then contaminate other foods as well. "For meat, chemical de-hairing of the animal before hide removal and steam vacuuming of the carcass after hide removal will reduce contamination," says Sofos. With colleagues Keith Belk, John Scanga, Glenn Schmidt, and Gary Smith – as well as several graduate students and research associates – Sofos has found that spraying carcasses with high-pressure hot water or organic, lactic or acetic acid also works.

Sofos studies some of the most common foodborne pathogenic bacteria, including *E. coli* O157:H7, *Listeria monocytogenes*, and *Salmonella*. He seeks to control pathogens in beef, in ready-to-eat products, such as hot dogs, bologna, jerky, and dried fruits.

"We work with producers and processors, as well as the government, so that the work we do can be applied," says Sofos. "We also have a consumer education component."

Professor and Colorado Extension food science and human nutrition specialist Pat Kendall serves as a critical link for getting Sofos's research results in front of the people that will benefit most. Complications arising from foodborne illness, such as dehydration, pneumonia, kidney failure, and miscarriage, result in 5,000 deaths in the United States annually, notes Kendall. "People with the highest risk are those whose immune systems aren't able to fight the disease." That includes pregnant women, young children, the elderly, and people with chronic disease and HIV.

Kendall focuses her education efforts on reaching those who prepare or serve food to others and people who are at increased risk of foodborne illness due to compromised immune systems. Teaching food service workers is one of her top priorities, since they prepare food for any number of different people. The fact that Americans now eat more than half of their meals away from home makes it even more critical that restaurant and cafeteria workers follow food safety procedures. Recently, Kendall also began working with growers and vendors at farmers' markets to teach them safe and sanitary preparation of food samples.

Kendall finds that the food industry is especially receptive to Cooperative Extension's food safety training programs. "The industry people have a lot on the line. I find that they're always looking for ways to prepare food more safely, especially if it's something that also improves the quality."

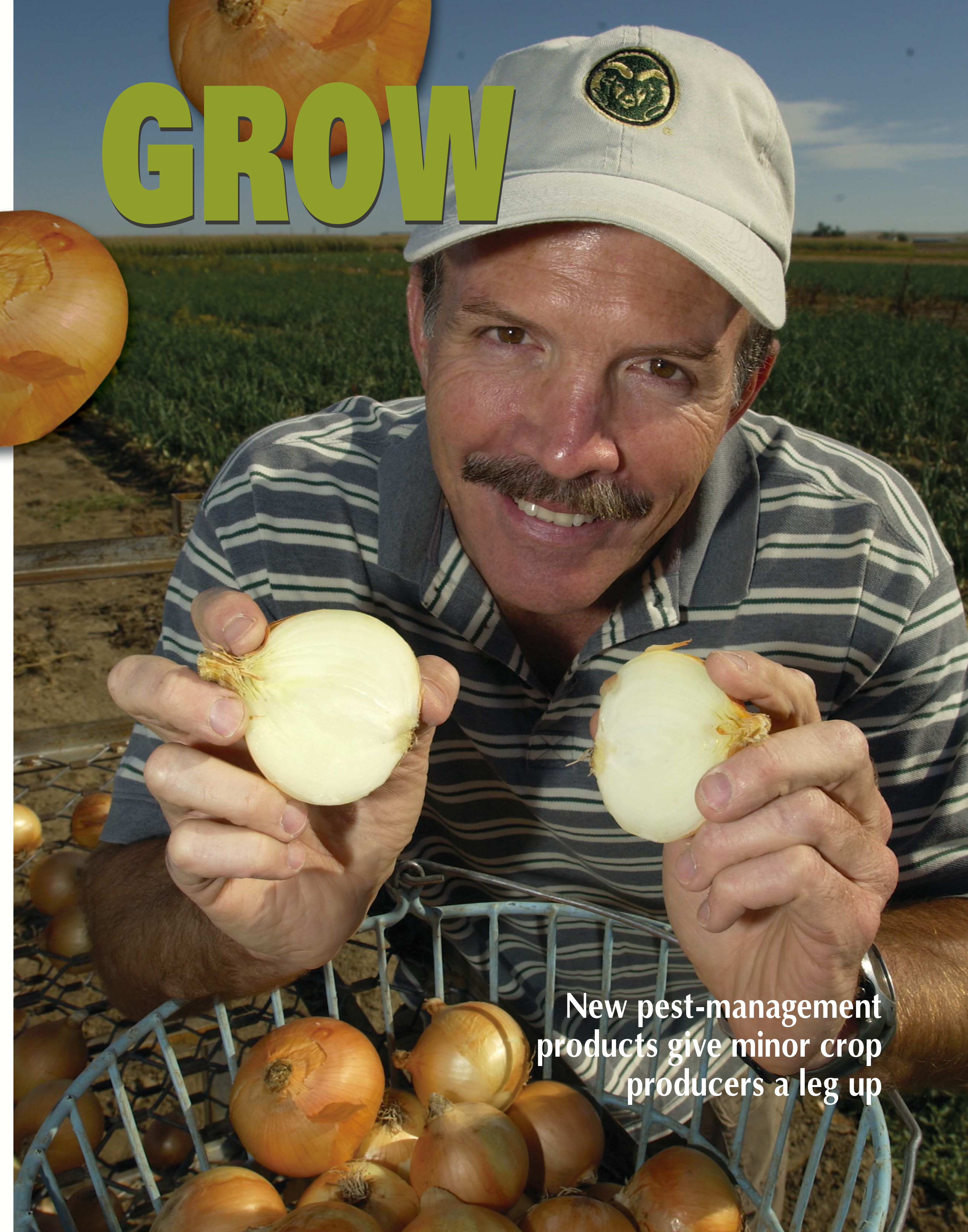
Procedures tested in the laboratory, and which Kendall tries out on taste panels, often result in a better product. Take dried apples, for instance. Treating the fruit slices with ascorbic acid or lemon juice before drying enhances destruction of *E. coli* O157:H7 during drying, adds Vitamin C, and prevents discoloration.

Sofos and Kendall strive to stay on top of food safety issues. New pathogens continually emerge. Furthermore, some decontamination procedures may actually cause other, more resistant bacteria to surface. They're now studying competing pathogens to see how they behave, if they're a potential risk, and how they can be controlled. "It's important to recognize potential risks that may surface in the future and be prepared to deal with them," Sofos says.

Another factor that will escalate the need for better food safety in the future will be changing demographics. Within the next 50 years, the number of elderly in the United States is expected to double, to 80 million, with the bulk of that increase occurring as baby boomers age between now and 2030. "Food safety will be even more critical", says Sofos, "We have to be prepared to face known, as well as newly emerging pathogens."

. . . READ ALL ABOUT IT

HELPING ONION GROWERS GROW



New pest-management products give minor crop producers a leg up

In Colorado, onions are a $50 million per year industry. Onion crops cover nearly 14,000 acres, making Colorado one of the country's top three onion producers.

Yet onions are considered small potatoes when compared to the nation's biggest crops – wheat, soybeans, corn, and rice. Companies that develop pest management products prefer to cater to the big guys. By controlling such pests as insects, weeds, and diseases, they save farmers thousands of dollars annually.

Scott Nissen, an associate professor of weed science, believes onion growers should have the same competitive edge. Since coming to Colorado State in 1995, he's been working for the smaller growers to do just that.

Onions have the potential to be one of the highest return-per-acre crops says Nissen, but, profits are compromised by how much farmers spend on hand labor to manage onions' most tenacious enemy: weeds.

That's where Nissen helps out. He and his collaborators develop alternative uses for EPA-approved products that effectively control weeds, thereby reducing the need for expensive hand labor.

"Onions can't stand much competition," Nissen explains. The plants have very little leaf surface area, leaving fertile fields open to weeds throughout the growing season. "You see weeds in onion fields that don't look like that weed in any other situation, because they're so much bigger and more competitive than the onions." To get maximum yields and profit margins, onion farmers must keep their fields weed-free for as long as possible.

Until recently, late-season weed control was done by hand. "Crews of hand laborers would walk the fields with small hoes and knock the weeds out by hand," Nissen explains. "Those costs have skyrocketed to where, even in a modest infestation, a grower could spend between $100 and $200 an acre."

But in 1998, farmers began using Dual Magnum, an herbicide for which Nissen developed the data to support a Special Local Need label and which now is used on 80 to 90 percent of Colorado's onion crops. The product has proven to be safe and effective, controlling Colorado's most common annual weed species. When applied to a clean field after the onions have two to three true leaves, Dual Magnum inhibits the growth of weed seedlings. Growers who apply the herbicide again four to six weeks later may realize the greatest benefit, says Nissen. "Then there isn't the need for hand labor late in the season."

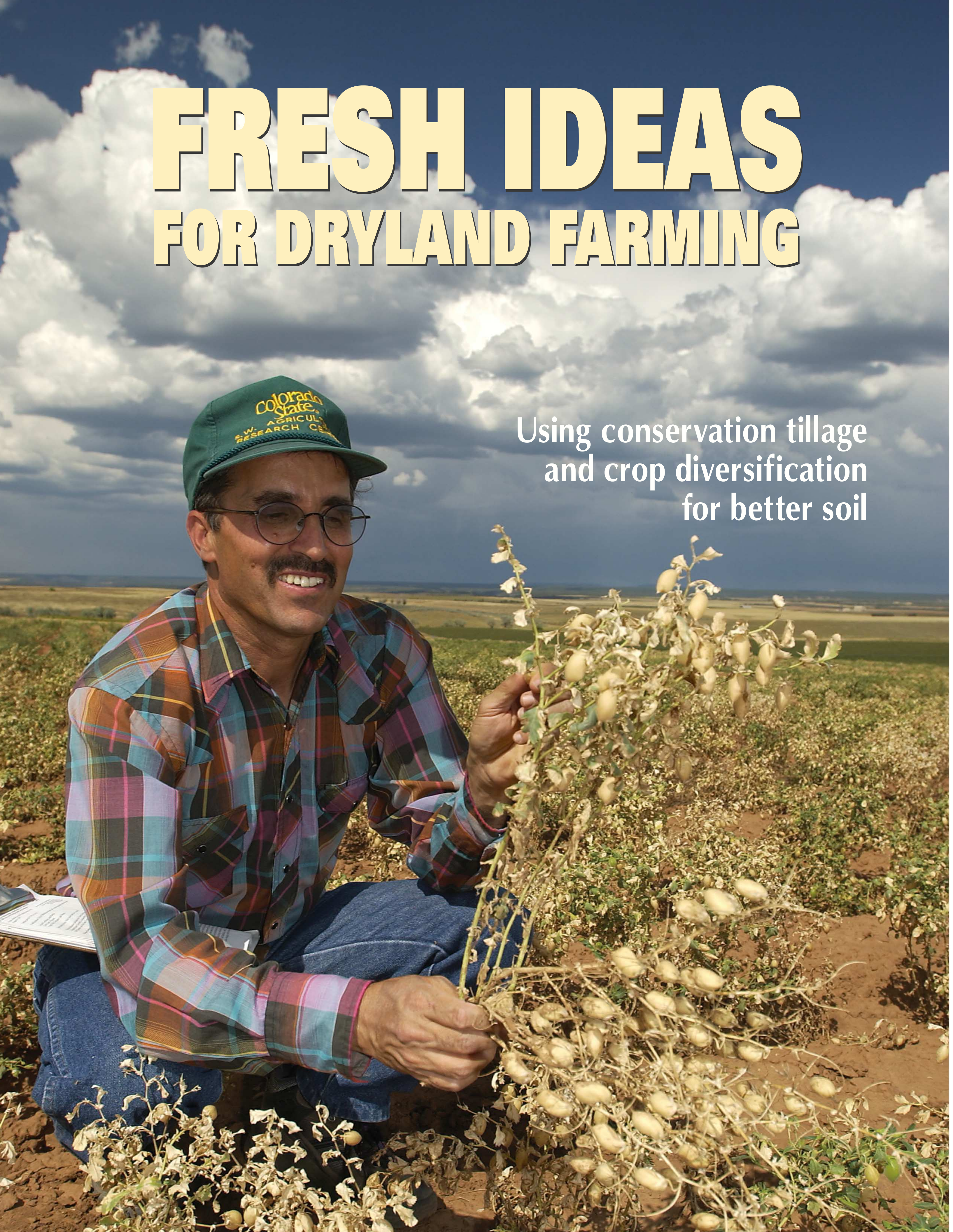
The product costs about $18 per acre to apply. "If farmers can get by with one late-season application, they'll realize a considerable savings compared to the cost of labor," says Nissen.

While Nissen's work is focused primarily on onions – the Colorado Onion Association funds most of his research – he also develops alternative uses for products that often are effective with other crops, such as spinach, potatoes, and beans. He is one of several Colorado State University members of a federal program called IR-4 whose mission is to provide pest management solutions to growers of fruits, vegetables, and other minor crops in all 50 states. One benefit of participating in IR-4 is that the program pays to test and register products believed to have good crop safety and weed-control efficacy.

Registering a new product "costs anywhere from $80 to $250 million, so companies focus on the greatest return – crops like corn, soybeans, wheat, and rice," explains Nissen. "So IR-4 was developed to give minor crop growers access to the same products that are being developed for major crops. It's been extremely successful."

Under the direction of environmental and pesticide education specialist Sandra McDonald, Colorado State has become a mini-field site for IR-4. Research Associate and field coordinator Clark Oman grows crops, applies the products, and sends the produce to labs for residue testing. Once products have met EPA guidelines for safety and efficacy, they are labeled for use.

"We're working on lots of other products for onions and other minor crops that have a track record and minimal environmental impact."



FRESH IDEAS FOR DRYLAND FARMING

Using conservation tillage and crop diversification for better soil

Sleeping Ute Mountain dominates the landscape of the Four Corners region. However, Abdel Berrada, research scientist at the Southwest Colorado Research Center is doing anything but resting. He is tirelessly working to keep ahead of the needs of the agricultural community of the Colorado Plateau with his research on sustainable dryland cropping systems.

Farmers in the semi-arid environment of the Four Corners region face some unique challenges. The elevation is relatively high, around 6,000 feet, making for a short growing season. Killing frosts occur late in the spring and early in the fall. The modest amount of rainfall comes later in the growing season than in most areas, creating another stress. The soil's relatively low organic matter, and steep slopes contribute to erosion with summer storms. Yet the region's pinto bean and alfalfa crops are known for their high quality – a benefit of the cool, arid environment.

Together with Gary Peterson, professor of soil and crop sciences at Colorado State, Berrada is taking a systems approach to develop sustainable dryland farming practices for southwestern Colorado and southeastern Utah. He is evaluating the use of conservation tillage and crop diversification to improve soil quality and increase yields.

Traditionally, the dryland farmers of the Southwest utilize systems of winter wheat followed by dry beans, or winter wheat followed by a year of fallow. To store moisture and control weeds, the fields commonly are disked and plowed after the fall wheat harvest. The fields often are worked two to five more times in the spring and summer with a field cultivator before planting dry beans. The resultant removal of the crop residue leaves the soil at risk of erosion.

There also is an economic trade-off with both traditional systems. With the wheat-fallow system, the land is only able to produce one crop every two years. The wheat-bean system tends to sacrifice some wheat productivity because the beans force a later-than-optimal planting of the winter wheat.

Berrada believes there may be better options. With a three-year grant from the USDA's Western Region Sustainable Agriculture Research and Education Program, Berrada is looking at several different approaches. He's comparing the traditional methods with options such as minimum tillage, alternative crops, and two, and three-year fallow cycles in numerous combinations. Application of fertilizer and weed control methods are also being tested. "We are here to experiment," explains Berrada. "We can make mistakes and it's okay." Farmers can't take the risk.

Crops Berrada is testing in the systems include winter wheat, pinto bean, oat, corn, safflower, alfalfa, and chickpea. He's combining these crops in various rotations with different tilling practices and cycles of fallow. Berrada is looking for combinations that create optimum yields, minimize weed problems, make effective use of water, add nutrients to the soil, and reduce the risk of erosion. Since the real world is Berrada's laboratory, every year's weather pattern introduces a new variable. In addition, the economics of the systems need to be considered. The price of a crop, the price of getting it to market, additional equipment, and regional infrastructure are all concerns. Sorting out the benefits and detriments of the combinations is complex and time-consuming.

Chickpeas, commonly known as garbanzo beans, hold some promise as an alternative to pinto beans for the southwestern farmers. Chickpeas are attractive because they utilize the same farming equipment and infrastructure as the pinto beans the area farmers already are producing. In addition the chickpea is more frost-tolerant, allowing for earlier planting and consequently earlier harvesting than pinto beans. This allows the winter wheat to be planted early in September, when it's most appropriate. Bob Hammon a research associate at the Western Colorado Research Center at Fruita figures, for each day winter wheat planting is delayed beyond September 1 there is likely to be a one percent reduction in wheat yield.

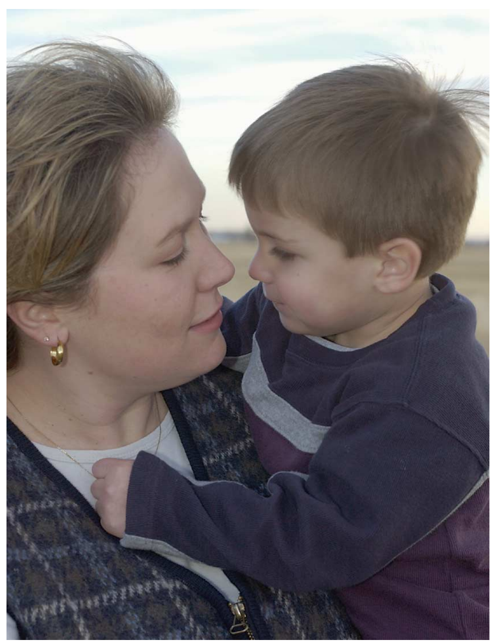
As he completes his second season of research under his Sustainable Agriculture Research and Education Program grant, Berrada feels he's just beginning on the research. "When you're working with crop rotations, you really need several years because it takes a long time to see changes in soil quality and pest dynamics," Berrada says. "That's probably why there are not a lot of cropping systems experiments out there."

THE FACE OF WELFARE REFORM IN RURAL COLORADO

The well-being of families is challenged

Out with the old, in with the new. The 60-year-old system of social support for impoverished Americans underwent a major upheaval in 1997. Aid to Family with Dependent Children (AFDC) and public assistance programs were basically dismantled.

The new program, Temporary Aid to Needy Families (TANF) resulting from the Personal Responsibility and Work Opportunity Reconciliation Act of 1997 (PRWORA) became the "welfare to work" program. Employment was the key issue. The intent of the program revisions was to help recipients get off of the welfare rolls and to a level of self-sufficiency. There is a new insistence that people be employed or in employment preparation activities, to receive assistance. Carole Makela, professor for the School of Education, wants to know if rural low income families are making ends meet.



The history of social support has long been controversial. Mother's Aid began in the 1900s followed by President Roosevelt introducing the highly debated AFDC in 1935. The following decades created what was referred to as the "culture of poverty" or the "cycle of dependency". In 1988, the Family Support Act (FSA) created the Job Opportunity and Basic Security (JOBS) program. These programs required recipients to go to work, enroll in school or enter a work-training program. The states then were required to provide support services for the recipients and to actively pursue child support payments. When the recipients failed to hold up their end of the deal, they were penalized by a reduction or loss of benefits, but the states faced no adverse consequences for failing to provide the support services.

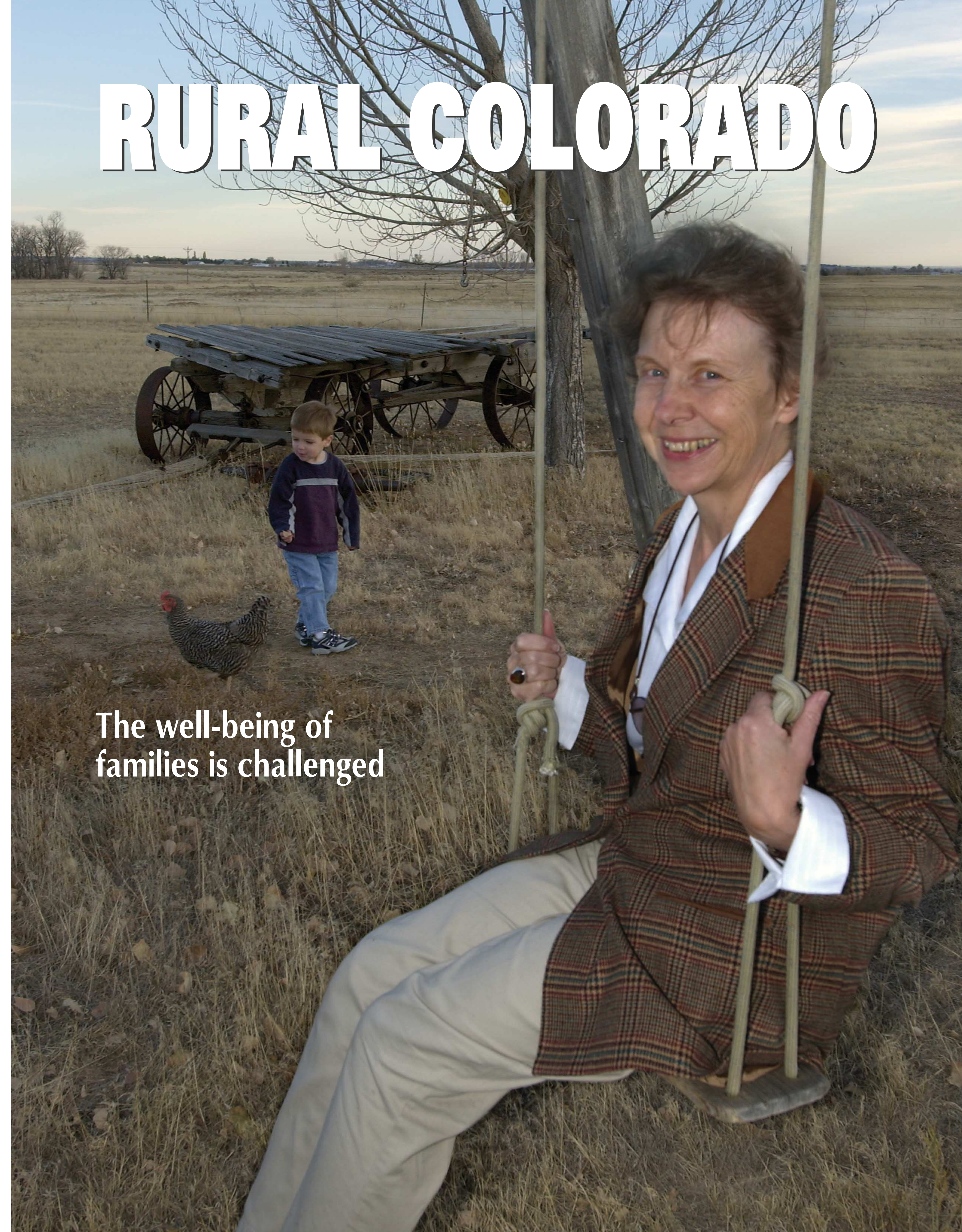
This led to the welfare reform legislation in 1997 when President Clinton intended to reform or change the system. Instead, legislation abolished it. Thus, TANF and PRWORA were created. There is no longer an entitlement to public welfare support, and there is a two-year limit on aid and a lifetime limit of five years, though states can have more stringent limits. In Colorado the program devolved to the county level.

The ability to function in the changed environment of policies and programs and the effect on the quality of life for rural families with children is being studied. Makela is tracking 30 to 40 families in selected Colorado counties. A baseline at the beginning of this project will identify the families' situation and will track changing policy within the counties and the state. The community environments and factors at the beginning of the project and at the end of the project will be identified.

Makela has found that it takes an average of $16.27 per hour in Larimer County to maintain a household for a single mother with two children. There are not many jobs in rural Colorado for persons with limited work experience and skills that pay that rate, working at a lower hourly rate calls upon the coping skills of individuals and families as well as support systems to maintain a household. Lack of support services such as affordable daycare, housing, and dependable transportation coupled with the time needed during the day for travel to and from work, daycare, doctors, and schools challenge the well-being of these families.

As a result of the reform, we have far fewer people on welfare. For Makela, the concern is if low-income families are maintaining or improving their situations whether they use TANF, the Earned Income Credit (EIC) or other programs. Or, have we just lowered the number of welfare cases and altered their lifestyles. The compilation of the data will determine the success and long-term viability of the newer program. Rural America will be tested.

"The moral test of government is how the government treats those who are in the dawn of life, the children; those who are in the twilight of life, the elderly; and those who are in the shadows of life, the sick, the needy and the handicapped" *Hubert H. Humphrey*



Colorado Agricultural Experiment Station Contributors

Colorado State University Colleges and Departments

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Department of Bioagricultural Sciences and Pest Management
Department of Horticulture and Landscape Architecture
Department of Soil and Crop Sciences

College of Applied Human Sciences

Department of Design and Merchandising
Department of Food Science and Human Nutrition
Department of Health and Exercise Science
Department of Human Development and Family Studies

College of Engineering

Department of Atmospheric Science
Department of Chemical and Bioresource Engineering
Department of Civil Engineering

College of Liberal Arts

Department of Sociology

College of Natural Resources

Department of Forest Sciences
Department of Rangeland Ecosystem Science
Natural Resource Ecology Laboratory (NREL)

College of Natural Sciences

Department of Biology
Department of Chemistry
Department of Statistics

College of Veterinary Medicine and Biomedical Sciences

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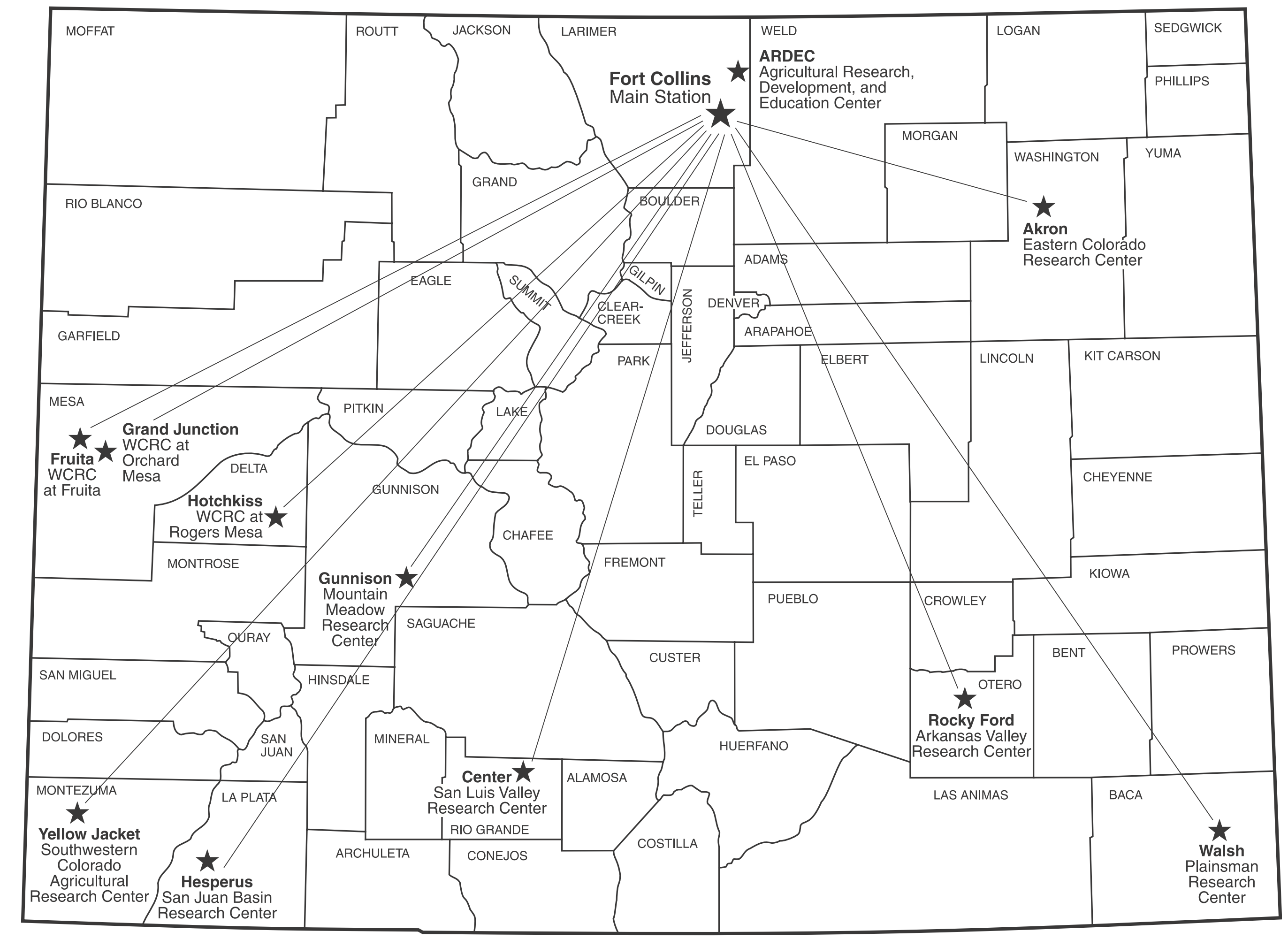
Colorado Agricultural Research System

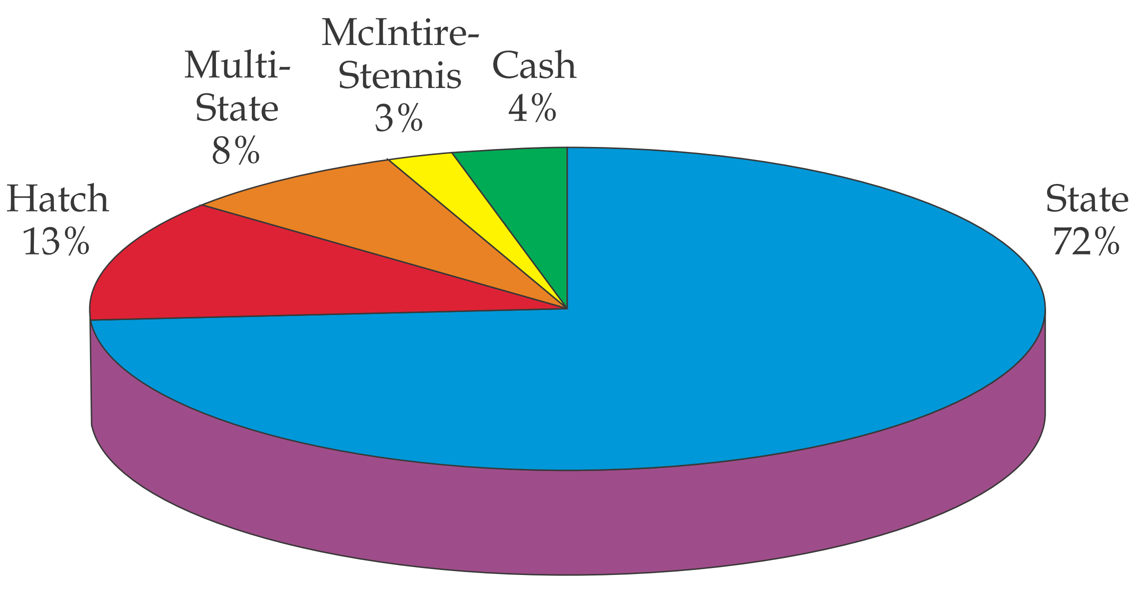


Colorado Agricultural Experiment Station Funding for Fiscal Year 2001-2002

The Agricultural Experiment Station at Colorado State University is funded by appropriations from the Colorado Legislature through the Colorado Commission on Higher Education, appropriations from the federal government through the United States Department of Agriculture, and from self-generated income through the sale of commodities. The relative amount of each funding source is shown in the chart.

- State – Funds appropriated by the Colorado legislature and allocated to Colorado State University by the Commission on Higher Education.
- Hatch – Funds appropriated by the federal government to each land-grant university for support of a base research program in agriculture and natural resources. These funds were authorized by the Hatch Act of 1887, as amended by the Agricultural Research, Education, and Extension Reform Act of 1998 and administered by the Cooperative States Research, Education, and Extension Service of the United States Department of Agriculture. The funds are prorated to each state based on a formula that includes several factors such as rural population and number of farms.
- Multi-State Research – A portion of the Hatch funds are mandated by Congress to be applied to research problems that are regional in nature and involve the efforts of several states. Funds are administered the same as Hatch funds.
- McIntire-Stennis – Funds appropriated by the federal government to support research in forestry and forest resources. Funds are administered the same as Hatch funds.
- Cash –Funds originating from the sale of goods and services associated with Agricultural Experiment Station programs. Commodities sold include crops and livestock, which are by-products of applied research programs conducted at research centers.

In addition to the above direct funding sources, scientists supported by the Agricultural Experiment Station are active in securing contract and grant funding from numerous private sources, as well as state and federal agencies. In the 2000-2001 fiscal year, contract and grant funding from these external sources contributed in excess of $20,000,000 of support to our research programs.



Total Budget: $11,892,914