NC STATE UNIVERSITY



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RESULTS

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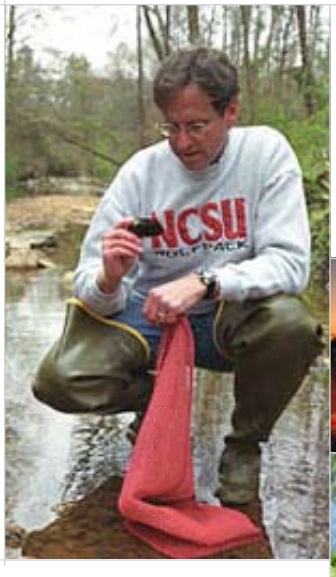
RESEARCH AND GRADUATE STUDIES AT NORTH CAROLINA STATE UNIVERSITY

ENVIRONMENT PERVASIVE IN NC STATE RESEARCH

The ten colleges that make up NC State span fields of study from social sciences to textiles to engineering to design. But a stealth college spans almost all of them, weaving itself into the research and extension efforts of dozens of departments without ever showing up on a campus map.



The environment is a major focus for professors throughout NC State. Surveys taken since the early 1990s have consistently identified hundreds of faculty members involved in projects linked to air and water quality, energy conservation, toxicology, habitat preservation, and environmental education and analysis. Chancellor James L. Oblinger says that's not surprising, considering that part of the University's land-grant mission involves promoting good stewardship of North Carolina's natural resources. That emphasis continues to grow as technology and economic growth place new demands on the state's water, air, fields, and forests. "The environment is closely linked to the University's strengths in agriculture, forestry, engineering, and veterinary medicine," Oblinger says, "and we want to use that vigor to move the state toward sustainability—growth that benefits both the environment and the economy."

No centralized College of the Environment exists on campus, so the breadth of programs may be under the radar for many. But Vice Chancellor for Research and Graduate Studies John Gilligan says that research cannot be separated from other work being done by engineers, biologists, and scientists in the other colleges. "We have a number of research centers working on basic science linked to the environment," Gilligan says, "and it would be difficult, but not impossible, to tie them all together."

Even without an umbrella college, faculty pull in tens of millions of dollars annually for environmental research. The University's leadership position in the field has attracted corporate and government entities to Centennial Campus for closer relationships with researchers. These include regional 0offices for the U.S. Department of Agriculture's Animal and Plant Health Inspection Service and the National Weather Service and the headquarters of the NC Wildlife Resources Commission. As William Ross, secretary of the NC Department of Environment and Natural Resources, puts it, "The research being conducted by NC State has been vitally important to our continuous efforts to bring about a cleaner environment, healthier lives, and a stronger economy for all North Carolinians."

This issue features some of the best of NC State's environmental research. ■

ENVIRONMENTAL TECHNOLOGIES

www.ncsu.edu/research/results

UNDERGROUND DECONTAMINATION

Planting Seeds for Soil Cleanup

Dr. Elizabeth Nichols examines sludge from a contaminated site to determine the effects of phytoremediation. ●

A sludgy mess sits a couple hundred yards from the Pasquotank River near Elizabeth City. Over the years, fuel has leaked out of underground storage tanks used to gas up boats, contaminating the soil. To Dr. Elizabeth Nichols, an assistant professor of environmental technology in the College of Natural Resources, it's the perfect place to do some landscaping.

Nichols doesn't landscape with showy annuals and flowering perennials. She practices phytoremediation, concentrating on plants that thrive in the toxic grounds sometimes left behind by former manufacturing plants, abandoned gas stations, and closed military bases. Her efforts in this growing field could soon offer government and the private sector an alternative to the more costly approaches of excavating and burning contaminated soil. "Financial resources are too limited to clean every contaminated area," she says, "and some sites are ideal for longer-term remediation approaches."

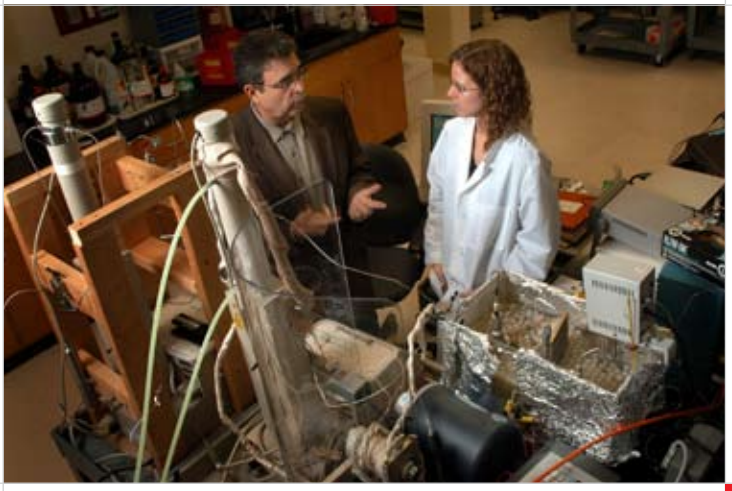
> "(Phytoremediation) could be an effective, affordable approach for many small sites that have been left unattended."

Building on the concept of riparian buffers that filter urban and agricultural runoff from streams, scientists in the late 1980s began experimenting with plants as a way to prevent underground contamination from spreading. At Elizabeth City, for example, Nichols, NC State graduate students, and collaborators from state and federal agencies this spring will plant a mix of deep-rooted shrubs and fast-growing trees like poplars, river birches, and willows to surround the contamination plume before it reaches the river. "There is still a lot to learn about how trees can impact residual, aged contamination," she says, "We don't yet know how much of the chemicals are absorbed by the trees and what effect it has on them."

Arrowheads and some other plant species thrive in the oily sediment near a former refinery in northwest Indiana. ●

Nichols' research has shown that some vegetation actually cleanses tainted soils. At an old refinery site in Gary, Indiana, where she has worked for two years, a reed-like plant, *Phragmites australis*, has been especially adept at growing in the petroleum-laden sediments along a creek. About 40 percent of the carbon the plant fixes during photosynthesis is released into the soil, she says, feeding bacteria that then break down the contamination. Because *Phragmites* is considered an invasive species across much of the U.S., Nichols is examining characteristics of the plant that help it thrive in such harsh conditions to determine if plants more suitable to various habitats could also be used for phytoremediation. "It's a slow-moving process that can't be used everywhere," she says. "But it could be an effective, affordable approach for many small sites that have been left unattended while more critical sites were cleaned." ■

Dr. Ruben Carbonell and graduate student Amy Zweber discuss an ongoing experiment to measure the amount of high-pressure CO_2 absorbed to thin polymer films. ●



GREEN CHEMISTRY

CO_2 Process Dissolves Toxic Waste Problems

A dry cleaner in Wake Forest and a Teflon® plant in Bladen County would appear to have little in common, but they are linked by a technology developed through a joint program at NC State and the University of North Carolina at Chapel Hill. The Center for Environmentally Responsible Solvents and Processes, founded in 1999 through a 10-year, $40 million National Science Foundation grant, has found numerous ways to replace water and toxic chemicals with high-pressure carbon dioxide as a solvent.

"There are so many applications for this technology, including improving the health and well-being of people, that it goes well beyond preserving the environment."

When CO_2 is pressurized to about 1,000 pounds per square inch at slightly more than room temperature, its density approaches that of a liquid, allowing it to dissolve many small molecules. Dr. Joseph DeSimone, who holds a joint position as chemistry professor at UNC and chemical engineering professor at NC State, has discovered a number of polymers that are soluble in such "supercritical CO_2." Scientists on both campuses have since found applications for the high-pressure gas in fields as diverse as dry cleaning, microelectronics, and pharmaceuticals. "One of our successes has been our flexibility," says Dr. Ruben Carbonell, chemical engineering professor and co-director of the center. "We've changed directions several times and moved into new applications."

Many industries use toxic chemicals like benzene and trichloroethylene as cleaning solvents. The chemicals then evaporate or are washed off, but Carbonell says they pollute the environment either way. Supercritical CO_2 not only eliminates chemicals from some manufacturing processes, he says, but also conserves water and energy because products no longer need to be rinsed and dried after a chemical bath. "Companies are not going to change their processes just for environmental reasons," he says. "The CO_2 has to create an advantage that results in more efficient processes or better products."

Supercritical CO_2 not only eliminates chemicals from some manufacturing processes, but also conserves water and energy.

The first advantage was to the dry cleaning industry, when MiCell Technologies, Inc., a joint NC State and UNC spin-off, founded the Hangers chain of dry cleaners to use CO_2 instead of perchlorethylene to eliminate stains. DuPont then licensed the technology to manufacture Teflon® and other similar coatings. Center researchers are now cleaning and etching circuit patterns on semiconductors with the supercritical fluid. Because the CO_2 can penetrate much smaller spaces than liquid solvents, designers can pack more circuits on a chip.

Another joint spin-off, Liquidia Technologies, Inc., uses a process developed by DeSimone to create polymer nanoparticles for drug delivery, sensors, and other applications. Such new avenues for research are important for the center to continue after the NSF grant runs out. "I see this evolving into a way that NC State and UNC students can seamlessly move between engineering, the sciences, and medicine," DeSimone says. "There are so many applications for this technology, including improving the health and well-being of people, that it goes well beyond preserving the environment." ■

Dry cleaning was the first industry to use supercritical CO_2 to replace toxic chemicals as a solvent. ●

www.nsfstc.unc.edu/

A mix of pipes and earthen basins assembled by Dr. Rich McLaughlin is the only erosion and sediment control research facility of its kind in the U.S. ●

WATER QUALITY

Cleaner Water Flows From Research

From gurgling mountain streams to the roar of the Atlantic, North Carolina is awash in water. But much of it is being flooded with sediment and contaminants by rapid development, growing industry, and changing agricultural practices. NC State researchers are developing new ways to control and monitor runoff and discharges into creeks and rivers. "Water quality problems are fairly universal," RiverNet Director Dr. Bill Showers says. "Everybody's got some water-related issues to address."

Measuring the amount of nitrogen released into the Neuse River was the primary issuehe wanted to addres when Showers, an associate professor in the Marine, Earth and Atmospheric Sciences Department persuaded the General Assembly to create RiverNet in the late 1990s. The system uses bundles of sensors to monitor water quality at seven locations between Raleigh and Kinston. Readings are taken every 15 minutes and sent electronically to NC State each night.

> "Water is a valuable resource. We have to treat it as such."

Excessive nitrogen discharges from farm fields and wastewater treatment plants have been blamed for fish kills in rivers and Pamlico Sound, but Showers says his data suggests the El Niño current in the Pacific also plays a key role in the fluctuating nitrogen levels by dictating how much rainfall North Carolina sees in a year. The RiverNet system is now serving as a springboard for other research, including using geographic information systems to predict potential problems from hog farms and conducting a U.S. Environmental Protection Agency-funded study of water quality near the Raleigh wastewater treatment plant. "Water quality is getting better, but it takes time," he says. "These things operate in hydrologic time frames, not human ones."

Drs. Greg Cope and Jay Levine measure water quality with more natural sensors—freshwater mussels that sit on the bottom of streams and act as canaries in an aquatic coal mine. As they constantly filter water to obtain microscopic bits of food, the mollusks also absorb contaminants. Consequently, four-fifths of the 60 species of freshwater mussels in North Carolina have either become extinct in recent years or are headed in that direction, says Cope, an associate professor of toxicology. "They're some of the most endangered animals on the planet," says Levine, an associate professor in the College of Veterinary Medicine, who analyzes the mussel equivalent of blood to learn more about their health.

Because of Cope and Levine's research, the EPA is poised to set tougher limits for the concentrations of ammonia and copper in water. Cope is also studying the trace amounts of pharmaceuticals, such as antidepressants and birth-control pills, that wind up in mussels. "An awful lot of attention is paid to

(Photo by Harold Henion)

Sensors set up by Ted Dodson on a bridge over the Neuse River continually sample water quality as part of the RiverNet system.

nutrients in the water, but the problem isn't just nitrogen and phosphorus," he says. "We don't know what contaminants are in there or how much is making it into our drinking supplies."

"WE'RE TRYING TO FIND ECONOMICAL WAYS FOR (DEVELOPERS) TO USE TECHNOLOGY FOR IMPROVED RESULTS."

Sediment is a major problem for aquatic life like mussels, so Dr. Rich McLaughlin is testing methods to stop runoff from construction sites from fouling creeks. Construction sites account for more than 100 tons of runoff per acre each year statewide, he says, which is 20 times the amount from agricultural land. Because collecting data at active sites is challenging—bulldozers continually rearrange the scenery and affect experiments—the associate professor of soil science built the Sediment and Erosion Control Research and Education Facility on Lake Wheeler Road. The jumble of flumes can mimic a summer storm by dumping five cubic feet of water per second into an earthen basin. It's the only erosion research facility of its kind in the U.S.

Piles of rocks typically used to dam retention ponds on construction sites don't slow rushing water enough to allow sediment to settle out, McLaughlin says. The basins at his Lake Wheeler Road site test ways to improve settling, from baffles made of coconut fiber to plastic floats that skim water off the top of a retention pond to drain into nearby creeks. He also is looking into the best way to apply polyacrylamide, a grainy additive used in water treatment, to coagulate sediment and speed settling. "Sediment control isn't a priority for developers because it's a cost to them," he says. "We're trying to find economical ways for them to use technology for improved results."

"(WATER QUALITY IMPROVEMENTS) OPERATE IN HYDROLOGIC TIME FRAMES, NOT HUMAN ONES."

Elsewhere on campus, technologies studied by Dr. Bill Hunt, an assistant professor in the Department of Biological and Agricultural Engineering, address stormwater runoff in urban settings, where just one inch of rain on an acre of parking lots, building roofs, and paved streets can send 22,000 gallons of water gushing into streams. Hunt works with developers statewide to find the best way to capture and filter runoff—from "green roofs," where gardens are planted atop buildings, to bioretention zones, which are specially designed islands in parking lots. NC State research has prompted the state to increase environmental credits to developers. Incorporating such designs lower nitrogen and phosphorus discharges, and using permeable pavement lets water percolate through rather than flow into a storm drain. "Water is a valuable resource," Hunt says. "We have to treat it as such." ■

Dr. Bill Hunt works with developers on designs that limit stormwater runoff, such as this roof garden atop a building at NC State's J.C. Raulston Arboretum.

Freshwater mussels help Dr. Greg Cope determine what contaminants are in streams because they absorb toxic materials while searching for food.

A 2,000-acre farm near Goldsboro headed by Dr. Nancy Creamer is among the most comprehensive organic farming research operations in the U.S.

ORGANIC FARMING

Using Mother Earth's Secret Recipe

A walk through the aisles of any supermarket will turn up dozens of organic items, from produce and dairy to meat and canned goods. With the organic foods industry growing by 20 percent a year since 1990—generating revenue of about $15 billion last year—Dr. Nancy Creamer is working to stock shelves with even more organic items for consumers.

As director of NC State's Center for Environmental Farming Systems (CEFS) in the College of Agriculture and Life Sciences, Creamer oversees a 2,000-acre farm in Wayne County that studies agricultural methods that can be both profitable for farmers and beneficial to the environment and rural communities. "There's a lot of potential to keep family farms and keep future generations in farming," says Creamer, who grew up on a poultry farm before studying agriculture systems in India. "Organic farming is the one niche profitable enough that even an individual can do it."

The CEFS farm, owned by the NC Department of Agriculture, has one of the most comprehensive organic research and education programs in the country, Creamer says. Before farmers can label their crops as organic, they must forgo conventional fertilizers and pesticides for three years and have a crop-rotation plan in place to maintain soil quality. She experiments with cover crops like rye and clover—other researchers study the use of compost or manure—to find alternative methods to fertilize the ground and control weeds while maintaining yields. "With conventional farming, you follow a recipe of applying chemicals at set times," she says. "But there's no cookbook for organic farming. You have to use knowledge of basic biology of crops and pests to succeed."

> "Organic farming is the one niche profitable enough that even an individual can do it."

Although organics grew out of the counterculture movement decades ago, little research had been conducted on the science behind the techniques until recent years, Creamer says. Plots on the CEFS farm are set aside to study and improve on systems developed by long-time organic farmers, such as investigating plants that attract beneficial insects, leaving cover crops as surface mulches to control weeds instead of tilling them into the soil, and using vegetative buffers to improve water quality. "There are billions of bacteria in the soil, and many have important roles we don't understand yet," she says. "We need to continue learning the biology of the soil to optimize the profitability of organic farming." ■

www.cefs.ncsu.edu/

AIR QUALITY

Clearing the Air Across N.C.

Dr. Chris Frey, left, examines his portable emissions monitor before testing the exhaust from a backhoe.

Air pollution has killed countless fir trees in the North Carolina mountains in recent years.

Large areas along the ridges of the North Carolina mountains have become dead zones in recent years partly because of pollution, says plant pathology professor Dr. Bob Bruck. Along with other factors, such as ozone levels and insect infestation, pollution has tipped the balance of the fragile ecosystem, most visibly affecting the large trees. Bruck has studied changes to the mountain ecosystem over the past two decades and was among the first scientists to suggest acid precipitation—polluted rain, fog, and snow–was killing spruce and fir forests along higher elevations of the Appalachian Mountains. "These areas are vacuum cleaners for pollution," he says. "They soak up all the sulfuric and nitric acids produced by power plants and cars."

> "People think that sitting in traffic jams is the major cause of urban air pollution. But what's really bad is when those drivers step on the gas."

Data Bruck collected on stunted trees, acidic soils, and the loss of native plant species in test plots on Mount Mitchell, along with research presented by others, helped convince Congress to pass the Clean Air Act of 1990. But he says the legislation hasn't solved the problem, partly because it doesn't regulate all vehicle emissions. Bruck continues to monitor the test plots annually and says the impact of pollution and acid rain is moving steadily down the mountains. "We've taken a rare and beautiful ecosystem and severely abused it," he says. "We must stop the domino effect at lower elevations."

Dr. Chris Frey is trying to do just that by studying vehicle emissions. A civil engineering professor, he is learning more about emission rates to lower exposure risks for people and help improve air quality statewide. Using a portable monitor with a tailpipe probe similar to those North Carolina service stations have used for years to test vehicles for annual state inspections, Frey analyzes emissions as he drives around town and on the highway.

Periods of acceleration far and away produce the greatest amount of pollution, Frey says, and account for about half of emissions on a trip in which most time is spent idling or cruising at a steady speed. "People think that sitting in traffic jams is the major cause of urban air pollution," he says. "But what's really bad is when those drivers step on the gas and start moving again." Because of Frey's research, the U.S. Environmental Protection Agency is developing a new vehicle emission model, which could lead to tougher air-quality standards for passenger vehicles.

State and local agencies struggling with the haze of ozone and other pollutants over North Carolina metro areas also can tap Frey's data to develop appropriate measures for limiting emissions. The NC Department of Transportation, for example, has tweaked the timing of traffic signals at some intersections to reduce stop-and-go commutes and the resulting emissions spike. "Non-attainment of national air quality standards can affect industrial growth and federal funding of highway projects," Frey says. "Providing realistic information about the relationship between vehicle dynamics and emissions is crucial to effectively preventing emissions." ■

www4.ncsu.edu/~frey/

Dr. Jeanne Koger records meter readings as a nearby furnace converts hog waste into ash for fertilizers and gases to power the furnace.

"Recycling the waste to create value-added products is much better for the environment and the economy."

www.cals.ncsu.edu/waste_mgt/apwmc.htm

HOG WASTE DISPOSAL

Research Seeks to Balance Technology Costs, Benefits

Managing animal waste is an ongoing challenge to the hog industry in eastern North Carolina. Ruptures in some hog farm waste lagoons have contaminated rivers. Spreading waste on fields as fertilizer sometimes results in extra nitrogen or phosphorus discharges, which can throw ecosystems out of whack. And the odor from farms often elicits nuisance complaints from neighbors. But after more than five years of research by NC State scientists, better ways to manage and utilize the waste might soon be at hand.

As part of a agreement in 2000 between the State and major hog producers, the University was charged with the responsibility of finding technologies that were both environmentally superior to the lagoon-and-spray system currently being used on most farms and economically feasible for farmers to implement. Dr. Mike Williams, who recently stepped down as director of NC State's Animal and Poultry Waste Management Center (APWMC), coordinated the effort, spending almost every day in recent years contemplating hog waste and its impact on North Carolina. "I don't think we're currently in a crisis, but I know that systems now being used aren't sustainable over the long term," he says. Drawing on research being conducted at APWMC and on other ideas in academia and private industry, Williams and his advisory board winnowed more than 100 possible waste disposal systems into a handful that University scientists like Drs. Jeanne Koger and Phil Westerman could test and tweak to meet the state's objectives.

NC State graduate students test the air quality inside and outside of hog barns in Pitt and Jones counties four times a year.

Waste from large-scale hog farms is now piped from barns into lagoons, and liquids are then sprayed on nearby fields.

A system devised by Koger, a researcher in the Department of Animal Science, and former NC State professor Dr. Theo van Kempen separates the solid and liquid waste with a conveyor belt and uses a furnace to gasify the feces. The gases released in the process are captured to help run the furnace, and the sterile, mineral-rich ash left behind can be used in fertilizer or animal feed, Koger says. "Recycling the waste to create value-added products is much better for the environment and the economy," she says. As she and engineer Preston Burnette work to scale up the technology and develop a system to recycle the liquid waste as well, they also eye other uses for the furnace, such as destroying animal carcasses after an avian flu outbreak or bioterror incident.

"It's easy to fix the water-quality issues with waste lagoons, but there are no easy fixes for the air quality."

Meanwhile, Westerman studied a system developed by a Canadian company using microbes in aerated filters to digest waste in ten-meter-diameter tanks. The system works, he says, but the energy needed to inject air into the filters to help the bacteria function wasn't cost-effective. In fact, says Westerman, a biological and agricultural engineering professor who specializes in animal waste issues, several of the treatment processes tested by researchers have been studied in some form for years and were not previously adopted by farmers because of added cost. "Unfortunately, that still seems to be the situation," he says.

The economics of waste disposal is a major consideration for North Carolina's $1.5 billion hog industry. Although North Carolina is one of the top hog producers nationally, farmers don't control the market enough to simply pass the capital and operating costs of a new technology on to consumers, says agricultural economics professor Dr. Michael Wohlgenant. Forcing producers to absorb the costs would be catastrophic for the industry, he says, and would ripple across the state economy. Models developed by Wohlgenant show that adopting a high-end system could cost the industry $485 million per year and eventually wipe out close to two-thirds of North Carolina's hog farms as major producers move operations to states with less stringent regulations.

"Managing hog waste will be a critical issue for North Carolina for the foreseeable future."

But Dr. Viney Aneja says changes will have to be made for the sake of human, as well as environmental, health. An air quality expert in the College of Physical and Mathematical Sciences, Aneja says hog waste lagoons release about 250 tons of ammonia into the state's atmosphere every day. In addition to contributing to the farms' odor problems, the ammonia reacts with other gases to create fine particulate matter, which can aggravate respiratory problems. NC State graduate students now take air samples four times a year at hog farms in Pitt and Jones counties to use in determining how the particles are formed. Aneja, who is coordinating a national workshop in June on hog farm emissions issues, also is beginning to examine air samples for other emissions, such as sulfur gas and volatile organic compounds. "It's easy to fix the water quality issues that arise from waste lagoons, but there are no easy fixes for the air quality," he says. "The emissions affect more than the ecosystem. They could ultimately have an effect on our health."

After reviewing the data compiled by University researchers, Williams submitted his final recommendations to state officials in January. The industry and the state are now considering the benefits and consequences of upgrading disposal systems. Williams says the move is necessary in spite of the potential economic distress, and he plans to continue monitoring the situation. "Managing hog waste will be a critical issue for North Carolina for the foreseeable future," he says. "The state cannot continue to be a sink for the nutrients produced by large-scale farms." ■

Dr. Mike Williams and NC State researchers looked at dozens of ideas for improved hog waste disposal before recommending a few systems to state officials.

Dr. Craig Harms monitors the reaction of a leatherback turtle to anesthesia while other researchers conduct tests on the animal. (Photo by Dr. Scott Eckert)

ENDANGERED SPECIES PROTECTION

Call of the Wild Returning to North Carolina

A howl is going up across northeastern North Carolina. Red wolves, which once flourished across the Southeast before flirting with extinction a generation ago, are gradually being reintroduced to the region. The program is one of several where College of Veterinary Medicine (CVM) researchers are working to prevent threatened or endangered species from fading into the history books. "It's exciting to be part of an effort to bring a species back from the brink," clinical science professor Dr. Michael Stoskopf says, "especially one that plays a major role in the biodiversity of this state."

The U.S. Fish and Wildlife Service launched the red wolf recovery program in the mid-1970s, when fewer than 100 remained in the wild. Between 100 and 150 now roam five counties in the northeast corner of the state, and NC State several years ago helped develop a system to limit interbreeding with coyotes. The management system reserves Dare County habitats exclusively for red wolves and uses sterilized hybrid animals to hold territories in neighboring counties until red wolf packs are ready to claim them.

University researchers have also created a geographic information system database to help monitor the red wolf populations and adjust the management system. And an expanded holding area at the CVM will soon aid in developing molecular tests to monitor the wolves' diets and potential disease threats. "We'll have more than one wolfpack on campus," Stoskopf says with a laugh. "Red wolves are more than just a nice conservation effort. They are a valuable research tool for better understanding dynamics in nature."

> "It's exciting to be part of an effort to bring a species back from the brink."

Likewise, Dr. Craig Harms is both studying and saving sea turtles at NC State's Center for Marine Sciences and Technology in Morehead City. "You rescue enough turtles that have been caught in fishing nets or struck by boats, and you eventually start to examine their overall health," Harms says. In analyzing turtle fecal cultures, for example, he has found extensive antibiotic resistance in the creatures, but not a corresponding number of bacterial infections. "We haven't determined if that immunity is just natural or related to human impact."

Twice a year, Harms examines a few dozen turtles to determine if the male-female ratio is adequate for breeding. He also acts as oceanside anesthesiologist from time to time, monitoring turtles' response to anesthetic drugs while they undergo tests on the beach. "We need to learn more about many animals so our actions don't end up harming them," he says. "Every species deserves the chance to thrive." ■

(Photo by Chris Lucash)

Drs. Michael Stoskopf and Anne Acton examine a red wolf on NC State's campus. Meanwhile, red wolf puppies are once again thriving in eastern North Carolina.

ALTERNATIVE ENERGY

Harvesting Fuel From Agricultural Bounty

Drs. Ratna Sharma, left, and Mari Chinn find the best processes for converting crops and agricultural waste into fuel. ●

Agriculture has been a mainstay of the North Carolina economy for generations, but NC State researchers like Drs. Ratna Sharma and Mari Chinn are working to help farmers feed more than humans and animals. The two assistant professors in the Department of Biological and Agricultural Engineering are experimenting with crops and agricultural waste materials to develop new fuel sources that could feed the state's economic growth by powering generators and vehicles.

"We are changing from a hydrocarbon to a carbohydrate economy."

Sharma uses microorganisms to begin breaking down cotton stalks before introducing enzymes to convert the cellulose in the woody plants into sugar, which is then fermented into ethanol. Because microbes are sometimes inefficient, she also works with chemicals, heat, and supercritical fluids—high-pressure gases that act as solvents—to find the best method to kick-start the process. "We are changing from a hydrocarbon to a carbohydrate economy," she says, noting she also experiments with wheat straw, barley, sorghum, and switchgrass as feedstocks to create ethanol.

Chinn works with more traditional crops, like North Carolina sweet potatoes, to produce biofuels. She also is investigating a combination of fermentation with a gasification furnace as an alternative production method. Partial combustion of plant-derived feedstocks generates gases that *Clostridium* bacteria can convert into ethanol and acetate, Chinn says. The acetate currently limits ethanol yields, so she is refining the process to boost ethanol output. Sharma says tapping such resources, much of which would be cast aside as waste, could create enough alternative fuels to meet about half of U.S. needs. "You're really getting something out of nothing."

Read more about NC State research into biofuels and other energy technologies in the Summer 2006 issue of RESULTS. ■

WRRI Chief Reviews Katrina Damage

Dr. David Mureau. ●

Dr. David Moreau, director of the Water Resources Research Institute at NC State and a professor of civil and environmental engineering, is a member of a National Academy of Engineering (NAE) panel that is peer reviewing evaluations of the failure of New Orleans levees after Hurricane Katrina. Both the federal government and the American Society of Civil Engineers are examining the performance of the levees during the storm.

In addition to reviewing the engineering analyses the two groups are putting together and making recommendations for improved hurricane protection for the future, Moreau says the NAE panel is encouraging the government to examine Katrina's environmental impact on the region and the effect of environmental changes on the storm.

"Katrina substantially altered wetland vegetation in the area, and the loss of wetlands around New Orleans may have contributed to the storm surge that reached the levees," Moreau says. "The Army Corps of Engineers has argued that wetland loss had little effect on storm surge, but that argument should be subjected to peer review."

Sea oats have wide heads for trapping blowing sand and extensive root structures to prevent dune erosion.

BEACH STABILIZATION

SOWING OATS TO PROTECT DUNES

As Hurricane Ophelia battered the North Carolina coast last fall, tearing at fragile beaches from Brunswick to Carteret counties, David Nash knew this would be a banner year for sea oats.

Nash, an agent with the Cooperative Extension Service in southeastern North Carolina, has in recent years cultivated a sea oats industry in North Carolina. The plants help stabilize beach dunes as well as provide an alternative crop for some farmers. "The ocean takes what it wants, and barrier islands are always shifting," he says. "But since man has moved in, we have created a system that needs to be managed."

"WE'RE JUST TRYING TO PUT BACK WHAT NATURE WOULD NORMALLY ESTABLISH."

With their extensive root structures and wide heads that trap blowing sand, sea oats are perfect to maintain dune lines, Nash says. But no one grew sea oats in the state, and plants imported from Florida are genetically different and don't seed well in North Carolina. So he adapted a system used to grow tobacco seedlings—seeds and a nutrient-rich soil mixture are placed in foam containers floating in water—and several years ago convinced the town of Oak Island to build a greenhouse to grow North Carolina sea oats. Now, municipal operations in Oak Island and Carolina Beach, as well as a handful of private growers, produce about a million sea oat seedlings a year.

Nash also works with NC State horticulture professor Dr. Frank Blazich and crop science professor Dr. Paul Murphy to improve sea oat production. Murphy is looking to modify the plants genetically so they can be grown inland and their seeds harvested away from the peril of ocean storms. (Ophelia wiped out about a third of the state's sea oat seed production last year.) Meanwhile, Blazich's research has helped increase the germination rate of the seedlings by adjusting greenhouse temperature and moisture levels.

Blazich and Nash also are studying other native beach plants, such as bitter panicum and seashore elder, to intersperse with sea oats along the beach for a more diverse habitat and stronger dunes. "We're just trying to put back what nature would normally establish," Nash says. ■

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RESEARCH AND GRADUATE STUDIES AT NCSU RESULTS

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