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2003 Annual Drinking Water Quality Report
City of Raleigh
PWS ID# 03-92-010

The City of Raleigh is pleased to present our Annual Water Quality report for 2003. The Safe Drinking Water Act (SDWA) requires that the City of Raleigh provide this report to all of its customers on an annual basis. This report will give you a snapshot of the water we produced last year. The Public Utilities Department of the City of Raleigh is proud to report that its drinking water meets all federal and state standards as required by the U.S. Environmental Protection Agency (USEPA) with no violations during January through December of 2003.

What EPA Wants You to Know

Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of contaminants does not necessarily indicate that water poses a health risk. More information about contaminants and potential health effects can be obtained by calling the **Environmental Protection Agency's Safe Drinking Water Hotline (800-426-4791).**

Some people may be more vulnerable to contaminants in drinking water than the general population. Immuno-compromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants can be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. EPA/CDC guidelines on appropriate means to lessen the risk of infection by cryptosporidium and other microbiological contaminants are available from the **Safe Drinking Water Hotline (800-426-4791).**

The sources of drinking water (both tap water and bottled water) include rivers, lakes, streams, ponds, reservoirs, springs, and wells. As water travels over the surface of the land or through the ground, it dissolves naturally occurring minerals and, in some cases, radioactive material, and can pick up substances resulting from the presence of animals or from human activity. Contaminants that may be present in source water include *microbial contaminants*, such as viruses and bacteria, which may come from sewage treatment plants, septic systems, agricultural livestock operations, and wildlife; *inorganic contaminants*, such as salts and metals, which can be naturally-occurring or result from urban storm water runoff, industrial or domestic wastewater discharges, oil and gas production, mining, or farming; *pesticides and herbicides*, which may come from a variety of sources such as agriculture, urban storm water runoff, and residential uses; *organic chemical contaminants*, including synthetic and volatile organic chemicals, which are by-products of industrial processes and petroleum production, and can also come from gas stations, urban storm water runoff, and septic systems; and *radioactive contaminants*, which can be naturally-occurring or be the result of oil and gas production and mining activities.

In order to ensure that tap water is safe to drink, EPA prescribes regulations which limit the amount of certain contaminants in water provided by public water systems. FDA regulations establish limits for contaminants in bottled water, which must provide the same protection for public health.

When You Turn on Your Tap, Consider the Source

Raleigh uses surface water from Falls Lake as its source for water. Falls Lake, located northwest of the City of Raleigh, has a surface area of over 12,500 acres and can provide Raleigh with up to 100 million gallons of water a day to serve approximately 128,600 metered customers and a service population of approximately 344,000 people.

The City and other agencies continuously monitor the water quality at Falls Lake. Results from the monitoring indicate Falls Lake continues to be an excellent source of raw water for drinking water treatment. The State of North Carolina has completed an assessment of our source water as required by the SDWA. This completed report will be available to the public in late 2004. To obtain information on the availability of this source water assessment, you may contact the **North Carolina Department of Department of Environment and Natural Resources (NCDENR), Public Water Supply Section, Source Water Assessment Program, 1634 Mail Service Center, Raleigh, NC 72699-1634 or at (919) 715-2633.**

How Your Water is Treated and Distributed

The treatment process consists of a series of steps. First, raw water from Falls Lake is pumped to the E.M. Johnson Water Treatment plant where the treatment process starts. The water goes into a contact chamber where ozone is added, then to a mixing tank where ferric sulfate, sodium hydroxide and a polymer are added. The addition of these chemicals causes small particles to adhere to one another *(coagulation)*. The particles are allowed to settle to the bottom of large settling tanks and are then removed *(sedimentation)*. The water then flows through filters of carbon and sand to remove any remaining particles *(filtration)*. Finally, chloramines, a combination of chlorine and ammonia, are added to disinfect the water *(disinfection)* and ensure that the water is safe to drink when it reaches the customers.

In March of each year, Raleigh stops the addition of ammonia and uses chlorine alone, as its disinfectant. During this four-week period, Raleigh water customers will taste and smell the chlorine in the water they receive with out ammonia. Ammonia masks the taste and odor of the chlorine during the remaining 11 months of the year.

Once the water has been treated at the E.M. Johnson Water Treatment plant, it is pumped from the plant into approximately 1,476 miles of water transmission and distribution mains. These mains range in size from two inches to 54 inches in diameter. There are five elevation zones in the distribution system due to the changing topography in Raleigh's water service area. These elevation zones receive water from 13 booster pump stations and include 16 storage tanks.

All municipal water systems, including Raleigh's, are sized for fire protection demands by using elevated water storage tanks. Although necessary for fire protection, the system sizing can negatively impact water quality during low customer demand periods, which must be addressed by hydrant flushing. During hot, dry weather conditions the demand for water by Raleigh's customers causes the speed that water travels through the distribution system to increase significantly. This increase may sometimes cause brief, temporary periods of discoloration of the water. Water main breaks or leaks can also cause water discoloration.

Water Quality Data Table of Detected Contaminants

We routinely monitor for over 120 contaminants in your drinking water according to Federal and State laws. The table below lists all the drinking water contaminants that we detected in the last round of sampling for the particular contaminant group. The presence of contaminants does not necessarily indicate that water poses a health risk. **Unless otherwise noted, the data presented in this table is from testing done January 1 through December 31, 2003.** The EPA or the State requires us to monitor for certain contaminants less than once per year because the concentrations of these contaminants are not expected to vary significantly from year to year. Some of the data, though representative of the water quality, is more than one year old.

Unregulated contaminants are those for which EPA has not established drinking water standards. The purpose of unregulated contaminant monitoring is to assist EPA in determining the occurrence of unregulated contaminants in drinking water and whether future regulation is warranted.

The City of Raleigh's E.M. Johnson Water Treatment Plant performs sufficient testing to ensure the safety of your drinking water. The drinking water laboratory at the water treatment plant has certification and approval from the State of North Carolina and the USEPA to perform water quality analysis. In 2003, staff chemists and technicians at the drinking water laboratory collected, tested and analyzed Raleigh's drinking water between 6,000 and 7,000 times a month for many substances such as trace metals, petroleum products, pesticides and bacteria. During 2003, the City of Raleigh was in compliance with all national Primary Drinking Water Regulations.

Important Drinking Water Definitions:

Not-Applicable (N/A) – Information not applicable/not required for that particular water system or for that particular Rule.
Parts per million (ppm) or Milligrams per liter (mg/l) - one part per million corresponds to one minute in two years or a single penny in $10,000.
Parts per billion (ppb) or Micrograms per liter - one part per billion corresponds to one minute in 2,000 years, or a single penny in $10,000,000.
Picocuries per liter (pCi/L) - picocuries per liter is a measure of the radioactivity in water.
Nephelometric Turbidity Unit (NTU) - nephelometric turbidity unit is a measure of the clarity of water. Turbidity in excess of 5 NTU is just noticeable to the average person.
Action Level (AL) - the concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow.
Treatment Technique (TT) - A treatment technique is a required process intended to reduce the level of a contaminant in drinking water.
Maximum Residual Disinfection Level Goal – The "Level" (MRDLG) of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
Maximum Residual Disinfection Level – The "Highest Level" (MRDL) of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
Maximum Contaminant Level - The "Maximum Allowed" (MCL) is the highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology
Maximum Contaminant Level Goal - The "Goal" (MCLG) is the level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.

Extra Note: MCLs are set at very stringent levels. To understand the possible health effects described for many regulated constituents, a person would have to drink 2 liters of water every day at the MCL level for a lifetime to have a one-in-a-million chance of having the described health effect.

Microbiological Contaminants

Contaminant (units)	MCL Violation Y/N	Your Water	MCLG	MCL	Likely Source of Contamination
Total Coliform Bacteria (presence or absence)	No	3.7%	0	5% of monthly samples are positive	Naturally present in the environment

Turbidity

Contaminant (units)	MCL Violation Y/N	Your Water	MCLG	MCL	Likely Source of Contamination
Turbidity (NTU)	No	0.109	N/A	TT = 5 NTU	Soil runoff
		100%		TT = percentage of samples < 0.5 NTU	

* Turbidity is a measure of the cloudiness of the water. We monitor it because it is a good indicator of the effectiveness of our filtration system. The turbidity rule requires that 95% or more of the monthly samples must be below 0.5 NTU.

Inorganics Contaminants

Contaminant (units)	Sample Date	MCL Violation Y/N	Your Water	Range Low High	MCLG	MCL	Likely Source of Contamination
Fluoride (ppm)	01/2003	No	0.92	N/A	4	4	Erosion of natural deposits; water additive which promotes strong teeth; discharge from fertilizer and aluminum factories

Unregulated Inorganics Contaminant

Contaminant (units)	Sample Date	Your Water	Range Low High	Proposed MCL
Sulfate (ppm)	01/2003	53	N/A	250

Unregulated VOC Contaminants

Contaminant (units)	Sample Date	Your Water	Range Low High
Chloroform (ppb)	01/2003	36.6	24.8 – 48.3
Bromodichloromethane (ppb)	01/2003	8.99	7.70 – 11.0
Chlorodibromomethane (ppb)	01/2003	1.45	<1.0 – 3.13

Lead and Copper Contaminants

Contaminant (units)	Sample Date	Your Water	# of sites found above the AL	MCLG	MCL	Likely Source of Contamination
Copper (ppm) (90th percentile)	Jun – Sept, 2002	0.16	0	1.3	AL=1.3	Corrosion of household plumbing systems; erosion of natural deposits; leaching from wood preservatives
Lead (ppb) (90th percentile)	June – Sept, 2002	0.003	0	0	AL=15	Corrosion of household plumbing systems, erosion of natural deposits

Disinfection By-Product Precursors Contaminants

Contaminant (units)	Sample Date	MCL Violation Y/N	Your Water	Range Low High	MCLG	MCL	Likely Source of Contamination
Total Organic Carbon (ppm) (TOCs)	2003	N	1.43	1.9 – 2.7	N/A	TT	Naturally present in the environment

Disinfection By-Product Contaminants

Contaminant (units)	MCL Violation Y/N	Your Water	Range Low High	MCLG	MCL	Likely Source of Contamination
TTHM (ppb) [Total Trihalomethanes]	No	47.0	33.9 – 56.0	N/A	80	By-product of drinking water chlorination
HAA5 (ppb) [Total Haloacetic Acids]	No	37.7	25.6 – 61.1	N/A	60	By-product of drinking water disinfection
Chloramines (ppm)	No	3.5	N/A	MRDLG = 4	MRDL = 4	Water additive used to control microbes
Chlorine (ppm) (March 2003 only)	No	1.5	N/A	MRDLG = 4	MRDL = 4	Water additive used to control microbes

Unregulated Disinfection By-Product Contaminants

Contaminant (units)	MCL Violation Y/N	Your Water	Range Low High	MCLG	MCL	Likely Source of Contamination
Monochloroacetic Acid (ppb)	No	<2.0	<2.0 – 2.14	N/A	N/A	By-product of drinking water disinfection
Dichloroacetic Acid (ppb)	No	17.3	9.51– 26.8	N/A	N/A	By-product of drinking water disinfection
Trichloroacetic Acid (ppb)	No	19.0	9.64 – 32.2	N/A	N/A	By-product of drinking water disinfection
Monobromoacetic Acid (ppb)	No	<1.0	<1.0 – 1.84	N/A	N/A	By-product of drinking water disinfection
Dibromoacetic Acid (ppb)	No	<1.0	<1.0 – 1.49	N/A	N/A	By-product of drinking water disinfection

Secondary Contaminants, required by the NC Public Water Supply Section, are substances that affect the taste, odor, and/or color of drinking water. These aesthetic contaminants normally do not have any health effects and normally do not affect the safety of your water.

Water Characteristics Contaminants

Contaminant (units)	Sample Date	Your Water	Range Low High	Secondary MCL
Sodium (ppm)	01/2003	26.9	N/A	N/A
pH, units	01/2003	7.87	N/A	6.5 to 8.5
Manganese (ppm)	1/2003	0.02	N/A	0.05
Alkalinity (ppm as Calcium Carbonate)	01/2003	30.3	N/A	N/A
Hardness (as Calcium Carbonate	01/2003	23.3	N/A	N/A

Radon and Cryptosporidium Monitoring

Radon is a radioactive gas that you can't see, taste, or smell. It is found naturally occurring throughout the U.S. EPA expects to issue a Radon Rule, which will set a standard for Radon in drinking water. The City of Raleigh tested for Radon in its finished water and found it to be <100 pCi/L. There is no current MCL for Radon. However, the EPA is considering an MCL of 300 pCi/L.

Cryptosporidium is a microorganism that can cause intestinal illness. The City of Raleigh voluntarily tests for Cryptosporidium and DID NOT detect Cryptosporidium in its water in 2003. The City of Raleigh also tested for Methyl tert-butyl ether (MTBE) and found it to be below the detection limit of 5 ppb for MTBE. At this time no limit for MTBE has been established, however the EPA is considering a limit of 30 ppb.

What If I Have Any Questions Or Would Like to Become More Involved?

Public Utilities is a separate department within the City of Raleigh local government and is responsible for the operation and maintenance of the City's drinking water system. The Raleigh City Council meets most months on the first and third Tuesday at 1:00 p.m. in the Avery Upchurch Municipal Complex at 222 W. Hargett Street.

The Public Utilities Department provides public presentations and conducts activities about water and sponsors WATERFEST, a children's water festival held during the first week in May each year. For information about the programs, call (919) 857-4540 or visit the City's web site at www.raleigh-nc.org/putilities/index.htm.

Please call the City of Raleigh Public Utilities Department to report a water main break or sanitary sewer backup or overflow. To report a main break or sewer backup/overflow during normal business hours (M-F, 7:30 a.m. – 4:00 p.m.) please call 250-2737. When calling at times other than normal business hours, please dial the after-hours emergency number 829-1930. Thanks for your help!

The City of Raleigh Public Utilities Department is a member of the American Water Works Association and the Association of Metropolitan Water Agencies. If you have any questions about this report please call us at (919)

857-4540 or visit the City's website at www.raleigh-nc.org/putilities/index.htm. We want our valued customers to be informed about their water utility.

What's New in Public Utilities?

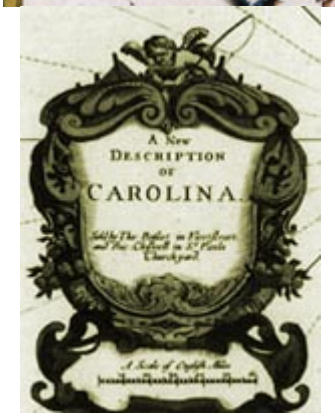
The City of Raleigh Public Utilities Department moved their administrative offices to a new location effective March 1, 2004. The new offices are located on the 6th floor of **One Exchange Plaza, 219 Fayetteville Street Mall** in downtown Raleigh and the new phone number is **(919) 857-4540**.

Public Works
Administration
Engineering
Sewer Utilities
Water Utilities
Fleet Maintenance
Beautification
Building & Grounds
Solid Waste
Street Maintenance
Wastewater Plant
Water Plant

Where Does My Water Come From?

The City of Sanford's customers are fortunate because we enjoy an ab
water source, the Cape Fear River. The Haw, the Deep River, and the
Cape Fear River Basin. The water treatment plant is located on Highv
of Broadway, and parts of Lee and Chatham Counties. Due to upgrad
distribution system improvements, our treatment plant can provide a
treatment facility provides roughly 2 billion gallons of clean drinking

To learn more about our watershed on the Internet, go to U.S. EPA's



ONLINE REPORTS & SUMMARIES OF NORTH CAROLINA ARCHAEOLOGICAL SITES & STUDIES

North Carolina's First Colonists: 12,000 Years Before Roanoke

Stephen R. Claggett
Office of State Archaeology
North Carolina State Historic Preservation Office

Four hundred years ago the English Roanoke colonists met numerous native inhabitants along the coast of what would become the state of North Carolina. Even earlier, during the 1540s, Spanish explorers under the leadership of Hernando de Soto "discovered" several Indian groups occupying the interior regions of the Carolinas. Today we know that the coastal Indians were part of a larger group occupying the entire mid-Atlantic coastal area, identifiable by a shared language and culture called Algonkian. The Native Americans whom de Soto met included Siouan, Iroquoian and Muskogean speakers, whose descendants are now recognized as the historic tribes of the Catawba, Cherokee and Creek Indians. Within a very short period of time--some 50 years--after those first contacts, the early European explorers of North Carolina had met, interacted with, and begun the process of significant cultural displacement of all the major native groups in the state.

What can we learn about those Indian groups from accounts of the earliest European explorers? Surviving chronicles from de Soto and the Roanoke colonists include many details of the land and its potential or imagined wealth. But with the notable exceptions of the John White paintings and Thomas Hariot's writings, we possess surprisingly little knowledge about the early historic Indians who lived in our state. Tantalizing bits of information can be gleaned from the early series of exploration accounts, but when the actual diversity and complexities of "Indian" culture are considered, we must conclude that their description by explorers was incidental to those for geography, searches for treasure, or daily hardships of the first European explorers.

The later colonial period of North Carolina history likewise exhibits an unfortunate lack of interest on the part of white Americans for details of Indian life. Although colonial government records included brief descriptions of military expeditions and political affairs involving Indian populations, detailed pictures of Indian culture elude modern researchers. Despite crucial involvement of the Carolina Indians in colonial economic ventures, as suppliers of skins for the enormously profitable deerskin trade, as military allies or, too frequently, as slaves, most knowledge we do have comes from unofficial sources. Only the observations of a few men like John Lederer, William Bartram and John Lawson give us even an incomplete view of declining Indian cultures, one roughly comparable to the purposely detailed accounts of White and Hariot. Indeed, it would not be inaccurate to say that the writings of Lawson and Hariot, supplemented by White's paintings, constitute the best history of American Indians in North Carolina until the nineteenth century, by which time much of Indians' culture was gone forever. Population estimates, locations and accurate names for various tribal groups, and clear descriptions of Indian political and social life unfortunately cannot be gained from historical documents alone.

And what about the ancestors of those historic period Indians? Where did they come from, and how do we know anything at all about their cultures? None of the native cultures in North Carolina had any sort of written language. They relied instead on oral traditions for their origins, myths and histories. Most of our knowledge of North Carolina's prehistoric inhabitants comes from the scant early historical accounts and, especially, the types of information that can be gained

through archaeology.

Archaeology is the discipline which provides extensive time depth to studies of change in human societies, population distributions, and cultural adaptations in response to long-term environmental changes. Archaeology is the science (some would say an art) which provides us with answers to questions about the very first "colonists" in North Carolina. In the most general sense, archaeology is the study of human societies for which no or few written records exist, through the careful recovery and analysis of the material remains--the "artifacts"--of these extinct cultures. Archaeology is a branch of anthropology, which involves other types of humanistic and scientific studies of human cultures.

Archaeology is also a discipline with its own set of capabilities and limitations. Trained in methods of excavation, analysis and report writing, archaeologists devote considerable time to adapting the skills of many other disciplines to their own advantage. Application of scholarly techniques from zoology, chemistry, physics, botany, mathematics and computer studies enables archaeologists to explore the immense complexity of environments and cultures which surrounded our ancestors.

Archaeologists trace the chronicle of Native Americans to at least 12,000 years ago. The earliest aboriginal groups reached North Carolina not long after people first crossed into the New World from Siberia during the final stages of the last Ice Age, or Pleistocene era. The distinctive fluted projectile points used by the earliest Indian groups show remarkable similarities across the American continents. The distributions of such artifacts suggest rapid population growth and movement of the initial colonizing bands of people through Canada and the Great Plains, and into the eastern woodlands of which North Carolina is a part.

PaleoIndians, as archaeologists call those first people, were well adapted, technologically and socially, to climates, vegetation and animal populations very different from those of today. The late Pleistocene era saw wetter, cooler weather conditions as a general rule for areas like the Eastern Seaboard, which was some distance from the southern reaches of the glacial ice. Now-extinct elephants (mastodons and mammoths), wild horses, ground sloths, camels and giant bison roamed the forests and grasslands of our area. Animals not extinct, but now absent from the Southeast, included moose, caribou, elk and porcupine. PaleoIndians preyed on these animals, using their meat, skins and other parts for food, clothing, tools and other needs. They also devoted considerable time to gathering wild plant foods and likely fished and gathered shellfish in coastal and riverine environments.

Native groups who followed the PaleoIndians are called Archaic cultures by archaeologists. Those people occupied eastern North America during a long time period from about 9000 to 2000 B.C., and were the direct descendants of the PaleoIndians. Archaic Indians improved techniques of fishing, gathering and hunting for post-glacial (Holocene) environments, which differed from the Pleistocene. Forest types in the Southeast gradually became more like those of today, as weather patterns changed and the vast glacial ice sheets retreated from the margins of North America.

Archaeologists see Archaic cultures as very successful adaptations to the new forest communities and animal populations of those times. Archaic people made a wide variety of stone, wood, basketry and other tools, that reflect the varied subsistence patterns of generalized fishing, gathering and hunting of the many different species of plants and animals that shared their post-glacial environments. Archaic people possessed great knowledge of their environments and the potential food and raw material sources that surrounded them. Their camps and villages occur as archaeological sites throughout North Carolina, on high mountain ridges, along river banks, and across the Piedmont hills..

Archaic people did lack three things, however, that most people associate with prehistoric Indians. These cultural elements are: bows and arrows, pottery and plant agriculture. In fact, the acceptance of these elements into North Carolina's Archaic cultures marks the transition to the next cultural stage called Woodland.

No overnight change from a pre-ceramic, non-agricultural Archaic stage to Woodland times is recognizable in the archaeological record. Instead, there was very gradual and piecemeal adoption of these new traits into local groups' cultural patterns. For example, there probably were several "beginnings" of pottery manufacture by North Carolina Indians. Agriculture likewise underwent a long period of acceptance. Woodland Indians continued to follow most of the subsistence practices of their Archaic forebears, hunting, fishing, and gathering during periods of seasonal abundance of deer, turkeys, shad and acorns. Labor was committed to tasks of clearing fields, planting and harvesting crops like sunflowers, squash, gourds, beans and maize only when it was certain that those efforts could assure surpluses needed for winter and early spring months when natural food sources were sparse.

Bow and arrow equipment was also an innovation of the Woodland stage, although the ultimate origin of that hunting technology is unknown. Small triangular and stemmed projectile points, suitable in terms of size and weight for attachment to arrow shafts, are recovered for the first time on Woodland period sites. Prior to then, the hafted stone tools of Archaic and PaleoIndians were used for spears, knives and dart points (used with spear throwers, or *atlatls*). Use of bows and arrows probably led to shifts in hunting patterns among Woodland Indians, since the primary game animals like white tail deer could now be harvested efficiently by single, stalking hunters.

Despite the introduction of these new elements into prehistoric Indian lifeways, much remained the same. Woodland Indians continued patterns of seasonal exploitation of many game and plant resources. Archaeological sites from the period, which began some time around 2000 B.C., are found on all portions of the landscape, although there was a tendency to settle in larger, semi-permanent villages along stream valleys, where soils were suitable for Woodland farming practices utilizing hoes and digging sticks.

The house patterns, defensive walls (or palisades), and substantial storage facilities at some sites also demonstrate that Woodland Indians were more committed to settled village life than their Archaic predecessors. Distributions of ceramic (pottery) styles and other artifacts suggest to archaeologists that Woodland Indians began to recognize territorial boundaries. The more obvious boundaries may reflect early language groups of the Siouan, Iroquoian and Algonkian Indians later met by the Europeans. Intangible cultural elements cannot be recovered from archaeological deposits at any site, of course, so related questions about tribal affiliations, language or religious practices will remain unanswered forever.

Woodland cultures dominated most of North Carolina well into the historic period. Most Indian groups met by early European explorers followed Woodland economic and settlement patterns, occupying small villages and growing crops of maize, tobacco, beans and squash, while still devoting considerable effort to obtaining natural foods like deer, turkey, nuts and fish. A few cultural elements, however, suggest that some Indians had adopted religious and political ideas from a fourth major prehistoric tradition, called Mississippian. Archaeologists recognize certain patterns of artifacts, settlement plans and economics that distinguish Mississippian Indian culture from earlier or perhaps contemporary Woodland occupations.

Mississippian culture can be described neatly as an intensification of Woodland practices of pottery-making, village life and agriculture. But much more was involved in the distinction, especially in terms of political and religious organization and associated militarism. Mississippian culture had few representatives in prehistoric North Carolina. Exceptions are the so-called Pee Dee Indians, who constructed and occupied the major regional center at Town Creek (Montgomery County), and ancestral mountain Cherokee groups. Mississippian-type town centers are more common to the south and west of North Carolina. Centers typically included one or more flat-topped, earthen "temple" mounds, public areas and buildings ("council houses") used for religious and political assemblies. Wooden palisades, earthen moats or embattlements were placed around many villages for defensive purposes.

Mississippian societies described by early French and Spanish explorers were organized along strict lines of social hierarchies determined by heredity or exploits in war. Military aggressiveness was an important part of Mississippian culture, serving to gain and defend territories, group prestige and favored trade and tribute networks. The surviving, and often flamboyant, artifact inventories from Mississippian sites reflect needs for personal status identification and perpetuation of favored lineages. Pottery vessels were made in new and elaborate shapes, often as animal and human effigy forms; other artifacts of exotic copper, shell, wood and feathers mirror the emblematic needs of the noble classes to confirm their status. Far-reaching trade and tribute networks were maintained at great expense to provide necessary items to the ruling classes of Mississippian Indian groups throughout the Southeast and Midwest.

The direct involvement of North Carolina Indians with those large, powerful Mississippian groups is difficult for archaeologists to measure. Minor elements of Mississippian culture may be found in various parts of our state, at least in the forms of pottery designs or ornaments connected with religious or political symbolism. Algonkian Indians met by the Roanoke colonists exhibited some religious ties with Mississippian practices more common in the far South. Cherokee religion and certain traits of pottery manufacture likewise may hint at more "elaborate" parallels in Georgia, Alabama, Tennessee, and elsewhere in the heart of Mississippian territory. Ancestral ties of language or other cultural elements probably always linked North Carolina's Indians more closely with northern and western traditions, however, and such associations may have prevented the total acceptance of Mississippian cultural traits so pervasive in other Southeastern regions.

Through the 18th and 19th centuries, Native Americans in the eastern and central portions of North Carolina were largely displaced as the colony's and state's frontiers were populated by Euro-American and African-American colonists, farmers, slaves and townspeople. Some Indian "tribes" in the coastal and piedmont regions voluntarily relocated in advance of colonial frontier expansion. Painfully direct results of armed conflicts like the Tuscarora and Yemassee Wars included forced removals of native populations onto a few small reservations. More commonly, native populations were forced to join allied tribes in Virginia, Pennsylvania, New York and elsewhere.

Native Americans who avoided direct involvement in such situations nevertheless participated in larger systems of colonial politics, settlement and trade that produced far-reaching disruptions of their traditional cultural patterns. The historical effects of disease on native populations may never be precisely defined, for instance, but the aggregate effects included major population displacements, or splitting up and reconsolidation of populations (especially across the Piedmont).

The fracturing of social ties, group identities, and loss of native languages and other cultural elements during the 18th and 19th centuries persisted into the 20th. Some of these problems have been addressed through Federal and state government recognition of modern Indian tribes and communities, which began, for a variety of legal and social purposes, in the early 19th century and which continues today.

There are at present several modern Native American groups in North Carolina--direct descendants of prehistoric and early historic ancestors recognized in archaeological and historical records. Groups include: Indians of Person County; Haliwa-Saponi; Coharie; Cumberland County Association of Indian People; Lumbee; Waccamaw-Siouan; Guilford Native American Association; Metrolina Native American Association; and, the Eastern Band of Cherokee Indians. Some 70,000 Native Americans now reside in North Carolina and are represented by those tribal governments or corporate structures and through the North Carolina Commission of Indian Affairs.

Archaeological information is imperfect; archaeologists are limited in what they can explain by vagaries of preservation, modern destruction of sites, and the simple fact that many cultural elements leave no direct traces in the ground. But

archaeology exists as the only science with the techniques, theories and evaluative frameworks for providing any information on the 12,000 or more years of human occupation which occurred before the "discovery" of the New World only 500 or so years ago. The inherent curiosity that we possess about things that are old, mysterious or simply unfamiliar expands quite naturally into a desire to truly understand how prehistoric North Carolinians lived, adapted and thrived. Archaeology provides us the means to achieve that goal.

Further Reading:

- Intrigue of the Past: North Carolina's First Peoples
- The Prehistory of North Carolina: A Basic Cultural Sequence

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Harris Nuclear Plant
PO Box 165
New Hill, NC 27562

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United States Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, DC 20555

Serial: HNP-96-181

SHEARON HARRIS NUCLEAR POWER PLANT
DOCKET NO. 50-400/LICENSE NO. NPF-63
REPORT OF FISH KILL IN HARRIS LAKE

Sir or Madam:

On September 16, 1996 a fish kill occurred in a 25 to 30 acre isolated finger of Harris Lake. This was reported to the appropriate North Carolina wildlife and environmental agencies and to the NRC as a 4-hour non-emergency event per 10CFR50.72. Investigation determined that the fish kill was not causally related to plant operation, but was the result of heavy precipitation that accompanied Hurricane Fran. Additional details are provided in Attachments 1 - 3.

If you have any questions regarding this submittal, please contact Ms. D. B. Alexander at (919) 362-3190 or Mr. R.T. Wilson at (919) 362-2444.

Sincerely,

J. W. Donahue
Director of Site Operations
Harris Plant

MV

Attachments

c: Mr. J. B. Brady (NRC Senior Resident Inspector - HNP)
Mr. S. D. Ebneter (NRC Regional Administrator - Region II)
Mr. N. B. Le (NRC Project Manager - NRR)

IE23

State Road 1134 New Hill NC

bc: Ms. P. B. Brannan
Mr. G. W. Davis
Ms. S. F. Flynn
Mr. H. W. Habermeyer, Jr.
Mr. G. D. Hicks (BNP)
Mr. M. D. Hill
Mr. W. J. Hi[illegible]man
`Ir. W. R. Ro[illegible]ason
Mr. R. F. Saunders
Ms. W. C. Langston (PE&RAS File)
Mr. R. D. Martin
Mr. W. S. Orser
Mr. G. A. Rolfson
Mr. R. S. Stancil
Mr. T. D. Walt
Nuclear Records
File: HI/A-2D
File: H-X-230

Attachment 1
Fish Kill in the Thomas Creek Area of Harris Lake

At the request of Harris Plant personnel, members of the Biological Assessment Unit (BAU) investigated a fish kill located in the upper Thomas Creek area of Harris Lake (Attachment 2). The fish kill was reported to BAU personnel at approximately 9:45 a.m. on September 16, 1996, at which time most fish appeared to have been dead between 24 and 36 hours. Upon visiting the site no stressing fish were observed and the incident was presumed to be over.

The fish kill site was an isolated area, approximately 25-30 acres, located upstream of the Harris Nuclear Plant construction access road. This area was connected to downstream portions of Harris Lake by a submerged culvert under the road. The culvert appeared to be collapsed trapping the fish and water upstream of the road embankment.

Several naturally occurring events acting singularly or in concert and all the result of heavy precipitation accompanying hurricane Fran, are presumed responsible for the low dissolved oxygen concentrations observed in the fish kill area. Although the water level had declined to near normal levels at the time of the fish kill investigation, sedimentation deposits on shoreline vegetation indicate that large areas of terrestrial vegetation located in the Thomas Creek floodplain had been inundated. We believe that heavy hurricane precipitation resulted in a large-scale flood event in Thomas Creek. This flood not only floated large quantities of leaf litter and other naturally occurring organic material into the area, but also probably scoured and resuspended a portion of the lake bottom. Resuspended lake sediments usually contain large quantities of partially reduced naturally occurring organic material previously deposited in the lake sediment from the water column. This partially reduced material would include various sulfur and nitrogen containing compounds which would exert a Chemical Oxygen Demand (COD) on the water.

The organic material, which floated into the lake during the flood or entered the water when the surrounding lake shore was flooded, probably began decomposition which exerted a biochemical oxygen demand (BOD) on the water. The combined effects of an increased COD and BOD may have been sufficient to reduce dissolved oxygen concentrations to levels which initiated a fish kill. This explanation is substantiated by the elevated COD and BOD measurements. Total Organic Carbon (TOC) concentrations were also elevated indicating the presence of organic material (Attachment 2). With the exception of toluene, which was not at concentrations sufficient to cause a fish kill, all other measured parameters were either below quantitation limits or were within a range of values previously observed in Harris Lake.

Low dissolved oxygen concentrations were also observed in the White Oak Creek headwater area of Harris Lake during September 18, 1996 (Attachment 3). The White Oak Creek area was also subjected to a large flood which floated terrestrial vegetation into the lake and resuspended lake sediments. This material is suspected to have been responsible for reduced oxygen concentrations in the White Oak Creek headwater area of Harris Lake. These low concentrations appear to substantiate the theory that naturally occurring organic material reduced

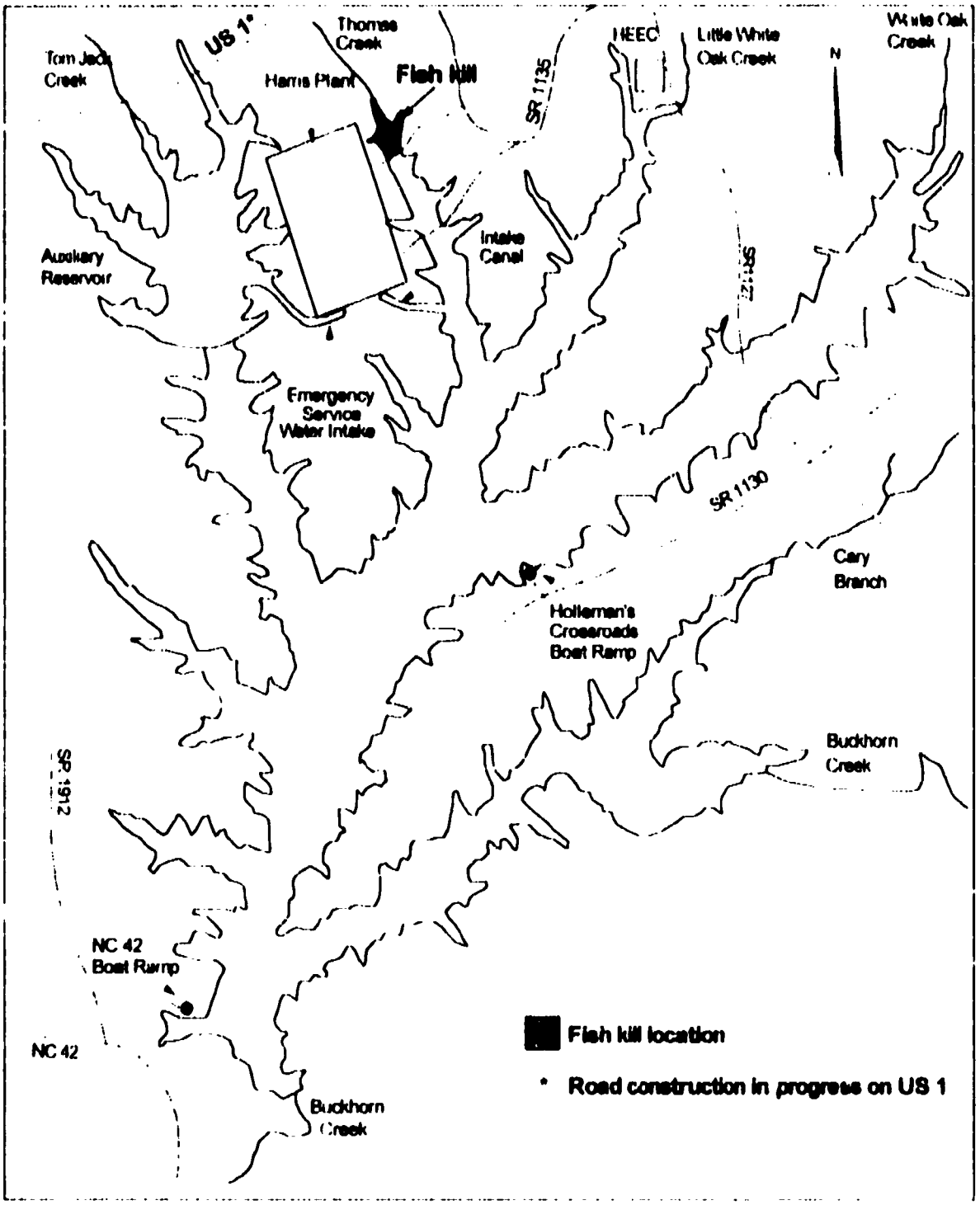
oxygen concentrations in the fish kill area.

Since dissolved oxygen concentrations less than 1.0 mg/liter are lethal of most freshwater fish, the primary cause of the fish kill was a lack of adequate dissolved oxygen in the water column. Surface water dissolved oxygen concentrations measured during the mid-day ranged from 0.2 to 0.4 mg/liter during September 16 to 18, 1996 (Attachment 3).

A visual inspection of roadway accessible creeks in the Thomas Creek drainage upstream of the fish kill area was conducted on September 18, 1996. There was no indication of any accidental chemical spill, animal waste lagoon breaches or extensive areas of soil erosion in these upstream reaches.

Remediation efforts for the fish kill area will include the periodic monitoring of dissolved oxygen concentrations to document the return of sufficient oxygen to support aquatic life and the eventual repair of the culvert to allow downstream fish to migrate into the area. Supplemental fish relocation by capturing fish in other areas of Harris Lake and stocking them in the recovering area may be implemented.

Attachment 2
Location of fish kill observed in Harris Lake, September 16, 1996.



Attachment 3

Selected limnological variables from the surface waters of the Thomas Creek and White Oak Creeks areas of Harris Lake, September 16-30, 1996.

Variable	Thomas Creek area				White Oak Creek area
	09/16/96	09/17/96	09/18/96	09/30/96	09/16/96
Temperature (°C)	22.8	23.0	23.0	20.8	24.3
Dissolved oxygen (mg/l)	0.3	0.2	0.4	0.2	2.7
pH	-	-	6.2	-	6.9
Conductivity (µS/cm)	-	-	67	-	79
Biological oxygen demand (mg/l)	13.1	15.8	-	-	-
Chemical oxygen demand (mg/l)	74	72	99	-	-
Total organic carbon (mg/l)	-	19.2	-	-	-
Volital organics (µg/l)					
Benzene		BQL*			
Bromodichloromethane		BQL			
Bromoform		BQL			
Bromomethane		BQL			
Carbon tetrachloride		BQL			
Chlorobenzene		BQL			
Chloroethane		BQL			
2-Chloroethylvinyl ether		BQL			
Chloroform		BQL			
Chloromethane		BQL			
Dibromochloromethane		BQL			
1,2-Dichlorobenzene		BQL			
1,3-Dichlorobenzene		BQL			
1,4-Dichlorobenzene		BQL			
1,1-Dichloroethane		BQL			
1,2-Dichloroethane		BQL			
1,1-Dichloroethene		BQL			
1,2-Dichloroethene (total)		BQL			
1,2-Dichloropropane		BQL			
cis-1,3-Dichloropropene		BQL			
trans-2,3-Dichloropropene		BQL			
Ethylbenzene		BQL			
Methylene chloride		BQL			
1,1,2,2-tetrachloroethane		BQL			
Tetrachloroethene		BQL			
Toluene		17			
1,1,1-Trichloroethane		BQL			
1,1,2-Trichloroethane		BQL			
Trichloroethene		BQL			
Trichlorofluoromethane		BQL			
Vinyl chloride		BQL			

*BQL=Below Quantitation Limit.

CP&L

Carolina Power & Light Company
PO Box 165
New Hill NC 27562

William R. Robinson
Vice President
Harris Nuclear Plant

APR 2 8 1997

United States Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, DC 20555

Serial: HNP-97-089

SHEARON HARRIS NUCLEAR POWER PLANT
DOCKET NO. 50-400/LICENSE NO. NPF-63
ANNUAL ENVIRONMENTAL (NON-RADIOLOGICAL) OPERATING REPORT

Dear Sir or Madam:

In accordance with Section 5.4.1 of the Environmental Protection Plan issued as Appendix B of the Operating License (NPF-63) for the Shearon Harris Nuclear Power Plant, Carolina Power & Light Company provides the enclosed Annual Environmental (Non-Radiological) Operating Report for 1996.

If you have questions or need additional information regarding this report, please contact Ms. D. B. Alexander at (919) 362-3190.

Sincerely,

Wr R Robinson

MV

c: Mr. J. B. Brady (HNP Senior NRC Resident)
Mr. L. A. Reyes (NRC Regional Administrator, Region II)
Mr. N. B. Le (NRC - NRR Project Manager)

State Road 1134 New Hill NC Tel 919 362 2502 Fax 919 362 2095

CP&L

April 1, 1997

Mr. Benjamin C. White
Manager - Environmental Services
Operations and Environmental Support Department

Dear Mr. White:

A review of the Harris Nuclear Plant Unit 1 (HNP) Annual Environmental (Nonradiological) Operating Report was recently completed. The report is issued annually to comply with the reporting requirements of the U. S. Nuclear Regulatory Commission (NRC) established in Appendix B, Environmental Protection Plan (Nonradiological), of the HNP Facility Operating License No. NPF-63. The objective of the review was to assess the accuracy and completeness of the report for the period January 1, 1996, through December 31, 1996.

The scope of our work was limited to a review of the controls, procedures, and supporting documents related to the report and interviews with HNP and Environmental Services personnel. Based on the audit procedures performed, the Annual Environmental (Nonradiological) Operating Report appears to be complete, accurate, and in compliance with NRC reporting requirements.

We appreciate the excellent cooperation received from Environmental Services and HNP personnel. If you have any questions concerning this report, please do not hesitate to contact us.

Sincerely,

John W. Griffith
Manager - Financial and Environmental Audits

JWG/gtv
c: Mr. W. S. Orser
Mr. W. R. Robinson
Mr. C. W. Rose
Mr. T. D. Walt

Audit Team
Mr. Gil T. Vinzani

SHEARON HARRIS NUCLEAR POWER PLANT

UNIT 1

ANNUAL ENVIRONMENTAL (NONRADIOLOGICAL) OPERATING REPORT

APPENDIX B

for

January 1- December 31, 1996

CAROLINA POWER & LIGHT COMPANY

Docket No. 50-400

Facility Operating License No. NPF-63

1.0 INTRODUCTION

Carolina Power & Light Company (CP&L) received a low-power Facility Operating License (No. NPF-53) and full-power Facility Operating License (No. NPF-63) for the Shearon Harris Nuclear Power Plant (SHNPP), Unit 1, from the U.S. Nuclear Regulatory Commission (NRC) on October 24, 1986, and January 12, 1987, respectively. Appendix B (the Environmental Protection Plan [nonradiological]) of the full-power license requires submittal of an Annual Environmental (nonradiological) Operating Report to the NRC describing the implementation of the plan during the previous year. The purpose of this document is to fulfill the requirement for the period January 1-December 31, 1996.

2.0 PLANT CONSISTENCY REQUIREMENTS [EPP Section 3.0]

2.1 Plant Design and Operation

There were no changes in plant design or operation and there were no tests or experiments performed which involved a potentially significant unreviewed environmental question during the reporting period.

2.2 Reporting Related to the NPDES Permit

All required NPDES monitoring data were submitted to the North Carolina Division of Water Quality (NCDWQ) *via* monthly discharge monitoring reports and separate correspondence as warranted.

3.0 UNUSUAL OR IMPORTANT ENVIRONMENTAL EVENTS [EPP Section 4.1]

3.1 Natural Disasters

A fish kill was observed by Harris Plant personnel during the morning of September 16, 1996. The fish kill was confined to an isolated area, approximately 25-30 acres, located in the headwaters of the Thomas Creek arm of Harris Lake and upstream of the Harris Nuclear Plant construction access road causeway. This headwater area of the lake was connected to a downstream area of the Thomas Creek arm by a submerged culvert. The culvert had previously collapsed, trapping fish and impounding additional water in the affected area.

CP&L biologists presumed several naturally occurring events, including introduction of partially decayed terrestrial vegetation and the resuspension of creek and lake sediments, were responsible for the depletion of dissolved oxygen in the affected area. The addition of vegetation and the resuspension of sediments were the result of flooding due to heavy precipitation associated with hurricane Fran (September 5 and 6, 1996). Low dissolved oxygen concentrations [0.2 to 0.4 parts per million (ppm)] are presumed to be the primary factor responsible for the fish mortality. The NCDWQ and the Nuclear Regulatory Commission (NRC)

were informed of the fish kill.

Harris Plant personnel removed and buried the larger fish. Surface water dissolved oxygen concentrations recovered from 0.2 parts per million on September 17, 1996, to 6.2 ppm on February 14, 1997.

3.2 Power Plant Related Events

No occurrence of an unusual or important environmental event that would indicate or could result in a significant environmental impact causally related to plant operation occurred during the reporting period. No releases or exceedances of permit conditions caused any significant environmental impact.

4.0 ENVIRONMENTAL MONITORING [EPP Section 4.2]

4.1 Aquatic Monitoring [EPP Section 4.2.1]

Under the authority of the Clean Water Act, the state of North Carolina issued a National Pollutant Discharge Elimination System (NPDES) permit (NC0039586) for the SHNPP on September 1, 1996, that remains in effect until March 31, 2001. This permit included the CP&L Harris Energy & Environmental Center (HE&EC) sewage treatment plant discharge as an outfall (007). This permit requires that the laboratory analyses performed on all effluent samples be performed by a state-certified laboratory. In accordance with this requirement, the SHNPP Environmental & Chemistry Laboratory was certified by the NCDEM as a Wastewater Laboratory, effective January 1, 1995, and is valid through December 31, 1997. The Toxicity Testing Laboratory and the Chemistry Laboratory at the CP&L HE&EC were also certified by the NCDEM for toxicity testing and wastewater analyses, respectively, to support the SHNPP operations. The HE&EC Chemistry Laboratory certification was renewed on January 1, 1995, and is valid through December 31, 1997. The Toxicity Testing Laboratory was certified to perform testing under two consecutive Biological Toxicity Laboratory certifications from November 1, 1995, through November 1, 1996, and from November 1, 1996, through November 1, 1997. In addition, during 1996 the CP&L Chemistry Laboratory at the Harris Energy & Environmental Center and the Toxicity Testing Laboratory contracted with private laboratories, Industrial and Environmental Analysts and Hydrologic Laboratories, Inc., respectively, to perform some of the analyses.

4.1.1 Effluent Monitoring

Routine effluent monitoring was conducted and reported to the NCDWQ as required by the NPDES permit. No NPDES noncompliances occurred during 1996 while the reportable events were:

A. December 16, 1996, fecal coliform sample (outfall 002) not

analyzed

Industrial and Environmental Analysts, Inc., the commercial contract laboratory utilized by the Harris Nuclear Plant, did not analyze the December 16, 1996, fecal coliform sample (outfall 002) in accordance with the requirements as stated in 40 CFR Part 136. The required holding time elapsed prior to sample analysis. Consequently, the December 16, 1996, fecal coliform sample analysis was reported as an estimated value. Pursuant to a January 14, 1997, telephone conversation between Mr. Steve Mitchell of the Raleigh Regional Office of NCDWQ, and Ms. Joanie Cooke of CP&L, the facility indicated compliant conditions for the reporting period.

B. December 30 and 31, 1996, samples for biochemical oxygen demand suspect due to high blank and seed results.

Industrial and Environmental Analysts, Inc., also identified the December 30 and 31, 1996, effluent samples for biochemical oxygen demand for outfall 002 to be suspect due to high blank and seed results. The contract laboratory discovered that the 0.2-micron filter used during the analytical procedure contained activity which caused an elevated result on the blank sample and contaminated the dilution water. However, the dilution water was not utilized on the effluent samples. Consequently the effluent sample results should not have been impacted. The effluent sample results were identified as suspect due to the deviation on the blank sample.

4.1.2 Aquatic Biological Monitoring

Biological Assessment Unit personnel conducted the scheduled semiannual monitoring for Asiatic clams (*Corbicula*) in the HNP Emergency Service Water System (e.g., intake structures and the Fire Protection System) on April 29, 1996.

No Asiatic clams were collected from the Main Reservoir Intake Structure, Service Water System Bays, or Cooling Water Makeup Bays. However, the equivalent of 2 and 240 deceased clams, represented as shells, were collected from Cooling Water Makeup Bays B and C, respectively. The clam shells may indicate that clams are accumulating in these areas. Asiatic clams were collected from the Emergency Service Water System Bays 6 and 8. Actual numbers collected were three clams at Bay 6 and six clams at Bay 8. Estimated densities at these locations were 129 and 258 clams per square meter, respectively. All clams were estimated to be approximately 2 to 4 years in age. No clams were collected in the Service Building Fire Protection System.

Sampling during the fall for Asiatic clams was conducted on October 30,

1996. Nine live clams were collected from the Main Reservoir Intake Structure (MRIS) Service Water System Bay 1A-SA (estimated density 388 clams per square meter) and one live clam (estimated density 43 clams per square meter) was collected from the MRIS Cooling Water Makeup Bay 1X. Dead clams, as represented by shells, were collected from MRIS Cooling Water Makeup Bay 1 & 2X and Bay 1X at estimated densities of 129 and 8318 clams per square meter, respectively. No live or dead clams were found in Bay 8. All clams were estimated to be approximately 1 to 4 years in age. No clams were collected in the Service Building Fire Protection System.

Asiatic clams caused no biofouling of plant water systems during 1996.

During 1996 monitoring for zebra mussels *Dreissena polymorpha* and quagga mussels *D. bugensis* was conducted in areas of likely infestation, i.e., at Hollemans Crossroads boat ramp and water quality station marker buoys at Transects E and P. No zebra or quagga mussels were found during 1996.

Since 1988 hydrilla *Hydrilla verticillata*, a nonnative aquatic weed, has been established in Harris Lake. A visual survey made during November 1996, reconfirmed that hydrilla was established in water less than 3-meters deep in all major arms of the reservoir. The total areal coverage was estimated to be approximately 475 hectare. Compared to previous years hydrilla did not appear to be as dense or to have reached the water surface in many areas of the lake. This slightly diminished growth may be attributable to below-normal temperatures during the winter of 1995-96.

A visual survey for hydrilla was also conducted in the auxiliary reservoir during December 1996. Although 800 grass carp *Ctenopharyngodon idella* were stocked in October 1994 and again in 1996 to control hydrilla, it continued to spread in the auxiliary reservoir. Most of the shoreline in the bay receiving discharges from the SHNPP is colonized by hydrilla to a depth of 3-meters. It appears that moderate hydrilla control has occurred in the bay nearest the auxiliary reservoir intake canal. This bay was stocked with 800 grass carp during 1994 and 400 during 1996. It is possible that the grass carp stocked during 1994 did not control hydrilla in the discharge receiving bay because they did not migrate into that area. Both bays are connected by a narrow channel.

Approximately 400 grass carp were stocked in the discharge receiving bay during 1996. Similar to observations made in the main lake, the growth of hydrilla appeared slightly diminished during the summer and fall of 1996, possibly due to below-normal temperatures during the winter of 1995-96. Monitoring of the effectiveness of the grass carp will determine necessity for future stocking.

No impacts to SHNPP operations from hydrilla have occurred nor are they expected because of the low velocity of water drawn from the main lake into the cooling tower makeup water intake structure. Another factor, which limits potential impacts from hydrilla, is limited available habitat in the intake canal for hydrilla colonization. Available habitat would include all shoreline areas contained in the littoral zone. These areas are relatively narrow due to the steep-sided banks of the intake canal and are presently colonized by various forms of emergent aquatic vegetation presumed to out-compete hydrilla.

4.2 Terrestrial Monitoring

[EPP Section 4.2.2]

Terrestrial monitoring is not required.

4.3 Noise Monitoring

[EPP Section 4.2.3]

Noise monitoring is not required.

5.0 EPP AUDIT

[EPP Section 5.1]

An audit conducted by an independent corporate entity was performed to verify the completeness and accuracy of the conditions and activities described in this annual environmental operating report. The results of that audit are summarized in the attached letter.

6.0 PLANT REPORTING REQUIREMENTS

[EPP Section 5.4]

6.1 EPP Noncompliances

There were no EPP noncompliances identified during the reporting period.

6.2 Changes in Station Design

There were no changes in plant design or operation and there were no tests or experiments performed which involved a potentially significant unreviewed environmental question during the reporting period.

6.3 Nonroutine Reports

There were no nonroutine reports submitted in accordance with EPP Section 5.4.2. There were no NPDES noncompliances identified during the reporting period.

Center for PLANT Conservation

Restoring America's native plants

CPC National Collection Plant Profile

Parnassia caroliniana

Family: Saxifragaceae (Saxifrage Family)
Common Name: Carolina grass-of-parnassus
Author: Michx.
Growth Habit: Perennial
CPC Number: 3099

Distribution
Protection
Conservation
References

Profile Links
ITIS
Tropicos
PLANTS

Parnassia caroliniana is Not Sponsored

Primary custodian for this plant in the CPC National Collection of Endangered Plants is:
North Carolina Botanical Garden

Parnassia caroliniana

Parnassia caroliniana is a moisture-loving species that occurs in the Coastal Plain and Sandhills of the southeast. It grows in fire-maintained, wet savannas and in ecotonal areas between pine uplands and seepage slopes or streamhead pocosins. The solitary white flowers of Carolina grass-of-parnassus are notable for their conspicuous green veins, which create a delicate pattern on the petals. In the early 1900s, the abundance of this species was noted by H.A. Rankin: "…hundreds of acres may be seen liberally dotted with its white stars…it finds its best development in the lower places, and here it often almost covers the ground" (Alexander 1934). This is not the case today, with activities such as timber production and commercial and residential development causing alteration of hydrology and fire regimes, which has diminished the range of Parnassia caroliniana and continues to pose a significant threat to its habitat.

The Carolina grass-of-parnassus closely resembles one of its rare relatives, Parnassia grandiflora, or large-leaved grass-of-parnassus. Both have basal leaves that are rounded with long leafstalks as well as a single, stalkless rounded leaf on the flower stalk. These two species can be distinguished primarily by their flowers, which appear in November for both species. The flowers of P. caroliniana have 9-18 green, brown, or yellow veins on each of its five white oval petals while P. grandiflora has only 5-9 bright green veins on each of its five white oval petals. (FNAI 2000)

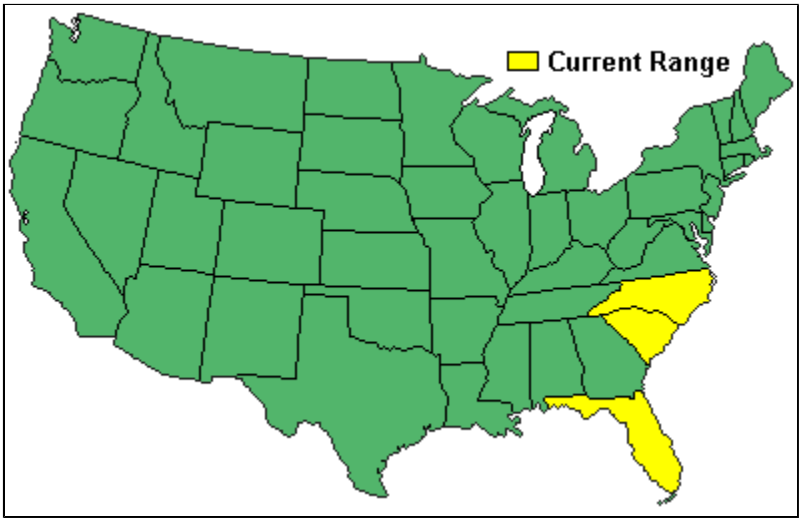
Distribution & Occurrence

Top

State Range

Florida
North Carolina

South Carolina



Habitat

Both Parnassia species (P. caroliniana and P. grandiflora) grow in wet prairies and open, grassy seepage slopes. (FNAI 2000)

Distribution

North Carolina, South Carolina, and disjunct to the Florida panhandle. (FNAI 2000)

Number Left

Over 80 element occurrences (NatureServe 2001)

Protection

Top

Global Rank:	G2	9/12/1996	Guide to Global Ranks
Federal Status:	2	1/19/1996	Guide to Federal Status
Recovery Plan:	No		

State/Area Protection

State/Area	Rank	Status	Date
Florida	S1	LE	2/1/1989
North Carolina	S2	E	
South Carolina	S1S2	NC	6/18/1990

Conservation, Ecology & Research

Top

Ecological Relationships

Found with Pinus palustris, Pinus serotina, Taxodium ascendens, especially where shallowly underlain by coquina limestone (Weakley 2000).

Threats

- Habitat loss (due to development, agriculture, timber production)
- Fire suppression

(NatureServe 2001)

Current Research Summary

- Hydrologists Joel Wagner and Michael Martin of the National Park Service are restoring Savannah Wetland at Moores Creek National Battlefield, North Carolina. Included is an investigation of the effects of temporary hydrologic restoration and a prescribed burn regime on populations of Parnassia caroliniana as well as other species of this NC Coastal Plain savanna community.
- Dr. George Folkerts, Auburn University. Surveying pitcher-plant bogs in the Gulf Coastal Plain (Alabama) to determine occurrence, abundance and response to disturbance of several plant species, including Parnassia caroliniana.

Current Management Summary

- Active management/management research in North Carolina and Alabama.

Research Management Needs

- Survey for additional occurrences, especially in Georgia and Alabama.
- Monitor existing populations
- Seek conservation of wet savanna habitat
- Research reproductive biology

Ex Situ Needs

- Obtain seed from more populations
- Establish protocol for germination

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Top

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|Close|

National Collection of Endangered Plants

CPC Home Page

The Center for Reptile and Amphibian Conservation and Management

Eastern Tiger Salamander

Ambystoma tigrinum tigrinum

Identification

This chubby, small eyed salamander has a dark background color, ranging from black to deep brown, and is patterned with yellowish or olive irregular light markings. The belly is an olive-yellowish color marbled with a dark pigment. The snout of the Eastern Tiger Salamander is rounded and the eyes are often gold in color. Larvae change in color as they morph, but are generally olive or yellowish-green with dark spotting, becoming more grayish or greenish-brown as they progress into adulthood. The Eastern Tiger Salamander is the largest salamander in the Great Lakes region.

Distribution and Status

The range of the Eastern Tiger Salamander extends from Long Island along the coast through the Gulf of Mexico, east through Texas, north to the western Ohio Valley as well as the southern Great Lakes basin, west to Minnesota and onto the eastern plains states, and it is absent from the Appalachian highlands and lower Mississippi delta. The Eastern Tiger Salamander survives in all eight Midwestern states.

Ecology

The Eastern Tiger Salamander requires a nearby pond for breeding and is able to live in a variety of habitats including woodlands, marshes, grasslands, farmlands, and even in suburbs. They spend much of their time in burrows, which they often dig themselves.

Threats and Management Issues

Numerous Eastern Tiger Salamanders are killed on roads each year. The introduction of predatory fish to breeding habitats also has negative impacts on populations as eggs and larvae are easy prey. The species does however respond well to the construction of fish-free ornamental ponds or stock ponds, which can create new breeding sites.

Resources

General reference guides and websites.
Reference guides and websites specific to Amphibians.

Links to more information on the Eastern Tiger Salamander outside the Herp Center

New Jersey Division of Fish and Wildlife
Illinois Natural History Survey
Herps of Minnesota
Michigan DNR

The Center for Reptile and Amphibian Conservation and M

Four-toed Salamander

Hemidactylium scutatum

Identification

The Four-toed Salamander is a relatively small salamander with adults typically only reaching lengths of 2 to 3.5 inches (5 to 10cm). As its name implies, the Four-toed Salamander can be readily identified from the presence of only four toes on each hind foot. Most other salamander species have five hind toes. Other distinguishing features of this species include a milk white belly that is peppered with black markings and a conspicuous constriction at the base of the tail. The dorsal

surface is usually reddish-brown and its sides are typically grayish.

Distribution and Status

The Four-toed Salamander's distribution is patchy across much of its range. The most continuous distribution extends from Maine west to southeastern Ontario and south through the middle of Ohio to northern Georgia. In the Great Lakes region, the Four-toed Salamander is found at sites across much of Michigan and Wisconsin into northeastern Illinois, northern Indiana and northern Ohio. Disjunct populations are also scattered south towards the Gulf of Mexico and further north in Canada (US distribution map; Midwest distribution map). The Four-toed Salamander is a species of concern in all of the Midwestern states in which it resides. Even in Michigan and Wisconsin, where the range looks continuous, habitat destruction has likely restricted extant (not

extinct) populations to small, isolated areas of suitable habitat. The Four-toed Salamander is listed as Endangered in Indiana, Threatened in Illinois, it is a species of Special Concern in Minnesota, Ohio and Wisconsin, and it is a species of long term concern in Missouri. In Michigan the species is uncommon and its distribution is likely isolated in localized areas. The Four-toed Salamander is not found in Iowa. Click HERE for state by state status descriptions.

Ecology

Four-toed Salamanders prefer undisturbed, moist, deciduous, evergreen or mixed forests in close proximity to suitable breeding habitat. These areas include shallow, shaded pools and seeps, creeks, swamps and bogs. In summer, Four-toed Salamanders inhabit the forest, but during spring females migrate to forest breeding pools. The females nest in moss mats on the margins of these aquatic areas. When a female is ready to lay her eggs she normally turns upside down and lays her eggs in such a way that they attach to moss

strands or other structures that may be hanging down. This process is aided by the eggs which are coated in a sticky material that helps them adhere to these hanging surfaces, or to other eggs. Proving to be an amazing animal, as well as hanging upside down to deposit their eggs, researchers have documented female Four-toed Salamanders taking between 12 and 72 hours to finish laying their clutch of eggs. Wow!

Threats and Management Issues

Four-toed Salamanders prefer forested habitats that contain suitable breeding sites, including slow-moving forest streams, marshes, bogs, vernal pools, and swamps. These areas are often scattered throughout forests and occur in small pockets. Because of these requirements, wide spread habitat loss such as land clearing from agricultural and urban development can destroy or isolate these areas. Conservation and management plans for the Four-toed Salamander need to prioritize the preservation of important breeding areas as well as maintaining or restoring natural corridors to adjacent forested habitat. Techniques and recommendations for managing land for amphibians, such as the Four-toed Salamander, can be found in the Habitat Management

Guidelines for Amphibians and Reptiles of the Midwest.

Resources
General reference guides and websites.
Reference guides and websites specific to Amphibians.

Links to more information on Four-toed Salamander outside the Herp Center
Four-toed Salamander - Information presented in a simple level
Reptiles and Amphibians of Minnesota: Four-toed Salamander - Similar to this page
Herps of Connecticut: A Project of Herpetology 209, Yale University: Four-toed Salamander - Contains detailed information and other Four-toed Salamander links, yet the large text on the site nevertheless distracting

U.S. Department of Energy - Energy Efficiency and Renewable Energy

EERE State Partnerships and Activities: State Energy Alternatives

Alternative Energy Resources in North Carolina

Below is a short summary of alternative energy resources for North Carolina. For more information on each technology, visit the State Energy Alternatives Technology Options page.

For more information, including links to resource maps, energy statistics, and contacts for North Carolina, visit EERE's State Activities and Partnerships Web site's North Carolina page.

Biomass

Studies indicate that North Carolina has good biomass resource potential. For more state-specific resource information, see Biomass Feedstock Availability in the United States: 1999 State Level Analysis.

Geothermal

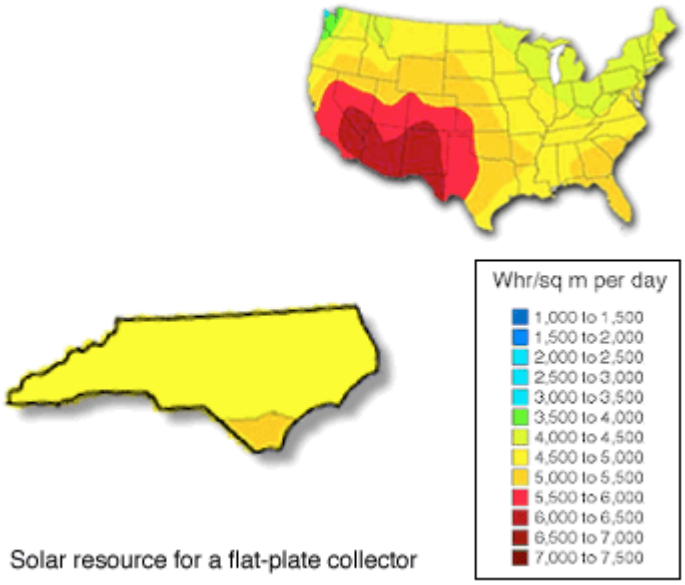
North Carolina has low to moderate temperature resources that can be tapped for direct heat or for geothermal heat pumps. However, electricity generation is not possible with these resources.

Hydropower

North Carolina has a moderate hydropower resource as a percentage of the state's electricity generation. For additional resource information, check out the Idaho National Laboratory's Virtual Hydropower Prospector (VHP). VHP is a convenient geographic information system (GIS) tool designed to assist you in locating and assessing natural stream water energy resources in the United States.

Solar

To accurately portray your state's solar resource, we need two maps. That is because different collector types use the sun in different ways. Collectors that focus the sun (like a magnifying glass) can reach high temperatures and efficiencies. These are called concentrating collectors. Typically, these collectors are on a tracker, so they always face the sun directly. Because these collectors focus the sun's rays, they only use the direct rays coming straight from the sun.

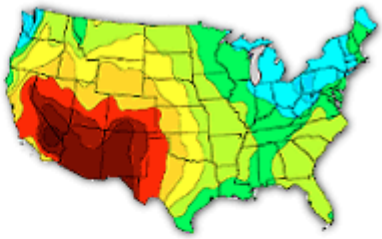


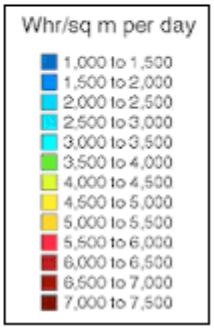
Solar resource for a flat-plate collector

Other solar collectors are simply flat panels that can be mounted on a roof or on the ground. Called flat-plate collectors, these are typically fixed in a tilted position correlated to the latitude of the location. This allows the collector to best capture the sun. These collectors can use both the direct rays from the sun and reflected light that comes through a cloud or off the ground. Because they use all available sunlight, flat-plate collectors are the best choice for many northern states. Therefore, this site gives you two maps: one is the resource for a concentrating collector and one is the resource for a flat-plate collector.

What do the maps mean? For flat-plate collectors, North Carolina has good, useful

resources throughout the state. For concentrating collectors, North Carolina could pursue some type of technologies, but thermal electricity systems are not effective with this resource.





Solar resource for a concentrating collector

Wind

Wind Powering America indicates that North Carolina has wind resources consistent with utility-scale production. The good to excellent wind resource areas are concentrated in two regions. The first is along the Atlantic coast and barrier islands. The second area is the higher ridge crests in western North Carolina. In addition, small wind turbines may have applications in some areas. For more information on North Carolina's wind resource, visit Wind Powering America's North Carolina Wind Activities.

Energy Efficiency

Energy efficiency means doing the same work, or more, and enjoying the same comfort level with less energy. Consequently, energy efficiency can be considered part of your state's energy resource base — a demand side resource. Unlike energy conservation, which is rooted in behavior, energy efficiency is technology-based. This means the savings may be predicted by engineering calculations, and they are sustained over time. Examples of energy efficiency measures and equipment include compact fluorescent light bulbs (CFLs), and high efficiency air conditioners, refrigerators, boilers, and chillers.

Saving energy through efficiency is less expensive than building new power plants. Utilities can plan for, invest in, and add up technology-based energy efficiency measures and, as a consequence, defer or avoid the need to build a new power plant. In this way, Austin, Texas, aggregated enough energy savings to offset the need for a planned 450-megawatt coal-fired power plant. Austin achieved these savings during a decade when the local economy grew by 46% and the population doubled. In addition, the savings from energy efficiency are significantly greater than one might expect, because no energy is needed to generate, transmit, distribute, and store energy before it reaches the end user.

Reduced fuel use, and the resulting decreased pollution, provide short- and long-term economic and health benefits.

For more information on current state policies related to energy efficiency, visit the Alliance to Save Energy's State Energy Efficiency Index.

Voluntary Reporting of Greenhouse Gases Program
Fuel and Energy Source Codes and Emission Coefficients

Fuel	Code	Emission Coefficients		
		Pounds CO2 per Unit Volume or Mass		Pounds CO2 per Million Btu
Petroleum Products				
Aviation Gasoline	AV	18.355	per gallon	152.717
		770.916	per barrel	
Distillate Fuel (No. 1, No. 2, No. 4 Fuel Oil and Diesel)	DF	22.384	per gallon	161.386
		940.109	per barrel	
Jet Fuel	JF	21.095	per gallon	156.258
		885.98	per barrel	
Kerosene	KS	21.537	per gallon	159.535
		904.565	per barrel	
Liquified Petroleum Gases (LPG)	LG	12.805	per gallon	139.039
		537.804	per barrel	
Motor Gasoline	MG	19.564	per gallon	156.425
		822.944	per barrel	
Petroleum Coke	PC	32.397	per gallon	225.130
		1356.461	per barrel	
		6768.667	per short ton	
Residual Fuel (No. 5 and No. 6 Fuel Oil)	RF	26.033	per gallon	173.906
		1,093.384	per barrel	
Natural Gas and Other Gaseous Fuels				
Methane	ME	116.376	per 1000 ft3	115.258
Landfill Gas	LF	[1]	per 1000 ft3	115.258
Flare Gas	FG	133.759	per 1000 ft3	120.721
Natural Gas (Pipeline)	NG	120.593	per 1000 ft3	117.080
Propane	PR	12.669	per gallon	139.178
		532.085	per barrel	
Electricity	EL	Varies depending on fuel used to generate electricity		
Electricity Generated from Landfill Gas	LE	Varies depending on heat rate of the power generating facility		

Coal	CL			
Anthracite	AC	5685.00	per short ton	227.400
Bituminous	BC	4931.30	per short ton	205.300
Subbituminous	SB	3715.90	per short ton	212.700
Lignite	LC	2791.60	per short ton	215.400
Renewable Sources				
Biomass	BM	Varies depending on the composition of the biomass		
Geothermal Energy	GE	0		0
Wind	WN	0		0
Photovoltaic and Solar Thermal	PV	0		0
Hydropower	HY	0		0
Tires/Tire-Derived Fuel	TF	6160	per short ton	189.538
Wood and Wood Waste [2]	WW	3812	per short ton	195.0
Municipal Solid Waste [2]	MS	1999	per short ton	199.854
Nuclear	NU	0		0
Other	ZZ	0		0

1 For a landfill gas coefficient per thousand standard cubic foot, multiply the methane factor by the share of the landfill gas that is methane.

2 These biofuels contain "biogenic" carbon. Under international greenhouse gas accounting methods developed by the Intergovernmental Panel on Climate Change, biogenic carbon is part of the natural carbon balance and it will not add to atmospheric concentrations of carbon dioxide.[3] Reporters may wish to use an emission factor of zero for wood, wood waste, and other biomass fuels in which the carbon is entirely biogenic. Municipal solid waste, however, normally contains inorganic materials principally plastics that contain carbon that is not biogenic. The proportion of plastics in municipal solid waste varies considerably depending on climate, season, socio-economic factors, and waste management practices. As a result, EIA does not estimate a non-biogenic carbon dioxide emission factor for municipal solid waste. The U.S. Environmental Protection Agency estimates that, in 1997, municipal solid waste in the United States contained 15.93 percent plastics and the carbon dioxide emission factor for these materials was 5,771 lbs per ton.[4] Using this information, a proxy for a national average non-biogenic emission factor of 919 lbs carbon dioxide per short ton of municipal solid waste can be derived. This represents 91.9 lbs carbon dioxide per million Btu, assuming the average energy content of municipal solid waste is 5,000 Btu/lb.

3 Intergovernmental Panel on Climate Change. *Greenhouse Gas Inventory Reference Manual: Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories*, Vol. 3, Pg. 6.28, (Paris France 1997).

4 U.S. Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1998*, EPA 236-R-00-001, Washington, DC, April 2000.

Wake County
Insured Employment in North Carolina
for Aggregate of all types by Sector (2 digit)
for 2005

"*" in table indicates disclosure suppression.

Industry	NAICS Code	No of Units	Annual Avg Empl
Total Federal Government	000000	88	4,795
Total State Government	000000	94	37,765
Total Local Government	000000	194	33,729
Total Private Industry	000000	23,718	329,447
Total All Industries	000000	24,095	405,737
Agriculture, Forestry, Fishing & Hunting	11	77	796
Mining	21	11	215
Utilities	22	*	*
Construction	23	2,813	29,625
Manufacturing	31	695	21,480
Wholesale Trade	42	1,649	18,591
Retail Trade	44	2,798	48,747
Transportation and Warehousing	48	400	11,226
Information	51	501	16,668
Finance and Insurance	52	1,385	14,277
Real Estate and Rental and Leasing	53	1,114	7,894
Professional and Technical Services	54	3,933	32,741
Management of Companies and Enterprises	55	139	9,646
Administrative and Waste Services	56	1,589	30,410
Educational Services	61	429	34,687
Health Care and Social Assistance	62	1,772	38,987
Arts, Entertainment, and Recreation	71	261	5,283
Accommodation and Food Services	72	1,474	32,087

Other Services, Ex. Public Admin	81	1,883	13,094
Public Administration	92	150	36,373
Unclassified	99	1,009	1,441

Getting Started - Glossary of Terms - Contact Information

Lee County
Insured Employment in North Carolina
for Aggregate of all types by Sector (2 digit)
for 2005

"*" in table indicates disclosure suppression.

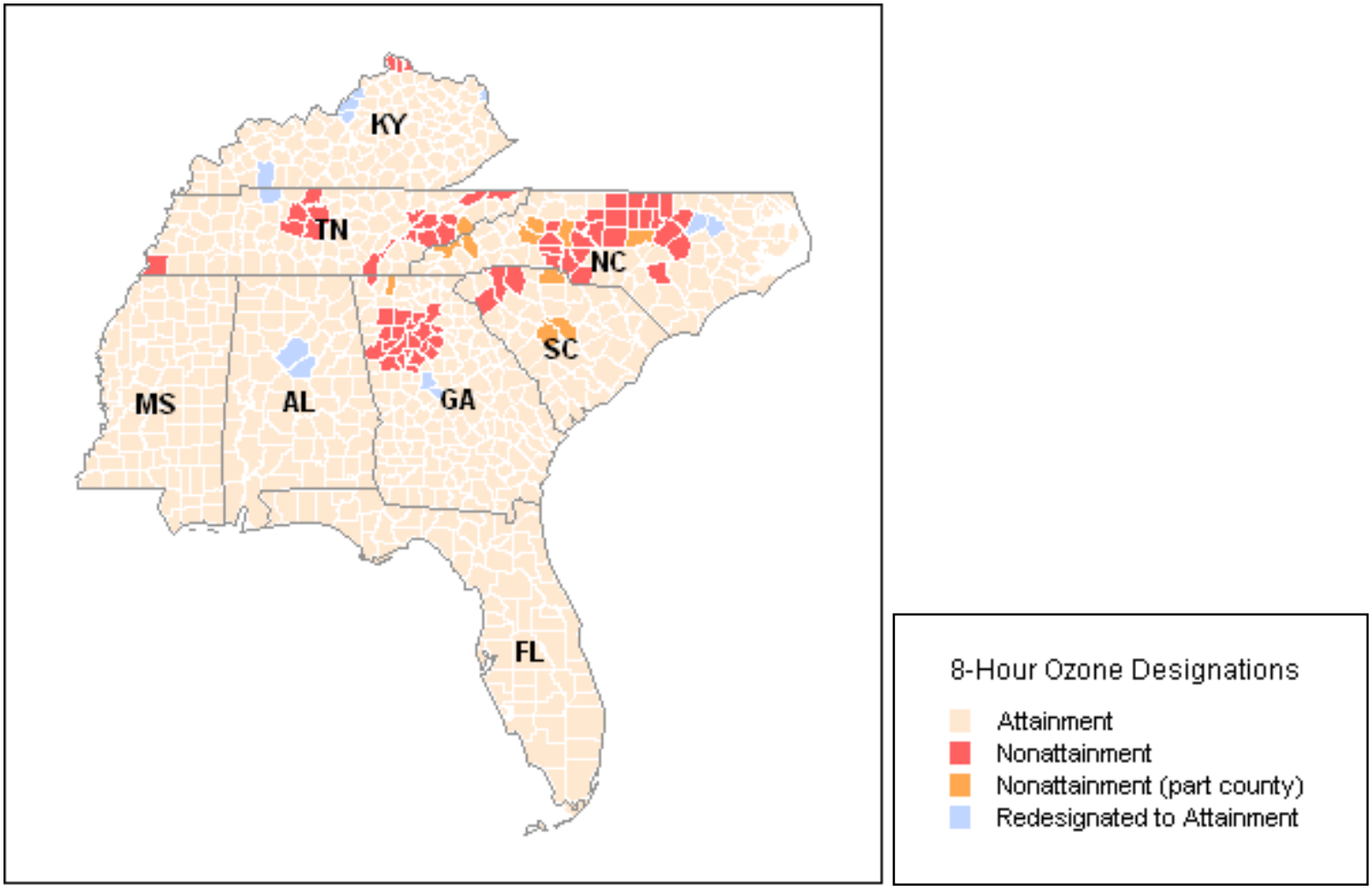
Industry	NAICS Code	No of Units	Annual Avg Empl
Total Federal Government	000000	12	164
Total State Government	000000	18	702
Total Local Government	000000	21	2,275
Total Private Industry	000000	1,356	24,803
Total All Industries	000000	1,406	27,943
Agriculture, Forestry, Fishing & Hunting	11	17	80
Mining	21	5	61
Utilities	22	6	202
Construction	23	176	1,319
Manufacturing	31	93	10,791
Wholesale Trade	42	74	1,096
Retail Trade	44	238	2,806
Transportation and Warehousing	48	27	292
Information	51	14	189
Finance and Insurance	52	77	403
Real Estate and Rental and Leasing	53	63	206
Professional and Technical Services	54	90	401
Management of Companies and Enterprises	55	*	*
Administrative and Waste Services	56	63	1,439
Educational Services	61	26	1,952
Health Care and Social Assistance	62	141	2,766
Arts, Entertainment, and Recreation	71	17	237
Accommodation and Food Services	72	92	1,661

Other Services, Ex. Public Admin	81	112	459
Public Administration	92	27	1,118
Unclassified	99	41	53

Getting Started - Glossary of Terms - Contact Information

Region 4: State Designations

Boundary Designations for 8-hour Ozone Standard - EPA Region 4
(as of October 9, 2007)



You will need Adobe Reader to view some of the files on this page. See EPA's PDF page to learn more.

This table identifies all counties EPA has designated as nonattainment. In some cases EPA designated partial counties. These are identified by a (P). Also, some counties are participating in an early action compact. These are identified as EAC. If a county is not listed below, EPA has designated it as unclassifiable/attainment. The resedignations request section of this site contains a table of redesignated areas and links to the related Federal Register documents.

State	Nonattainment Area Name	Counties	Classification	Maximum Attainment Date (from June 15, 2004)	Current/ Proposed Classification	Resdesignation Effective Date
Alabama	Birmingham Map (PDF) (1 p, 44KB)	Jefferson Shelby	Basic	June 2009	Maintenance	6/12/06
Florida	entire state is attainment					
Georgia	Atlanta, GA Map (PDF) (1 p, 124KB)	Barrow Cherokee Clayton Cobb Coweta DeKalb Douglas Fayette Forsyth Fulton Gwinnett Henry Paulding Rockdale Bartow Carroll Hall Newton Spalding Walton	Marginal	June 2007	Marginal	-
	Chattanooga TN-GA * Map (PDF) (1 p, 84KB)	Catoosa	Basic	June 2009	Basic	-
	Macon, GA Map (PDF) (1 p, 40KB)	Bibb Monroe (P)	Basic	June 2009	Maintenance	10/19/07
	Murray Co Chattahoochee Nat. Forest Mountains, GA Map (PDF) (1 p, 54KB)	Murray (P)	Basic	June 2009	Basic	pending

Kentucky	Cincinnati-Hamilton, OH-KY-IN Map (PDF) (1 p, 62KB)	Boone Campbell Kenton	Basic	June 2009	Basic	-
	Huntington-Ashland, KY-WV Map (PDF) (1 p, 102KB)	Boyd	Basic	June 2009	Maintenance	9/4/07
	Louisville, KY-IN Map (PDF) (1 p, 72KB)	Bullitt Jefferson Oldham	Basic	June 2009	Maintenance	8/6/07
	Clarksville-Hopkinsville, TN-KY Map (PDF) (1 p, 67KB)	Christian	Basic	June 2009	Maintenance	2/24/06
Mississippi	entire state is attainment					
North Carolina	Charlotte-Gastonia-Rock Hill, NC-SC Map (PDF) (1 p, 101KB)	Gaston Mecklenburg Cabarrus Iredell (P) Lincoln Rowan Union	Moderate	June 2010	Moderate	-
	Greensboro-Winston-Salem-High Point, NC† (EAC) Map (PDF) (1 p, 96KB)	Davidson Davie Forsyth Guilford Alamance Caswell Randolph Rockingham	(EAC)†	June 2007	(EAC)†	-

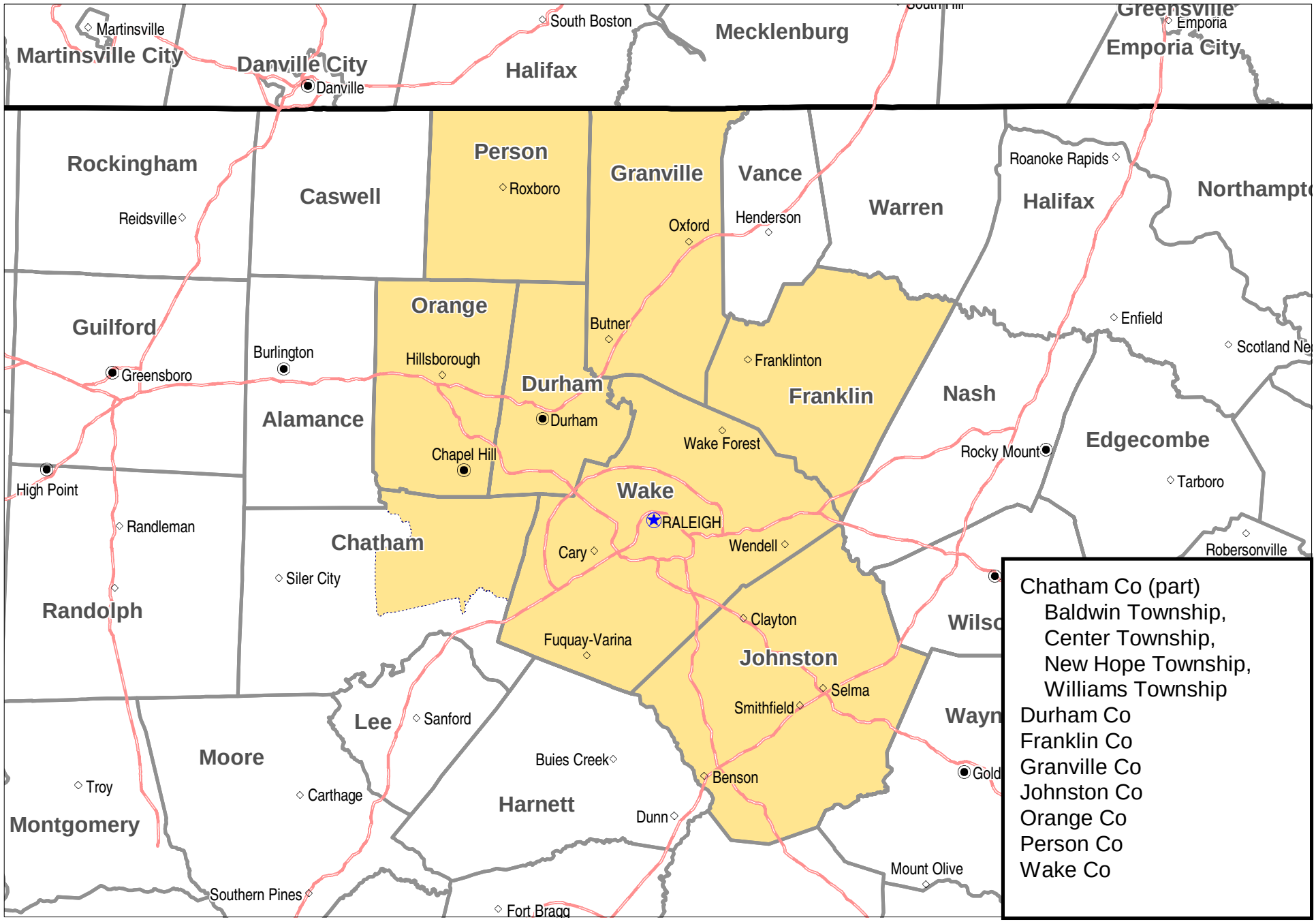
	Raleigh-Durham-Chapel Hill, NC Map (PDF) (1 p, 119KB)	Durham Granville Wake Chatham (P) Franklin Johnston Orange Person	Basic	June 2009	Basic	pending
	Hickory-Morganton-Lenoir, NC (EAC) Map (PDF) (1 p, 60KB)	Alexander Burke (P) Caldwell (P) Catawba	(EAC)	Dec 2007	(EAC)	-
	Haywood and Swain Cos (Great Smoky Mountains National Park), NC Map (PDF) (1 p, 55KB)	Haywood (P) Swain (P)	Basic	June 2009	Basic	-
	Fayetteville, NC (EAC) Map (PDF) (1 p, 51KB)	Cumberland	(EAC)	Dec 2007	(EAC)	-
	Rocky Mount, NC Map (PDF) (1 p, 52KB)	Edgecomb Nash	Basic	June 2009	Maintenance	1/5/07
South Carolina	Greenville-Spartanburg-Anderson, SC (EAC) Map (PDF) (1 p, 105KB)	Anderson Greenville Spartanburg	(EAC)	Dec 2007	(EAC)	-
	Charlotte-Gastonia-Rock Hill, NC-SC Map (PDF) (1 p, 101KB)	York (P)	Moderate	June 2010	Moderate	-

	Columbia, SC (EAC) Map (PDF) (1 p, 60KB)	Richland (P) Lexington (P)	(EAC)	Dec 2007	(EAC)	-
Tennessee	Knoxville, TN Map (PDF) (1 p, 100KB)	Cocke (P) Knox Anderson Blount Jefferson Loudon Sevier	Basic	June 2009	Basic	-
	Memphis, TN-AR† Map (PDF) (1 p, 52KB)	Shelby	Marginal†	June 2007	Marginal†	-
	Nashville, TN (EAC) Map (PDF) (1 p, 84KB)	Davidson Rutherford Sumner Williamson Wilson	(EAC)	Dec 2007	(EAC)	-
	Chattanooga, TN-GA * Map (PDF) (1 p, 84KB)	Hamilton Meigs	Basic	June 2009	Basic	-
	Clarksville-Hopkinsville, KY-TN Map (PDF) (1 p, 67KB)	Montgomery††	Basic ††	June 2009 ††	Maintenance	11/21/05
	Johnson City-Kingsport-Bristol, TN (EAC) Map (PDF) (1 p, 105KB)	Hawkins Sullivan	(EAC)	Dec 2007	(EAC)	-

* EPA has granted a deferral of the effective date, to September 30, 2005, of the nonattainment designation for Hamilton and Meigs Counties, Tennessee, and Catoosa County, Georgia. Request (PDF) (21 pp, 2MB), Federal Register notice (PDF) (pp, 72KB), EPA Fact Sheet (PDF) (2 pp, 84KB).

† This area has received a bump down in classification. See the reclassifications page for information.

Raleigh-Durham-Chapel Hill, NC 8-hour Ozone Nonattainment Area



Boundaries and locations are for illustrative purposes only. This is not a regulatory document.

List of 156 Mandatory Class I Federal Areas

Code of Federal Regulations

Reference (40 CFR PART 81)

AREA NAME	ACREAGE	FEDERAL LAND MANAGER	PUBLIC LAW
81.401 Alabama.			
Sipsey Wilderness Area	12,646	USDA-FS	93-622
81.402 Alaska.			
Bering Sea Wilderness Area	41,113	USDI-FWS	91-622
Denali NP (formerly Mt. McKinley NP)	1,949,493	USDI-FWS	64-353
Simeonof Wilderness Area	25,141	USDI-FWS	94-557
Tuxedni Wilderness Area	6,402	USDI-FWS	91-504
81.403 Arizona.			
Chiricahua National Monument Wilderness Area.	9,440	USDI-NPS	94-567
Chiricahua Wilderness Area	18,000	USDA-FS	88-577
Galiuro Wilderness Area	52,717	USDA-FS	88-577
Grand Canyon NP	1,176,913	USDI-NPS	65-277
Mazatzal Wilderness Area	205,137	USDA-FS	88-577
Mount Baldy Wilderness Area	6,975	USDA-FS	91-504
Petrified Forest NP	93,493	USDI-NPS	85-358
Pine Mountain Wilderness Area	20,061	USDA-FS	92-230

Saguaro Wilderness Area	71,400	USDI-FS	94-567
Sierra Ancha Wilderness Area	20,850	USDA-FS	88-577
Superstition Wilderness Area	124,117	USDA-FS	88-577
Sycamore Canyon Wilderness Area	47,757	USDA-FS	92-241
81.404 Arkansas.			
Caney Creek Wilderness Area	4,344	USDA-FS	93-622
Upper Buffalo Wilderness Area	9,912	USDA-FS	93-622
81.405 California.			
Agua Tibia Wilderness Area	15,934	USDA-FS	93-632
Caribou Wilderness Area	19,080	USDA-FS	88-577
Cucamonga Wilderness Area	9,022	USDA-FS	88-577
Desolation Wilderness Area	63,469	USDA-FS	91-82
Dome Land Wilderness Area	62,206	USDA-FS	88-577
Emigrant Wilderness Area	104,311	USDA-FS	93-632
Hoover Wilderness Area	47,916	USDY-FS	88-577
John Muir Wilderness Area	484,673	USDA-FS	8-577
Joshua Tree Wilderness Area	429,690	USDI-NPS	94-567
Kaiser Wilderness Area	22,500	USDA-FS	94-577
Kings Canyon NP	459,994	USDI-NPS	76-424
Lassen Volcanic NP	105,800	USDI-NPS	64-184
Lava Beds Wilderness Area	28,640	USDI-NPS	92-493

Marble Mountain Wilderness Area	213,743	USDA-FS	88-577
Minarets Wilderness Area	109,484	USDA-FS	88-577
Mokelumme Wilderness Area	50,400	USDA-FS	88-577
Pinnacles Wilderness Area	12,952	USDI-NPS	94-567
Point Reyes Wilderness Area	25,370	USDI-NPS	94-544
Redwood NP	27,792	USDI-NPS	90-545
San Gabriel Wilderness Area	36,137	USDA-FS	90-318
San Gorgonio Wilderness Area	34,644	USDA-FS	88-577
San Jacinto Wilderness Area	20,564	USDA-FS	88-577
San Rafael Wilderness Area	142,722	USDA-FS	90-271
Sequoia NP	386,642	USDI-NS	({1})
South Warner Wilderness Area	68,507	USDA-FS	88-577
Thousand Lakes Wilderness Area.	15,695	USDA-FS	88-577
Ventana Wilderness Area	95,152	USDA-FS	91-58
Yolla-Bolly-Middle-Eel Wilderness Area	109,091	USDA-FS	88-577
Yosemite NP	759,172	USDI-NPS	58-49
81.406 Colorado.			
Black Canyon of the Gunnison Wilderness Area.	11,180	USDI-NPS	94-567
Eagles Nest Wilderness Area	133,910	USDA-FS	94-352
Flat Tops Wilderness Area.	235,230	USDA-FS	94-146

Great Sand Dunes Wilderness Area	33,450	USDI-NPS	94-567
La Garita Wilderness Area.	48,486	USDA-FS	88-577
Maroon Bells-Snowmass Wilderness Area	71,060	USDA-FS	88-577
Mesa Verde NP	51,488	USDI-NPS	59-353
Mount Zirkel Wilderness Area	72,472	USDA-FS	88-577
Rawah Wilderness Area	26,674	USDA-FS	88-577
Rocky Mountain NP	263,138	USDI-NPS	63-238
Weminuche Wilderness Area.	400,907	USDA-FS	93-632
West Elk Wilderness Area	61,412	USDA-FS	88-577
81.407 Florida.			
Chassahowitzka Wilderness Area.	23,360	USDI-FWS	94-557
Everglades NP	1,397,429	USDI-NPS	73-267
St. Marks Wilderness Area.	17,745	USDI-FWS	93-632
81.408 Georgia.			
Cohotta Wilderness Area	33,776	USDA-FS	93-622
Okefenokee Wilderness Area	343,850	USDI-FWS	93-429
Wolf Island Wilderness Area	5,126	USDI-FWS	93-632
81.409 Hawaii.			
Haleakala NP	27,208	USDI-NPS	87-744
Hawaii Volcanoes NP	217,029	USDI-NPS	64-171
81.41 Idaho.			
Craters of the Moon Wilderness Area	43,243	SDI-NPS	91-504

Hells Canyon Wilderness Area{1}	83,800	USDA-FS	94-199
Sawtooth Wilderness Area	216,383	USDA-FS	92-400
Selway-Bitterroot Wilderness Area{2}	988,770	USDA-FS	88-577
Yellowstone NP{3}	31,488	USDI-NPS	({4})

{1}Hells Canyon Wilderness, 192,700 acres overall, of which 108,900 acres are in Oregon and 83,800 acres are in Idaho.

{2}Selway Bitterroot Wilderness, 1,240,700 acres overall, of which 988,700 acres are in Idaho and 251,930 acres are in Montana.

{3}Yellowstone National Park, 2,219,737 acres overall, of which 2,020,625 acres are in Wyoming, 167,624 acres are in Montana, and 31,488 acres are in Idaho

{4}17 Stat. 32 (42nd Cong.).

81.411 Kentucky.

Mammoth Cave NP	51,303	USDI-NPS	69-283

81.412 Louisiana.

Breton Wilderness Area	5,000+	USDI-FWS	93-632

81.413 Maine.

Acadia National Park	37,503	USDI-NPS	65-278
Moosehorn Wilderness Area.	7,501	USDI-FWS	
(Edmunds Unit)	(2,782)		91-504
(Baring Unit).	(4,719)		93-632

81.414 Michigan.

Isle Royale NP.	542,428	USDI-NPS	71-835
Seney Wilderness Area	25,150	USDI-FWS	91-504

81.415 Minnesota.

Boundary Waters Canoe Area Wilderness Area	747,840	USDA-FS	99-577
Voyageurs NP	114,964	USDI-NPS	99-261

81.416 Missouri.

Hercules-Glades Wilderness Area	12,315	USDA-FS	94-557
Mingo Wilderness Area	8,000	USDI-FWS	95-557

81.417 Montana.

Anaconda-Pintlar Wilderness Area	157,803	USDA-FS	88-577
Bob Marshall Wilderness Area	950,000	USDA-FS	88-577
Cabinet Mountains Wilderness Area	94,272	USDA-FS	88-577
Gates of the Mtn Wilderness Area	28,562	USDA-FS	88-577
Glacier NP	1,012,599	USDI-NPS	61-171
Medicine Lake Wilderness Area	11,366	USDI-FWS	94-557
Mission Mountain Wilderness Area	73,877	USDA-FS	93-632
Red Rock Lakes Wilderness Area.	32,350	USDI-FWS	94-557
Scapegoat Wilderness Area.	239,295	USDA-FS	92-395
Selway-Bitterroot Wilderness Area{1}	251,930	USDA-FS	88-577
U. L. Bend Wilderness Area	20,890	USDI-FWS	94-557
Yellowstone NP{2}	167,624	USDI-NPS	({3})

{1}Selway-Bitterroot Wilderness, 1,240,700 acres overall, of which 988,770 acres are in Idaho and 251,930 acres are in Montana.

{2}Yellowstone National Park, 2,219,737 acres overall, of which 2,020,625 acres are in Wyoming, 167,624 acres are in Montana, and 31,488 acres are in Idaho.

{3}17 Stat. 32 (42nd Cong.)
[44 FR 69124, Nov. 30, 1979; 45 FR 6103, Jan. 25, 1980]

81.418 Nevada.

Jarbidge Wilderness Area	64,667	USDA-FS	88-577
81.419 New Hampshire.			
Great Gulf Wilderness Area	5,552	USDA-FS	88-577
Presidential Range-Dry River Wilderness Area.	20,000	USDA-FS	93-622
81.42 New Jersey.			
Brigantine Wilderness Area	6,603	USDI-FWS	93-632
81.421 New Mexico.			
Bandelier Wilderness Area.	23,267	USDI-NPS	94-567
Bosque del Apache Wilderness Area	80,850	USDI-FWS	93-632
Carlsbad Caverns NP.	46,435	USDI-NPS	71-216
Gila Wilderness Area.	433,690	USDA-FS	88-577
Pecos Wilderness Area	167,416	USDA-FS	88-577
Salt Creek Wilderness Area	8,500	USDI-FWS	91-504
San Pedro Parks Wilderness Area	41,132	USDA-FS	88-577
Wheeler Peak Wilderness Area	6,027	USDA-FS	88-577
White Mountain Wilderness Area.	31,171	USDA-FS	88-577
81.422 North Carolina.			
Great Smoky Mountains NP{1}	273,551	USDI-NPS	69-268
Joyce Kilmer-Slickrock Wilderness Area{2}	10,201	USDA-FS	93-622
Linville Gorge Wilderness Area.	7,575	USDA-FS	88-577
Shining Rock Wilderness Area.	13,350	USDA-FS	88-577

Swanquarter Wilderness Area	9,000	USDI-FWS	94-557

{1}Great Smoky Mountains National Park, 514,758 acres overall, of which 273,551 acres are in North Carolina, and 241,207 acres are in Tennessee.

{2}Joyce Kilmer-Slickrock Wilderness, 14,033 acres overall, of which 10,201 acres are in North Carolina, and 3,832 acres are in Tennessee.

81.423 North Dakota.

Lostwood Wilderness	5,557	USDI-FWS	93-632
Theodore Roosevelt NP	69,675	USDI-NPS	80-38

81.424 Oklahoma.

Wichita Mountains Wilderness	8,900	USDI-FWS	91-504

81.425 Oregon.

Crater Lake NP	160,290	USDA-NPS	57-121
Diamond Peak Wilderness.	36,637	USDA-FS	88-577
Eagle Cap Wilderness	293,476	USDA-FS	88-577
Gearhart Mountain Wilderness	18,709	USDA-FS	88-577
Hells Canyon Wilderness{1}	108,900	USDA-FS	94-199
Kalmiopsis Wilderness.	76,900	USDA-FS	88-577
Mountain Lakes Wilderness	23,071	USDA-FS	88-577
Mount Hood Wilderness.	14,160	USDA-FS	88-577
Mount Jefferson Wilderness	100,208	USDA-FS	90-548
Mount Washington Wilderness.	46,116	USDA-FS	88-577
Strawberry Mountain Wilderness	33,003	USDA-FS	88-577
Three Sisters Wilderness	199,902	USDA-FS	88-577

{1}Hells Canyon Wilderness, 192,700 acres overall, of which 108,900 acres are in Oregon, and 83,800 acres are in Idaho.

81.426 South Carolina.

Cape Romain Wilderness	28,000	USDI-FWS	93-632

81.427 South Dakota.

Badlands Wilderness	64,250	USDI-NPS	94-567
Wind Cave NP	28,060	USDI-NPS	57-16

81.428 Tennessee.

Great Smoky Mountains NP{1}.	241,207	USDI-NPS	69-268
Joyce Kilmer-Slickrock Wilderness {2}	3,832	USDA-FS	93-622

{1}Great Smoky Mountains National Park, 514,758 acres overall, of which 273,551 acres are in North Carolina, and 241,207 acres are in Tennessee.

{2}Joyce Kilmer Slickrock Wilderness, 14,033 acres overall, of which 10,201 acres are in North Carolina, and 3,832 acres are in Tennessee. [44 FR 69124, Nov. 30, 1979; 45 FR 6103, Jan. 25, 1980]

81.429 Texas.

Big Bend NP.	708,118	USDI-NPS	74-157
Guadalupe Mountains NP	76,292	USDI-NPS	89-667

81.43 Utah.

Arches NP.	65,098	USDI-NPS	92-155
Bryce Canyon NP.	35,832	USDI-NPS	68-277
Canyonlands NP	337,570	USDI-NPS	88-590
Capitol Reef NP.	221,896	USDI-NPS	92-507
Zion NP	142,462	USDI-NPS	68-83

81.431 Vermont.

Lye Brook Wilderness	12,430	USDA-FS	93-622

81.432 Virgin Islands.

Virgin Islands NP.	12,295	USDI-NPS	84-925

81.433 Virginia.

James River Face Wilderness.	8,703	USDA-FS	93-622
Shenandoah NP	190,535	USDI-NPS	69-268
81.434 Washington.			
Alpine Lakes Wilderness.	303,508	USDA-FS	94-357
Glacier Peak Wilderness.	464,258	USDA-FS	88-577
Goat Rocks Wilderness.	82,680	USDA-FS	88-577
Mount Adams Wilderness	32,356	USDA-FS	88-577
Mount Rainer NP.	235,239	USDI-NPS	({1})
North Cascades NP.	503,277	USDI-NPS	90-554
Olympic NP	892,578	USDI-NPS	75-778
Pasayten Wilderness	505,524	USDA-FS	90-544

{1}30 Stat. 993 (55th Cong.).

81.435 West Virginia.			
Dolly Sods Wilderness.	10,215	USDA-FS	93-622
Otter Creek Wilderness	20,000	USDA-FS	93-622
81.436 Wyoming.			
Bridger Wilderness	392,160	USDA-FS	88-577
Fitzpatrick Wilderness	191,103	USDA-FS	94-567
Grand Teton NP	305,504	USDI-NPS	81-787
North Absaroka Wilderness	351,104	USDA-FS	88-577
Teton Wilderness	557,311	USDA-FS	88-577
Washakie Wilderness	686,584	USDA-FS	92-476
Yellowstone NP{1}.	2,020,625	USDI-NPS	({2})

{1}Yellowstone National Park, 2,219,737 acres overall, of which 2,020,625 acres are in Wyoming, 167,624 acres are in Montana, and 31,488 acres are in Idaho.

{2}17 Stat. 32 (42nd Cong.).

81.437 New Brunswick, Canada.

Roosevelt Campobello International Park	2,721	({1})	88-363

{1} Chairman, RCIP Commission.

*All references are to Part 51 of the Code of Federal Regulations

Abbreviations:
USDI-NPS: U.S. Department of Interior, National Park Service
USDA-FS: U.S. Department of Agriculture, U.S. Forest Service
USDI-FWS: U.S. Department of Interior, Fish and Wildlife Service

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Last updated on Tuesday, March 6th, 2007.

http://www.epa.gov/visibility/class1.html

About Our Department

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Summary of Responsibilities

The Public Utilities Department is responsible for the overall maintenance of the town's water and sewer infrastructure. This includes not only the maintenance of existing infrastructure, but the inspection of new infrastructure such as water and sewer lines to ensure that all applicable guidelines are met during the construction phase.

Public Utilities is also responsible for insuring the towns compliance with all State and Federal regulations regarding water quality issues for water and sewer.

Wastewater Treatment and Collection

The Town maintains two wastewater treatment plants and thirteen sewer pump stations. Testing and monitoring of the wastewater effluent is an ongoing procedure. Wastewater effluent quality reports are submitted to the State on a monthly basis to help ensure that all quality standards are met. Monitoring tests are performed at the Town's own laboratory, as well at a State certified independent lab. The two plants which we currently operate discharge to the Neuse River and Cape Fear River basins. A new joint venture involving the Town of Fuquay-Varina and Harnett County will add a treatment plant in Lillington, that will provide the Town with 2.6 million gallons per day capacity in addition to our current 2.2 million gallons per day capacity. The addition of this new facility, and the anticipated phasing out of the Kenneth Branch facility will provide the Town with a net gain of 1.4 MGD sewer capacity.

The Town has an ongoing infiltration and inflow, "I & I" program, to reduce the amount of water from other

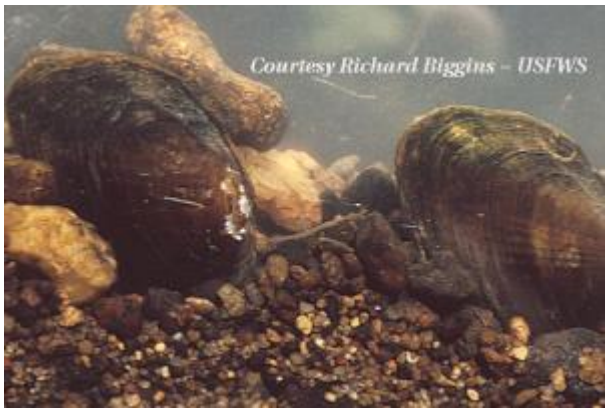
sources that reach our plant for treatment. The main source of infiltration and inflow is excess groundwater during heavy rainfall events. Each citizen of Fuquay-Varina can assist in this program by ensuring that your portion of the service line is intact, and that your clean out cover is in place and properly sealed.

Public Water Supply

The Town of Fuquay-Varina purchases water for consumption from the City of Raleigh, Harnett County and Johnston County. In addition to the monitoring and testing done by our sources of supply, Town personnel take samples throughout the system on a monthly basis to insure it customers have a safe water supply. These samples are tested by an independent State Certified Laboratory. We strive to ensure that our domestic water supply is the best available. Copies of our annual report are available through the Public Utilities Department. We currently have a capacity of 2,750,000 gallons per day available from our sources.

Chris Grimes, Public Utilities Director

U.S. Fish & Wildlife Service



Dwarf Wedge Mussel in North Carolina

DWARF WEDGE MUSSEL
Alasmidonta heterodon

STATUS: Endangered - Listed March 14, 1990

DESCRIPTION: The dwarf-wedge mussel is relatively small, rarely exceeding 1.5 inches in length. The shell's outer surface (periostracum) is usually brown or yellowish brown in color, with faint green rays that are most noticeable in young specimens. Unlike some mussel species, the male and female shells differ slightly, with the female being wider to allow greater space for egg development. A distinguishing characterictic of this mussel is it's dentition pattern; the right valve possesses two lateral teeth, while the left valve has only one. This trait is opposite of all other North American species having lateral teeth (Clark 1981).

This mussel is considered to be a long-term brooder, with gravid females reportedly observed in fall months. Like other freshwater mussels, this species' eggs are fertilized in the female as sperm are taken in through their siphons as they respire. The eggs develop with the female's gills into a larvae (glochidia). The females later release the glochidia which then attach to the gills or fins of specific host fish species. Based on anecdotal evidence, such as dates when gravid females are present or absent, it appears that release of glochidia occurs primarily in April in North Carolina (Michaelson and Neves 1995). Recent research has confirmed at least three potential fish host species for the dwarf-wedge mussel to be the tessellated darter, Johnny darter, and mottled sculpin (Michaelson 1995).

RANGE AND POPULATION LEVEL: The dwarf-wedge mussel occurs in at least 25 stream reaches along the Atlantic Coast from New Brunswick, Canada, to North Carolina. Documented populations in North Carolina are located in the following drainages and streams: Neuse River Drainage - Little River (Wake and Johnston County); Swift Creek (Wake and Johnston County); Middle and Buffalo Creek (Johnston County); Turkey Creek (Nash and Wilson County); Stony Creek (Nash); and Moccasin Creek (Nash, Wilson, and Johnston Counties); Tar River Drainage - Tar River and Shelton Creek (Granville County); Ruin, Little Ruin, and Tabbs Creek (Vance County); Cedar, Crooked, Fox, Shocco, and Little Shocco Creeks (Franklin County); and Shocco Creek (Warren County)

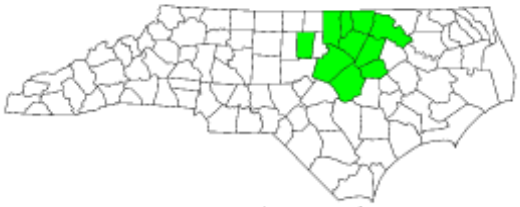
HABITAT: The dwarf wedge mussel inhabits creek and river areas with a slow to moderate current and a sand, gravel, or muddy bottom.

REASONS FOR CURRENT STATUS: Toxic effects from industrial, domestic and agricultural pollution are the primary threats to this mussel's survival. Increased acidity, caused by the mobilization of toxic metals by acid rain, is thought to be one of the chief causes of the species' extirpation from the Fort River in Massachusetts. One of the largest remaining populations has declined dramatically in the Ashuelot River, downstream of a golf course. This population probably has been affected by fungicides, herbicides, insecticides, and fertilizers which have been applied to the golf course. Agricultural runoff from adjacent corn fields and pastures also is contributing to this population's decline (Masters 1986). Freshwater mussels, including the dwarf wedge, are sensitive to potassium, zinc, copper, cadmium, and other elements associated with industrial pollution (Havlik and Marking 1987).

Species Distribution from known occurrences. Species may occur in similar habitats in other counties.

Green counties indicate observed within 20 years. Yellow counties indicate an obscure data reference to

the species in the county. Red counties indicate observed more than 20 years. Yellow counties indicate an obscure data reference to the species in the county.ago.



Map Generated Oct. 22 2003

Species Location Map based on information provided by the North Carolina Natural Heritage Program.

For additional information regarding this Web page, contact John Fridell, in Asheville, NC, at john_fridell@fws.gov

Visit the North Carolina ES Homepage

Visit the U.S. Fish and Wildlife Service Home Page

Keywords={same keywords listed above - used for search tools}

U.S. Fish & Wildlife Service

Michaux's Sumac in North Carolina

MICHAUX'S SUMAC

Rhus michauxii

STATUS: Endangered

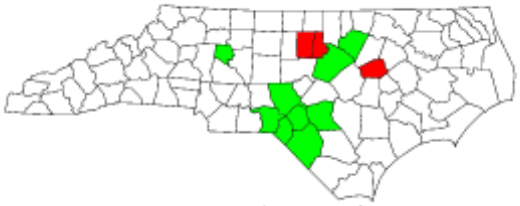
DESCRIPTION: Michaux's sumac is a rhizomatous, densely hairy shrub, with erect stems from 1 to 3 feet in height. The compound leaves contain evenly serrated, oblong to lanceolate, acuminate leaflets. Most plants are unisexual; however, more recent observations have revealed plants with both male and female flowers on one plant. The flowers are small, borne in a terminal, erect, dense cluster, and colored greenish yellow to white. Flowering usually occurs from June to July; while the fruit, a red drupe, is produced through the months of August to October.

RANGE AND POPULATION LEVEL: Michaux's sumac is historically thought to be endemic to the coastal plain and piedmont of the Carolinas, Georgia, and Florida.. The U.S. Fish and Wildlife Service listed the species as endangered on September 28, 1989, due to its rarity and vulnerability to threats. Only 36 extant populations are known, with 31 in North Carolina, three in Virginia, and two populations in Georgia. Currently, the plant is documented in the following North Carolina counties: Richmond, Hoke, Moore, Scotland, Franklin, Davie, Robeson, and Wake.

HABITAT: Michaux's sumac grows in sandy or rocky open woods in association with basic soils. Apparently, this plant survives best in areas where some form of disturbance has provided an open area. At least twelve of the plant's populations in North Carolina are on highway rights-of way, roadsides, or on the edges of artificially maintained clearings. Two other populations are in areas with periodic fires, and two populations exist on sites undergoing natural succession. One population is situated in a natural opening on the rim of a Carolina bay.

REASONS FOR CURRENT STATUS: Perhaps the most crucial factor endangering this species is its low reproductive capacity. A low percentage of the plant's remaining populations have both male and female plants. The North Carolina Natural Heritage Program wrote: . ". . . because of the clonal nature of this species and the scarcity of populations containing both male and female plants, the remaining populations may actually consist of only about two dozen genetic individuals". The plant is also threatened by fire suppression and habitat destruction due to residential and industrial development. Two of the plant's historic populations were destroyed by development, one by the construction of a water tower, and one by the conversion of the site to pine plantation.

*Species Distribution from known occurrences. Species may occur in similar habitats in other counties.*Green counties indicate observed within 20 years. Yellow counties indicate an obscure data reference to the species in the county. Red counties indicate observed more than 20 years ago.



Map Generated Oct. 22 2003

Species Location Map based on information provided by the North Carolina Natural Heritage Program. For additional information regarding this Web page, contact Dale Suiter, in Raleigh, NC, at dale_suiter@fws.gov

Visit the North Carolina ES Homepage

Visit the U.S. Fish and Wildlife Service Home Page

Keywords={same keywords listed above - used for search tools}

U.S. Fish & Wildlife Service
North Carolina Ecological Services

Cape Fear Shiner (*Notropis mekistocholas*)

Status: Endangered (with designated Critical Habitat)

Description: The Cape Fear shiner (*Notropis mekistocholas*) was first described as a new species in 1971. It is a small (approximately 2 inches long), yellowish minnow with a black band along the sides of its body. The shiner's fins are yellow and somewhat pointed. It has a black upper lip, and the lower lip bears a thin black bar along its margin. The Cape Fear shiner is known to consume plant and animal material. However, unlike most other minnows in the genus Notropis, the Cape Fear shiner's digestive tract is modified primarily for a plant diet by having an elongated, convoluted intestine.

Habitat: The Cape Fear shiner is generally associated with gravel, cobble, and boulder substrates, and has been observed in slow pools, riffles, and slow runs. These areas occasionally support water willow (*Justicia americana*), which may be used as cover or protection from predators (e.g. flathead catfish (*Pylodictis olivaris*), bass (*Micropterus spp.*) and crappie (*Pomoxis spp.*)). The Cape Fear shiner can be found swimming in schools of other minnow species but is never the most abundant species. During the spawning season, May through July, the Cape Fear shiner adults move to slower flowing pools to lay eggs on the rocky substrate. Juveniles are often found in slack water, among large rock outcrops of the midstream, and in flooded side channels and pools. Cape Fear shiners are sexually mature after their first year, and are known to live up to 6 year in captivity.

Distribution of the Cape Fear shiner

Distribution and Range: The Cape Fear shiner is endemic to the upper Cape Fear River Basin in the Central Piedmont of North Carolina. The species is known from tributaries and mainstreams of the Deep, Haw and Rocky Rivers in Chatham, Harnett, Lee, Moore and Randolph counties. Only five populations of the shiner are thought to exist. A population is designated when groups are separated by natural barriers or manmade obstructions such as dams. Two of the five remaining populations are very small and unstable and therefore at risk of extirpation. The precise number of shiners in each population is not known, but effective population sizes in the other three populations are estimated to be between 1500 and 3000 individuals. However, effective population sizes only consider the number of available breeding individuals.

Listing: The Cape Fear shiner was listed as Endangered with Critical Habitat on September 25, 1987 under the provisions of the Endangered Species Act of 1973 (as amended). In the last few decades, the shiner has undergone a reduction in range, population sizes and populations. At the time of listing only three populations where known; these areas were designated as critical habitat.

Critical Habitat: Critical habitat is defined under the Endangered Species Act as the specific areas within the geographical area occupied by a species which have physical or biological features essential to the conservation of the species and that may require special management considerations or protection, or specific areas outside the geographical area occupied by a species but for which those areas are essential for the conservation of the species.

Designated Critical Habitat Areas:

1. Chatham County, NC. Approximately 4.1 miles of the Rocky River from North Carolina State Highway 902 Bridge downstream to Chatham County Road 1010 Bridge;

2. Chatham and Lee Counties, NC. Approximately 0.5 river mile of Bear Creek, from Chatham County Road 2156 Bridge downstream to the Rocky River, then downstream in the Rocky River (approximately 4.2 river miles) to the Deep River, then downstream in the Deep River (approximately 2.6 river miles) to a point 0.3 river mile below the Moncure, North Carolina, U.S. Geological Survey Gaging Station; and,

Red areas denote designated Critical Habitat for the Cape Fear shiner.

3. Randolph and Moore Counties, NC. Approximately 1.5 miles of Fork Creek, from a point 0.1 river mile upstream of Randolph County Road 2873 Bridge downstream to the Deep River then downstream approximately 4.1 river miles of the Deep River in Randolph and Moore Counties, North Carolina, to a point 2.5 river miles below Moore County Road 1456 Bridge.

Primary constituent elements are physical and biological features of the designated critical habitat essential to the conservation of the species. The constituent elements for the Cape Fear shiner include clean streams with gravel, cobble, and boulder substrates with pools, riffles, shallow runs and slack water areas with large rock outcrops and side channels and pools with water of good quality with relatively low silt loads.

Threats: The main threats to Cape Fear shiner populations at the time of listing were a lack of basic biological information on the species such as life history information, how they may respond to stream channel modification, and changes to the stream flow. Dam construction in the Cape Fear River system has probably had the most serious impact on the species by inundating the shiners' rocky riverine habitat.

Today, the Cape Fear shiner is faced with many of the same threats that it faced at the time of listing. Segmentation or separation of small populations by dams and loss of riverine habitat to impoundments are major concerns. Deteriorating water quality at some previously occupied sites make those sites unsuitable to Cape Fear shiners today. In addition to known problems from population fragmentation, potential threats to the species and its habitat could come from such activities as changes in stream flow, runoff from agriculture and communities, road construction, impoundments, wastewater discharge, and other development projects in the watershed. Preventing further habitat deterioration and restoring degraded habitats can help ensure the future of the Cape Fear shiner.

Management and Protection: Ongoing research into the habitat requirements, population genetics, captive propagation, pollutant sensitivity, and life history parameters of the Cape Fear shiner is allowing biologists and managers to make better decisions regarding the species' management and conservation. Currently, captive and wild populations of Cape Fear shiner are being studied to learn more about the specie's behavior, biology, and ecology.

Education is also an important part of management. The North Carolina Zoological Park partnered with the Service in researching the Cape Fear shiner's life history. An added benefit of their involvement is an exhibit of Cape Fear shiners in the

Zoo's North Carolina Streamside complex. These Cape Fear shiners are accessible for public viewing along with information presented on their status and conservation.

Why Protect the Cape Fear shiner: Extinction is a natural process. Normally, new species develop through a process known as speciation at about the same rate they go extinct. However, because of air and water pollution, over-hunting, extensive deforestation, the loss of wetlands, and other human-impacts, extinctions are now occurring at a rate that far exceeds speciation. These actions are reducing the biodiversity on Earth.

The reduction of biodiversity reduces the ecological integrity of our environment. All living organisms perform a function in our environment and are dependent on the functions of other organisms. In turn, there is interconnectedness among species including us in the environment. In addition, Cape Fear shiners can act as indicators of a stream's chemical and physical quality and overall health. This is important because some of the streams where the shiner occurs are used for our own water supply.

What You Can Do to Help Protect the Cape Fear Shiner:

- Support land use planning that overtly maintains vegetated riparian buffers and water quality. Plant and maintain native vegetation along streams and creeks. These "vegetated buffers" prevent the erosion of soil and sediments into the water after heavy rains, keeping the stream clear and clean.
- Be careful when using and disposing toxic substances such as motor oil, pesticides, fertilizers, and other chemicals near creeks and streams. Always follow the instructions for chemical use, and properly dispose of any remaining material and the container.
- Keep livestock out of rivers and streams. Livestock can damage the stream banks by eating the bank vegetation and by causing erosion of the bank. Livestock and their waste can also pollute the water.
- Watch for fish kills, illegal dumping of waste, unusual water color or smell, and other changes in the river's condition. Report environmental emergencies (e.g., fish kills, oil or chemical spills) affecting water resources to the North Carolina Division of Emergency Management by calling 1-800-858-0368.

For More Information on the Cape Fear Shiner...

Annotated Bibliography of the Cape Fear shiner

Cape Fear shiner Fact Sheet 1

Cape Fear shiner Fact Sheet 2

Do you need additional help?

For additional information about the Cape Fear shiner or the information presented on this webpage, contact David Rabon in the Raleigh Field Office at david_rabon@fws.gov

Questions related to the Service's endangered species program or other program activities can be addressed to the appropriate staff from our Asheville or Raleigh Field Offices.

Other Sites of Interest

- North Carolina Natural Heritage Program
- North Carolina Wildlife Resources Commission

Page Updated: 25 September 2006

U.S. Fish & Wildlife Service

Red-cockaded Woodpecker

RED-COCKADED WOODPECKER

Picoides borealis

STATUS: Endangered

DESCRIPTION: About the size of the common cardinal, the red-cockaded woodpecker is approximately 7 inches long (18 to 20 centimeters), with a wingspan of about 15 inches (35 to 38 centimeters). Its back is barred with black and white horizontal stripes. The red-cockaded woodpecker's most distinguishing feature is a black cap and nape that encircle large white cheek patches. Rarely visible, except perhaps during the breeding season and periods of territorial defense, the male has a small red streak on each side of its black cap called a cockade, hence its name.

The red-cockaded woodpecker feeds primarily on beetles, ants, roaches, caterpillars, wood-boring insects, and spiders, and occasionally fruits and berries.

REPRODUCTION AND DEVELOPMENT: Red-cockaded woodpeckers are a territorial, nonmigratory, cooperative breeding species, frequently having the same mate for several years. The nesting season lasts from April through June. The breeding female lays three to four eggs in the breeding male's roost cavity. Group members incubate the small white eggs for 10 to 12 days. Once hatched, the nestlings remain in the nest cavity for about 26 days.

Upon fledging, the young often remain with the parents, forming groups of up to nine members, but more typically three to four members. There is only one pair of breeding birds within each group, and they normally raise only a single brood each year. The other group members called helpers, usually males from the previous breeding season, help incubate the eggs and raise the young. Juvenile females generally leave the group before the next breeding season, in search of solitary male groups.

RANGE AND POPULATION LEVEL: Historically, this woodpecker's range extended from Florida to New Jersey and Maryland, as far west as Texas and Oklahoma, and inland to Missouri, Kentucky, and Tennessee. Today it is estimated that there are about 6,000 groups of red-cockaded woodpeckers, or 15000 birds from Florida to Virginia and west to southeast Oklahoma and eastern Texas, representing about 1 percent of the woodpecker's original range. They have been extirpated in New Jersey, Maryland, Tennessee, Missouri and Kentucky.

HABITAT: The red-cockaded woodpecker makes its home in mature pine forests. Longleaf pines (*Pinus palustris*) are most commonly preferred, but other species of southern pine are also acceptable. While other woodpeckers bore out cavities in dead trees where the wood is rotten and soft, the red-cockaded woodpecker is the only one which excavates cavities exclusively in living pine trees. The older pines favored by the red-cockaded woodpecker often suffer from a fungus called red heart disease which attacks the center of the trunk,

causing the inner wood, the heartwood, to become soft. Cavities generally take from 1 to 3 years to excavate.

The aggregate of cavity trees is called a cluster and may include 1 to 20 or more cavity trees on 3 to 60 acres. The average cluster is about 10 acres. Cavity trees that are being actively used have numerous, small resin wells which exude sap. The birds keep the sap flowing apparently as a cavity defense mechanism against rat snakes and possibly other predators. The typical territory for a group ranges from about 125 to 200 acres, but observers have reported territories running from a low of around 60 acres, to an upper extreme of more than 600 acres. The size of a particular territory is related to both habitat suitability and population density.

The red-cockaded woodpecker plays a vital role in the intricate web of life of the southern pine forests. A number of other birds and small mammals use the cavities excavated by red-cockaded woodpeckers, such as chickadees, bluebirds, titmice, and several other woodpecker species, including the downy, hairy, and red-bellied woodpecker. Larger woodpeckers may take over a red-cockaded woodpecker cavity, sometimes enlarging the hole enough to allow screech owls, wood ducks, and even raccoons to later move in. Flying squirrels, several species of reptiles and amphibians, and insects, primarily bees and wasps, also will use red-cockaded woodpecker cavities.

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Coal Combustion: Nuclear Resource or Danger

By Alex Gabbard

Alex Gabbard at the coal pile for ORNL's steam plant.

Over the past few decades, the American public has become increasingly wary of nuclear power because of concern about radiation releases from normal plant operations, plant accidents, and nuclear waste. Except for Chernobyl and other nuclear accidents, releases have been found to be almost undetectable in comparison with natural background radiation. Another concern has been the cost of producing electricity at nuclear plants. It has increased largely for two reasons: compliance with stringent government regulations that restrict releases of radioactive substances from nuclear facilities into the environment and construction delays as a result of public opposition.

Americans living near coal-fired power plants are exposed to higher radiation doses than those living near nuclear power plants that meet government regulations

Partly because of these concerns about radioactivity and the cost of containing it, the American public and electric utilities have preferred coal combustion as a power source. Today 52% of the capacity for generating electricity in the United States is fueled by coal, compared with 14.8% for nuclear energy. Although there are economic justifications for this preference, it is surprising for two reasons. First, coal combustion produces carbon dioxide and other greenhouse gases that are suspected to cause climatic warming, and it is a source of sulfur oxides and nitrogen oxides, which are harmful to human health and may be largely responsible for acid rain. Second, although not as well known, releases from coal combustion contain naturally occurring radioactive materials--mainly, uranium and thorium.

Former ORNL researchers J. P. McBride, R. E. Moore, J. P. Witherspoon, and R. E. Blanco made this

point in their article "Radiological Impact of Airborne Effluents of Coal and Nuclear Plants" in the December 8, 1978, issue of Science magazine. They concluded that Americans living near coal-fired power plants are exposed to higher radiation doses than those living near nuclear power plants that meet government regulations. This ironic situation remains true today and is addressed in this article.

The fact that coal-fired power plants throughout the world are the major sources of radioactive materials released to the environment has several implications. It suggests that coal combustion is more hazardous to health than nuclear power and that it adds to the background radiation burden even more than does nuclear power. It also suggests that if radiation emissions from coal plants were regulated, their capital and operating costs would increase, making coal-fired power less economically competitive.

Finally, radioactive elements released in coal ash and exhaust produced by coal combustion contain fissionable fuels and much larger quantities of fertile materials that can be bred into fuels by absorption of neutrons, including those generated in the air by bombardment of oxygen, nitrogen, and other nuclei with cosmic rays; such fissionable and fertile materials can be recovered from coal ash using known technologies. These nuclear materials have growing value to private concerns and governments that may want to market them for fueling nuclear power plants. However, they are also available to those interested in accumulating material for nuclear weapons. A solution to this potential problem may be to encourage electric utilities to process coal ash and use new trapping technologies on coal combustion exhaust to isolate and collect valuable metals, such as iron and aluminum, and available nuclear fuels.

Makeup of Coal and Ash

Coal is one of the most impure of fuels. Its impurities range from trace quantities of many metals, including uranium and thorium, to much larger quantities of aluminum and iron to still larger quantities of impurities such as sulfur. Products of coal combustion include the oxides of carbon, nitrogen, and sulfur; carcinogenic and mutagenic substances; and recoverable minerals of commercial value, including nuclear fuels naturally occurring in coal.

The amount of thorium contained in coal is about 2.5 times greater than the amount of uranium

Coal ash is composed primarily of oxides of silicon, aluminum, iron, calcium, magnesium, titanium, sodium, potassium, arsenic, mercury, and sulfur plus small quantities of uranium and thorium. Fly ash is primarily composed of non-combustible silicon compounds (glass) melted during combustion. Tiny glass spheres form the bulk of the fly ash.

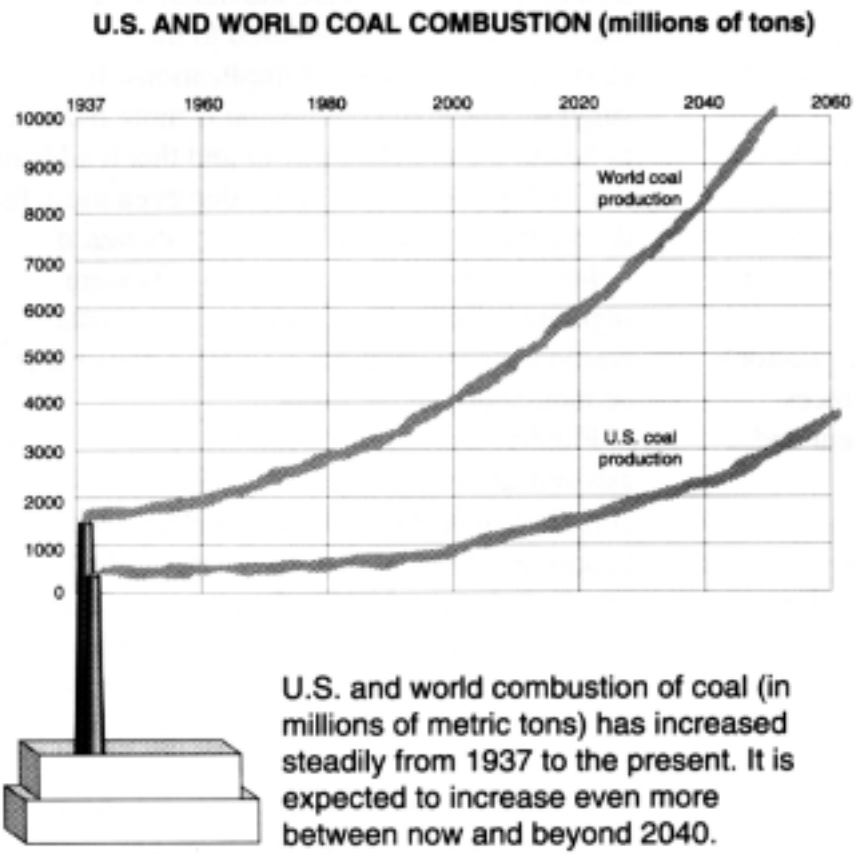
Since the 1960s particulate precipitators have been used by U.S. coal-fired power plants to retain significant amounts of fly ash rather than letting it escape to the atmosphere. When functioning properly, these precipitators are approximately 99.5% efficient. Utilities also collect furnace ash, cinders, and slag,

which are kept in cinder piles or deposited in ash ponds on coal-plant sites along with the captured fly ash.

Trace quantities of uranium in coal range from less than 1 part per million (ppm) in some samples to around 10 ppm in others. Generally, the amount of thorium contained in coal is about 2.5 times greater than the amount of uranium. For a large number of coal samples, according to Environmental Protection Agency figures released in 1984, average values of uranium and thorium content have been determined to be 1.3 ppm and 3.2 ppm, respectively. Using these values along with reported consumption and projected consumption of coal by utilities provides a means of calculating the amounts of potentially recoverable breedable and fissionable elements (see sidebar). The concentration of fissionable uranium-235 (the current fuel for nuclear power plants) has been established to be 0.71% of uranium content.

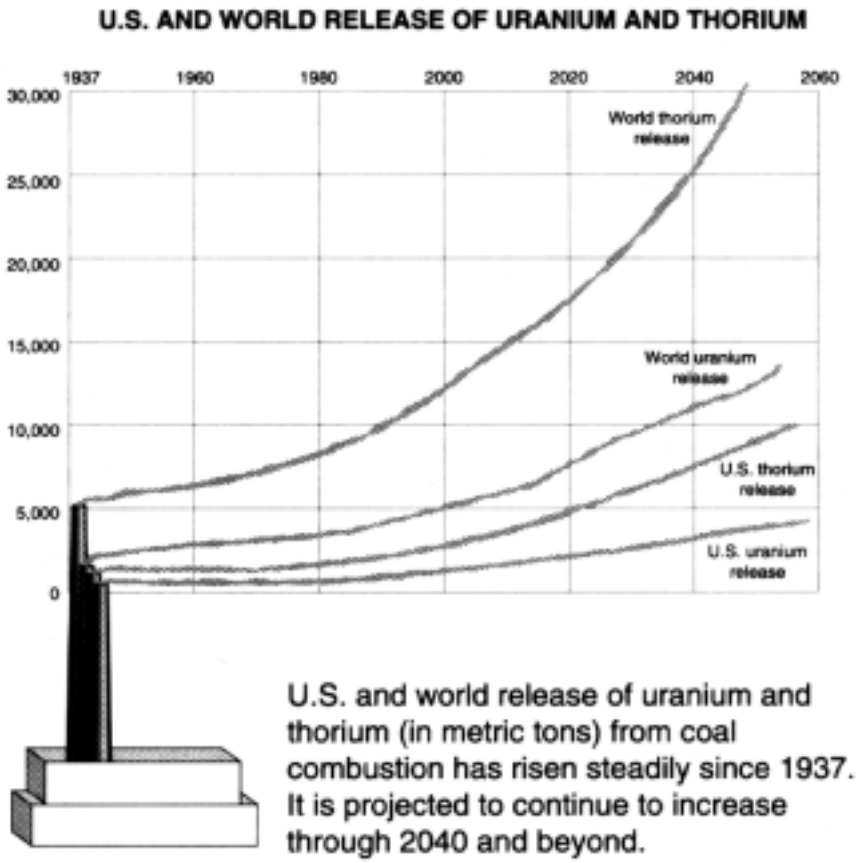
Uranium and Thorium in Coal and Coal Ash

As population increases worldwide, coal combustion continues to be the dominant fuel source for electricity. Fossil fuels' share has decreased from 76.5% in 1970 to 66.3% in 1990, while nuclear energy's share in the worldwide electricity pie has climbed from 1.6% in 1970 to 17.4% in 1990. Although U.S. population growth is slower than worldwide growth, per capita consumption of energy in this country is among the world's highest. To meet the growing demand for electricity, the U.S. utility industry has continually expanded generating capacity. Thirty years ago, nuclear power appeared to be a viable replacement for fossil power, but today it represents less than 15% of U.S. generating capacity. However, as a result of low public support during recent decades and a reduction in the rate of expected power demand, no increase in nuclear power generation is expected in the foreseeable future. As current nuclear power plants age, many plants may be retired during the first quarter of the 21st century, although some may have their operation extended through license renewal. As a result, many nuclear plants are likely to be replaced with coal-fired plants unless it is considered feasible to replace them with fuel sources such as natural gas and solar energy.



U.S. and world combustion of coal (in millions of metric tons) has increased steadily from 1937 to the present. It is expected to increase even more between now and beyond 2040.

As the world's population increases, the demands for all resources, particularly fuel for electricity, is expected to increase. To meet the demand for electric power, the world population is expected to rely increasingly on combustion of fossil fuels, primarily coal. The world has about 1500 years of known coal resources at the current use rate. The graph above shows the growth in U.S. and world coal combustion for the 50 years preceding 1988, along with projections beyond the year 2040. Using the concentration of uranium and thorium indicated above, the graph below illustrates the historical release quantities of these elements and the releases that can be expected during the first half of the next century, given the predicted growth trends. Using these data, both U.S. and worldwide fissionable uranium-235 and fertile nuclear material releases from coal combustion can be calculated.



U.S. and world release of uranium and thorium (in metric tons) from coal combustion has risen steadily since 1937. It is projected to continue to increase through 2040 and beyond.

Because existing coal-fired power plants vary in size and electrical output, to calculate the annual coal consumption of these facilities, assume that the typical plant has an electrical output of 1000 megawatts. Existing coal-fired plants of this capacity annually burn about 4 million tons of coal each year. Further, considering that in 1982 about 616 million short tons (2000 pounds per ton) of coal was burned in the United States (from 833 million short tons mined, or 74%), the number of typical coal-fired plants necessary to consume this quantity of coal is 154.

Using these data, the releases of radioactive materials per typical plant can be calculated for any year. For the year 1982, assuming coal contains uranium and thorium concentrations of 1.3 ppm and 3.2 ppm, respectively, each typical plant released 5.2 tons of uranium (containing 74 pounds of uranium-235) and 12.8 tons of thorium that year. Total U.S. releases in 1982 (from 154 typical plants) amounted to 801 tons of uranium (containing 11,371 pounds of uranium-235) and 1971 tons of thorium. These figures account for only 74% of releases from combustion of coal from all sources. Releases in 1982 from worldwide combustion of 2800 million tons of coal totaled 3640 tons of uranium (containing 51,700 pounds of uranium-235) and 8960 tons of thorium.

Based on the predicted combustion of 2516 million tons of coal in the United States and 12,580 million tons worldwide during the year 2040, cumulative releases for the 100 years of coal combustion following 1937 are predicted to be:

U.S. release (from combustion of 111,716 million tons):

Uranium: 145,230 tons (containing 1031 tons of uranium-235)

Thorium: 357,491 tons

Worldwide release (from combustion of 637,409 million tons):

Uranium: 828,632 tons (containing 5883 tons of uranium-235)

Thorium: 2,039,709 tons

Radioactivity from Coal Combustion

The main sources of radiation released from coal combustion include not only uranium and thorium but also daughter products produced by the decay of these isotopes, such as radium, radon, polonium, bismuth, and lead. Although not a decay product, naturally occurring radioactive potassium-40 is also a significant contributor.

The population effective dose equivalent from coal plants is 100 times that from nuclear plants

According to the National Council on Radiation Protection and Measurements (NCRP), the average radioactivity per short ton of coal is 17,100 millicuries/4,000,000 tons, or 0.00427 millicuries/ton. This figure can be used to calculate the average expected radioactivity release from coal combustion. For 1982 the total release of radioactivity from 154 typical coal plants in the United States was, therefore, 2,630,230 millicuries.

Thus, by combining U.S. coal combustion from 1937 (440 million tons) through 1987 (661 million tons) with an estimated total in the year 2040 (2516 million tons), the total expected U.S. radioactivity release to the environment by 2040 can be determined. That total comes from the expected combustion of 111,716 million tons of coal with the release of 477,027,320 millicuries in the United States. Global releases of radioactivity from the predicted combustion of 637,409 million tons of coal would be 2,721,736,430 millicuries.

For comparison, according to NCRP Reports No. 92 and No. 95, population exposure from operation of 1000-MWe nuclear and coal-fired power plants amounts to 490 person-rem/year for coal plants and 4.8 person-rem/year for nuclear plants. Thus, the population effective dose equivalent from coal plants is 100 times that from nuclear plants. For the complete nuclear fuel cycle, from mining to reactor operation to waste disposal, the radiation dose is cited as 136 person-rem/year; the equivalent dose for coal use, from mining to power plant operation to waste disposal, is not listed in this report and is probably

unknown.

During combustion, the volume of coal is reduced by over 85%, which increases the concentration of the metals originally in the coal. Although significant quantities of ash are retained by precipitators, heavy metals such as uranium tend to concentrate on the tiny glass spheres that make up the bulk of fly ash. This uranium is released to the atmosphere with the escaping fly ash, at about 1.0% of the original amount, according to NCRP data. The retained ash is enriched in uranium several times over the original uranium concentration in the coal because the uranium, and thorium, content is not decreased as the volume of coal is reduced.

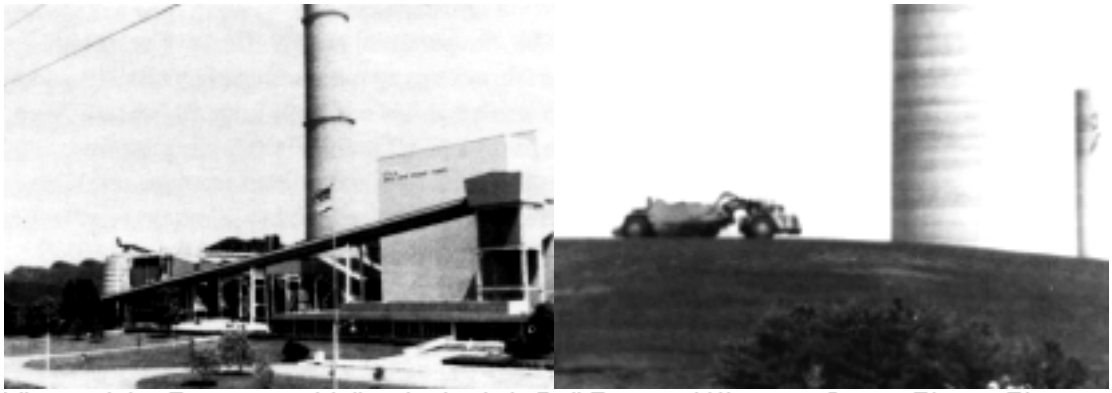
All studies of potential health hazards associated with the release of radioactive elements from coal combustion conclude that the perturbation of natural background dose levels is almost negligible. However, because the half-lives of radioactive potassium-40, uranium, and thorium are practically infinite in terms of human lifetimes, the accumulation of these species in the biosphere is directly proportional to the length of time that a quantity of coal is burned.

Although trace quantities of radioactive heavy metals are not nearly as likely to produce adverse health effects as the vast array of chemical by-products from coal combustion, the accumulated quantities of these isotopes over 150 or 250 years could pose a significant future ecological burden and potentially produce adverse health effects, especially if they are locally accumulated. Because coal is predicted to be the primary energy source for electric power production in the foreseeable future, the potential impact of long-term accumulation of by-products in the biosphere should be considered.

The energy content of nuclear fuel released in coal combustion is greater than that of the coal consumed

Energy Content: Coal vs Nuclear

An average value for the thermal energy of coal is approximately 6150 kilowatt-hours(kWh)/ton. Thus, the expected cumulative thermal energy release from U.S. coal combustion over this period totals about 6.87 x 10E14 kilowatt-hours. The thermal energy released in nuclear fission produces about 2 x 10E9 kWh/ton. Consequently, the thermal energy from fission of uranium-235 released in coal combustion amounts to 2.1 x 10E12 kWh. If uranium-238 is bred to plutonium-239, using these data and assuming a "use factor" of 10%, the thermal energy from fission of this isotope alone constitutes about 2.9 x 10E14 kWh, or about half the anticipated energy of all the utility coal burned in this country through the year 2040. If the thorium-232 is bred to uranium-233 and fissioned with a similar "use factor", the thermal energy capacity of this isotope is approximately 7.2 x 10E14 kWh, or 105% of the thermal energy released from U.S. coal combustion for a century. Assuming 10% usage, the total of the thermal energy capacities from each of these three fissionable isotopes is about 10.1 x 10E14 kWh, 1.5 times more than the total from coal. World combustion of coal has the same ratio, similarly indicating that coal combustion wastes more energy than it produces.



Views of the Tennessee Valley Authority's Bull Run and Kingston Steam Plants. These coal-fired facilities generate electricity for Oak Ridge and the surrounding area.

Consequently, the energy content of nuclear fuel released in coal combustion is more than that of the coal consumed! Clearly, coal-fired power plants are not only generating electricity but are also releasing nuclear fuels whose commercial value for electricity production by nuclear power plants is over $7 trillion, more than the U.S. national debt. This figure is based on current nuclear utility fuel costs of 7 mils per kWh, which is about half the cost for coal. Consequently, significant quantities of nuclear materials are being treated as coal waste, which might become the cleanup nightmare of the future, and their value is hardly recognized at all.

How does the amount of nuclear material released by coal combustion compare to the amount consumed as fuel by the U.S. nuclear power industry? According to 1982 figures, 111 American nuclear plants consumed about 540 tons of nuclear fuel, generating almost 1.1 x 10E12 kWh of electricity. During the same year, about 801 tons of uranium alone were released from American coal-fired plants. Add 1971 tons of thorium, and the release of nuclear components from coal combustion far exceeds the entire U.S. consumption of nuclear fuels. The same conclusion applies for worldwide nuclear fuel and coal combustion.

Another unrecognized problem is the gradual production of plutonium-239 through the exposure of uranium-238 in coal waste to neutrons from the air. These neutrons are produced primarily by bombardment of oxygen and nitrogen nuclei in the atmosphere by cosmic rays and from spontaneous fission of natural isotopes in soil. Because plutonium-239 is reportedly toxic in minute quantities, this process, however slow, is potentially worrisome. The radiotoxicity of plutonium-239 is 3.4 x 10E11 times that of uranium-238. Consequently, for 801 tons of uranium released in 1982, only 2.2 milligrams of plutonium-239 bred by natural processes, if those processes exist, is necessary to double the radiotoxicity estimated to be released into the biosphere that year. Only 0.075 times that amount in plutonium-240 doubles the radiotoxicity. Natural processes to produce both plutonium-239 and plutonium-240 appear to exist.

Conclusions

For the 100 years following 1937, U.S. and world use of coal as a heat source for electric power

generation will result in the distribution of a variety of radioactive elements into the environment. This prospect raises several questions about the risks and benefits of coal combustion, the leading source of electricity production.

First, the potential health effects of released naturally occurring radioactive elements are a long-term issue that has not been fully addressed. Even with improved efficiency in retaining stack emissions, the removal of coal from its shielding overburden in the earth and subsequent combustion releases large quantities of radioactive materials to the surface of the earth. The emissions by coal-fired power plants of greenhouse gases, a vast array of chemical by-products, and naturally occurring radioactive elements make coal much less desirable as an energy source than is generally accepted.

Second, coal ash is rich in minerals, including large quantities of aluminum and iron. These and other products of commercial value have not been exploited.

Third, large quantities of uranium and thorium and other radioactive species in coal ash are not being treated as radioactive waste. These products emit low-level radiation, but because of regulatory differences, coal-fired power plants are allowed to release quantities of radioactive material that would provoke enormous public outcry if such amounts were released from nuclear facilities. Nuclear waste products from coal combustion are allowed to be dispersed throughout the biosphere in an unregulated manner. Collected nuclear wastes that accumulate on electric utility sites are not protected from weathering, thus exposing people to increasing quantities of radioactive isotopes through air and water movement and the food chain.

Fourth, by collecting the uranium residue from coal combustion, significant quantities of fissionable material can be accumulated. In a few year's time, the recovery of the uranium-235 released by coal combustion from a typical utility anywhere in the world could provide the equivalent of several World War II-type uranium-fueled weapons. Consequently, fissionable nuclear fuel is available to any country that either buys coal from outside sources or has its own reserves. The material is potentially employable as weapon fuel by any organization so inclined. Although technically complex, purification and enrichment technologies can provide high-purity, weapons-grade uranium-235. Fortunately, even though the technology is well known, the enrichment of uranium is an expensive and time-consuming process.

Because electric utilities are not high-profile facilities, collection and processing of coal ash for recovery of minerals, including uranium for weapons or reactor fuel, can proceed without attracting outside attention, concern, or intervention. Any country with coal-fired plants could collect combustion by-products and amass sufficient nuclear weapons material to build up a very powerful arsenal, if it has or develops the technology to do so. Of far greater potential are the much larger quantities of thorium-232 and uranium-238 from coal combustion that can be used to breed fissionable isotopes. Chemical separation and purification of uranium-233 from thorium and plutonium-239 from uranium require far less effort than enrichment of isotopes. Only small fractions of these fertile elements in coal combustion residue are needed for clandestine breeding of fissionable fuels and weapons material by those nations that have nuclear reactor technology and the inclination to carry out this difficult task.

Fifth, the fact that large quantities of uranium and thorium are released from coal-fired plants without restriction raises a paradoxical question. Considering that the U.S. nuclear power industry has been required to invest in expensive measures to greatly reduce releases of radioactivity from nuclear fuel and fission products to the environment, should coal-fired power plants be allowed to do so without constraints?

If increased regulation of nuclear power plants is demanded, then we can expect a significant redirection of national policy in regulation of radioactive emissions from coal combustion

This question has significant economic repercussions. Today nuclear power plants are not as economical to construct as coal-fired plants, largely because of the high cost of complying with regulations to restrict emissions of radioactivity. If coal-fired power plants were regulated in a similar manner, the added cost of handling nuclear waste from coal combustion would be significant and would, perhaps, make it difficult for coal-burning plants to compete economically with nuclear power.

Because of increasing public concern about nuclear power and radioactivity in the environment, reduction of releases of nuclear materials from all sources has become a national priority known as "as low as reasonably achievable" (ALARA). If increased regulation of nuclear power plants is demanded, can we expect a significant redirection of national policy so that radioactive emissions from coal combustion are also regulated?

Although adverse health effects from increased natural background radioactivity may seem unlikely for the near term, long-term accumulation of radioactive materials from continued worldwide combustion of coal could pose serious health hazards. Because coal combustion is projected to increase throughout the world during the next century, the increasing accumulation of coal combustion by-products, including radioactive components, should be discussed in the formulation of energy policy and plans for future energy use.

One potential solution is improved technology for trapping the exhaust (gaseous emissions up the stack) from coal combustion. If and when such technology is developed, electric utilities may then be able both to recover useful elements, such as nuclear fuels, iron, and aluminum, and to trap greenhouse gas emissions. Encouraging utilities to enter mineral markets that have been previously unavailable may or may not be desirable, but doing so appears to have the potential of expanding their economic base, thus offsetting some portion of their operating costs, which ultimately could reduce consumer costs for electricity.

Both the benefits and hazards of coal combustion are more far-reaching than are generally recognized. Technologies exist to remove, store, and generate energy from the radioactive isotopes released to the environment by coal combustion. When considering the nuclear consequences of coal combustion, policymakers should look at the data and recognize that the amount of uranium-235 alone dispersed by

coal combustion is the equivalent of dozens of nuclear reactor fuel loadings. They should also recognize that the nuclear fuel potential of the fertile isotopes of thorium-232 and uranium-238, which can be converted in reactors to fissionable elements by breeding, yields a virtually unlimited source of nuclear energy that is frequently overlooked as a natural resource.

The amount of uranium-235 alone dispersed by coal combustion is the equivalent of dozens of nuclear reactor fuel loadings

In short, naturally occurring radioactive species released by coal combustion are accumulating in the environment along with minerals such as mercury, arsenic, silicon, calcium, chlorine, and lead, sodium, as well as metals such as aluminum, iron, lead, magnesium, titanium, boron, chromium, and others that are continually dispersed in millions of tons of coal combustion by-products. The potential benefits and threats of these released materials will someday be of such significance that they should not now be ignored.--*Alex Gabbard of the Metals and Ceramics Division*

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Welcome

The Harnett County Department of Public Utilities is a regional water and wastewater utility that provides service to approximately 60,000 people in Harnett County.

The Harnett County Regional Water Treatment Plant, located in the County seat of Lillington, supplies water to the municipalities of Lillington, Angier, Coats, and the village of Buies Creek. Harnett County also supplies water to the five contiguous counties of Cumberland, Lee, Wake, Johnston, and Moore. This plant utilizes the Cape Fear River as the source for the system's drinking water and was recognized in 2004 with the "Directors Award of Recognition' from the Partnership of Safe Water, a national volunteer initiative developed by the United States Environmental Protection Agency and other water organizations throughout the United States.

The Harnett County Regional Water Treatment Plant is one of 185 water plants throughout the United States to receive this distinction and one of three in North Carolina. Harnett County's water system consists of nine different rural water and sewer districts. These districts have a total of over 1500 miles of water mains and currently have over 30,000 active connections within their boundaries.Approximately 98% of all Harnett County residents have access to public water. HCDPU currently has 4 active wastewater treatment plants that serve approximately 12,000 people in Harnett County.

There are currently two separate construction initiatives under way which would raise the County's wastewater treatment capacity to 9.4 millions gallons per day from our current capacity of 1.95 million gallons per day and also more than double the number of people served. HCDPU is committed to expanding wastewater services to our citizens throughout the County and region.

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Carbon Dioxide Emission Factors for Coal

by

B.D. Hong and E. R. Slatick

(This article was originally published in Energy Information Administration, *Quarterly Coal Report, January-April 1994*, DOE/EIA-0121(94/Q1) (Washington, DC, August 1994), pp. 1-8.)

Introduction

Coal is an important source of energy in the United States, and the Nation's reliance on this fossil fuel for electricity generation is growing. The combustion of coal, however, adds a significant amount of carbon dioxide to the atmosphere per unit of heat energy, more than does the combustion of other fossil fuels.(1) Because of a growing concern over the possible consequences of global warming, which may be caused in part by increases in atmospheric carbon dioxide (a major greenhouse gas), and also because of the need for accurate estimates of carbon dioxide emissions, the Energy Information Administration (EIA) has developed factors for estimating the amount of carbon dioxide emitted as a result of U.S. coal consumption.

Carbon dioxide emission factors for U.S. coals have previously been available from several sources. However, those emission factors have shortcomings because they are based on analyses of only a few coal samples. Most are single factors applied to all coals, regardless of rank (i.e., whether anthracite, bituminous, subbituminous, or lignite) or geographic origin. Because single factors do not account for differences among coals, they fail to reflect the changing "mix" of coal in U.S. coal consumption that has occurred in the past and will occur in the future. Lacking standardization, the factors previously available also differ widely from each other.(2)

EIA's emission factors will improve the accuracy of estimates of carbon dioxide emissions, especially at State and regional levels, because they reflect the difference in the ratio of carbon to heat content by rank of coal and State of origin. EIA's emission factors are derived from the EIA Coal Analysis File, a large database of coal sample analyses. The emission factors vary significantly by coal rank, confirming a long-recognized finding, and also within each rank by State of origin. These findings were verified statistically.

Two types of carbon dioxide emission factors have been developed. First are basic emission factors covering the various coal ranks by State of origin. These basic emission factors are considered as "fixed" for the foreseeable future until better data become available. Second are emission factors for use in estimating carbon dioxide emissions from coal consumption by State, with consuming-sector detail. These emission factors are based on the mix of coal consumed and the basic emission factors by coal rank and State of origin. These emission factors are subject to change over time, reflecting changes in the mix of coal consumed.

EIA's emission factors will not only enable coal-generated carbon dioxide emissions to be estimated more accurately than before, but they will also provide consistency in estimates. Energy and environmental analysts will find EIA's emission factors useful for analyzing and monitoring carbon dioxide emissions from coal combustion, whether they are estimated by the State of origin of the coal, consuming State, or consuming sector.

Coal Combustion and Carbon Dioxide Emissions

The amount of heat emitted during coal combustion depends largely on the amounts of carbon, hydrogen, and oxygen present in the coal and, to a lesser extent, on the sulfur content. Hence, the ratio of carbon to heat content depends on these heat-producing components of coal, and these components vary by coal rank.

Carbon, by far the major component of coal, is the principal source of heat, generating about 14,500 British thermal units (Btu) per pound. The typical carbon content for coal (dry basis) ranges from more than 60 percent for lignite to more than 80 percent for anthracite. Although hydrogen generates about 62,000 Btu per pound, it accounts for only 5 percent or less of coal and not all of this is available for heat because part of the hydrogen combines with oxygen to form water vapor. The higher the oxygen content of coal, the lower its heating value.(3) This inverse relationship occurs because oxygen in the coal is bound to the carbon and has, therefore, already partially oxidized the carbon, decreasing its ability to generate heat. The amount of heat contributed by the combustion of sulfur in coal is relatively small, because the heating value of sulfur is only about 4,000 Btu per pound, and the sulfur content of coal generally averages 1 to 2 percent by weight.(4) Consequently, variations in the ratios of carbon to heat content of coal are due primarily to variations in the hydrogen content.

The carbon dioxide emission factors in this article are expressed in terms of the energy content of coal as pounds of carbon dioxide per million Btu. Carbon dioxide (CO_2) forms during coal combustion when one atom of carbon (C) unites with two atoms of oxygen (O) from the air. Because the atomic weight of carbon is 12 and that of oxygen is 16, the atomic weight of carbon dioxide is 44. Based on that ratio, and assuming complete combustion, 1 pound of carbon combines with 2.667 pounds of oxygen to produce 3.667 pounds of carbon dioxide. For example, coal with a carbon content of 78 percent and a heating value of 14,000 Btu per pound emits about 204.3 pounds of carbon dioxide per million Btu when completely burned.(5) Complete combustion of 1 short ton (2,000 pounds) of this coal will generate about 5,720 pounds (2.86 short tons) of carbon dioxide.

Methodology and Statistical Checks

EIA's carbon dioxide emission factors were derived from data in the EIA Coal Analysis File, one of the most comprehensive data sources on U.S. coal quality by coalbed and coal-producing county. Most of the samples in the file were taken from coal shipments to U.S. Government facilities, from tipples and from mines. From the more than 60,000 coal samples in the File, 5,426 were identified as containing data on heat value and the ultimate analysis(6) needed for developing the relationship between carbon and heat content of the coal, that is, the carbon dioxide emission factors. Coal rank was assigned to each sample according to the standard classification method developed by the American Society for Testing and Materials. These data observations (samples) covered all of the major and most of the minor coal-producing States (Table FE1). Except for Arizona, North Dakota, and Texas, all of the major coal-producing States were considered to have a sufficiently large number of data observations to yield reliable emission factors.

The ratio of carbon to heat content was computed for each of the 5,426 selected coal samples by coal rank and State of origin under the assumption that all of the carbon in the coal is converted to carbon dioxide during combustion.(7) Variations in the ratios were observed across both coal rank and State of origin. Analysis was performed to determine whether these variations were statistically significant and to ensure that other factors pertaining to the samples (that is, the year the sample was collected and the degree of cleaning the sample received) were not significantly responsible for the observed variations.

Table FE1. Number of Observations by Coal Rank and State of Origin

State of Origin	Anthracite	Bituminous	Sub-bituminous	Lignite
Alabama	--	224	--	--
Alaska	--	--	--	--
Arizona	--	8	--	--
Arkansas	--	8	--	--
California	--	--	--	--
Colorado	--	164	18	--
Georgia	--	1	--	--
Idaho	--	2	--	--
Illinois	--	332	--	--
Indiana	--	51	--	--
Iowa	--	67	1	--
Kansas	--	19	--	--
Kentucky: East	--	486	--	--
Kentucky: West	--	151	--	--
Louisiana	--	--	--	--
Maryland	--	13	--	--
Missouri	--	86	--	--
Montana	--	6	23	2
Nevada	--	4	--	--
New Mexico	--	50	--	--
North Dakota	--	--	--	16
Ohio	--	228	--	--
Oklahoma	--	155	--	--
Oregon	--	--	2	--
Pennsylvania	523	679	--	--
South Dakota	--	--	--	3
Tennessee	--	271	--	--
Texas	--	--	--	11
Utah	--	104	2	--
Virginia	--	169	--	--
Washington	--	181	36	4
West Virginia	--	1,071	--	--

Wyoming	--	133	121	1
Total.	**523**	**4,663**	**203**	**37**

Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, "Analysis of the Relationship Between the Heat and Carbon Content of U.S. Coals," September 1992.

Distributions of the data observations by year of collection and degree of cleaning were compiled (Table FE2). Because the dates of the samples range from 1900 through 1986, it was thought that changes in laboratory analysis techniques over the years might have influenced the resultant carbon-to-heat-content ratios. A regression analysis found that, with a R^2 value of only 0.01 (Table FE3), the year the sample was collected was not a useful factor in explaining the variation in the ratio, although there were small changes in the ratio over time.(8) This finding indicated that samples from earlier time periods could be combined with more recent samples to derive carbon dioxide emission factors.

Table FE2. Distribution of Observations by Year and Degree of Cleaning

Year	Number of Observations	Percent of Total
1900-1909	217	4.0
1910-1919	679	12.5
1920-1929	657	12.1
1930-1939	772	14.2
1940-1949	744	13.7
1950-1959	1,043	19.2
1960-1969	557	10.3
1970-1979	339	6.2
1980-1986	418	7.7
Total	5,426	100.0
Degree of Cleaning		
Raw	4,519	83.3
Washed	847	15.6
Partially washed	60	1.1

Note: Total may not equal sum of components due to independent rounding.
Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, "Analysis of the Relationship Between the Heat and Carbon Content of U.S. Coals," September 1992.

Of the total samples, 83 percent were raw coal, with the remainder either washed or partially washed. Cleaning should not materially affect the ratio of a coal's heat-to-carbon content because the process removes primarily non-combustible impurities. This was confirmed by an analysis of variance. There were differences in the carbon-to-heat-content ratios between washed or partially washed and raw coal, but with a R^2 value of 0.06, the differences did little to explain the variation in the ratios. Therefore, no data correction was warranted to account

for the small effect that coal cleaning had on emission factors.

Analysis of variance was used to test the statistical significance of differences in the carbon-to-heat-content ratios across coal rank and across State of origin within coal rank. The continuous response variable (the carbon dioxide emission factor) was related to classification variables of rank and State of origin. The carbon dioxide emission factor was assumed to be a linear function of the parameters associated with the coal rank and State of origin.(9)

The statistical analyses (Table FE3) indicated that: (1) there are statistically significant differences in carbon dioxide emission factors across both coal rank and State of origin; (2) coal rank and State of origin each explain approximately 80 percent of the variation in carbon dioxide emission factors; and (3) State of origin combined with coal rank is a slightly more powerful explanatory variable than either coal rank or State of origin alone.

Table FE3. Summary of Statistical Analyses Carbon Dioxide Emission Factors by Coal Rank and State of Origin

Variable	F Test	R^2	MSE	Root MSE
Year Collected	***	0.01	55.18	7.43
Degree of Cleaning	***	0.06	52.07	7.22
Coal Rank	***	0.78	12.24	3.50
State of Origin	***	0.81	10.78	3.28
State of Origin Combined				
with Coal Rank	***	0.82	9.98	3.16

Notes: The F test indicates the statistical significance of differences in the emission factors across levels of the explanatory variable; *** indicates significance at the 0.001 level. R^2 (coefficient of determination) indicates the proportion of total variation in the emission factors explained by the model. MSE (mean square error) is the variance of the emission factors, and root MSE is the corresponding standard deviation.

Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, “Analysis of the Relationship Between the Heat and Carbon Content of U.S. Coals,” September 1992.

Carbon Dioxide Emission Factors by Coal Rank and State of Origin

The (arithmetic) average emission factors obtained from the individual samples (assuming complete combustion) (Table FE4)(10) confirm the long-recognized finding that anthracite emits the largest amount of carbon dioxide per million Btu, followed by lignite, subbituminous coal, and bituminous coal. The high carbon dioxide emission factor for anthracite reflects the coal's relatively small hydrogen content, which lowers its heating value.(11) In pounds of carbon dioxide per million Btu, U.S. average factors are 227.4 for anthracite, 216.3 for lignite, 211.9 for subbituminous coal, and 205.3 for bituminous coal.

Table FE4. Average Carbon Dioxide Emission Factors for Coal by Rank and State of Origin

State of Origin	Anthracite	Bituminous	Sub-bituminous	Lignite
Alabama	--	205.5	--	--
Alaska	--	--	[a]214.0	--
Arizona	--	209.7	--	--
Arkansas	--	211.6	--	[b]213.5
California	--	--	--	[c]216.3
Colorado	--	206.2	212.7	--
Georgia	--	206.1	--	--
Idaho	--	205.9	--	--
Illinois	--	203.5	--	--
Indiana	--	203.6	--	--
Iowa	--	201.6	[d]207.2	--
Kansas	--	202.8	--	--
Kentucky: East	--	204.8	--	--
Kentucky: West	--	203.2	--	--
Louisiana	--	--	--	[b]213.5
Maryland	--	210.2	--	--
Missouri	--	201.3	--	--
Montana	--	209.6	213.4	220.6
Nevada	--	201.8	--	--
New Mexico	--	205.7	[e]208.8	--
North Dakota	--	--	--	218.8
Ohio	--	202.8	--	--
Oklahoma	--	205.9	--	--
Oregon	--	--	210.4	--
Pennsylvania	227.4	205.7	--	--
South Dakota	--	--	--	217.0
Tennessee	--	204.8	--	--
Texas	--	[f]204.4	--	213.5
Utah	--	204.1	207.1	--
Virginia	--	206.2	--	--
Washington	--	203.6	208.7	211.7
West Virginia	--	207.1	--	--

Wyoming	--	206.5	212.7	215.6
U.S. Average	**227.4**	**205.3**	**211.9**	**216.3**

[a]Based on carbon and heat content data supplied by Usibelli Coal Mining Company for the subbituminous C coal currently being produced in the State.

[b]Based on the CO_2 emission factor for Texas lignite.

[c]Based on the CO_2 emission factor for U.S. lignite.

[d]Derived from "Element Geochemistry of Cherokee Group Coals (Middle Pennsylvanian) from South-Central and Southeastern Iowa," *Technical Paper No. 5*, Iowa Geological Survey (Iowa City, IA, 1984), pp. 15, 48, and 49.

[e]Based on the CO_2 emission factor for subbituminous A coal.

[f]Based on the CO_2 ratio for U.S. high-volatile bituminous coal.

Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, "Analysis of the Relationship Between the Heat and Carbon Content of U.S. Coals," September 1992.

In general, the carbon dioxide emission factors are lowest for coal produced in States east of the Mississippi River (Figure FE1), where the predominant coals are bituminous in rank and therefore have relatively low emission factors. By comparison, the coal deposits in the West are largely subbituminous coals, which have relatively high emission factors. In a broad sense, the geographic differences reflect the greater degree of coalification--the process that transformed plant material into coal under the influence of heat and pressure--in the coal-bearing areas in the East.

In the Appalachian Coal Basin, the emission factors for bituminous coal range from a low of 202.8 pounds of carbon dioxide per million Btu in Ohio to a high of 210.2 in Maryland.(12) Pennsylvania anthracite, which is produced in small amounts, has the highest emission factor among all coal ranks (227.4). For Illinois Basin coal, all bituminous in rank, the emission factors are relatively uniform, ranging from 203.2 in western Kentucky to 203.6 in Indiana.

Figure FE1: Average Carbon Dioxide Emission Factors for Coal by Rank and State of Origin

Pounds of Carbon Dioxide per Million Btu

West of the Mississippi River, the emission factors for bituminous coal range from more than 201 pounds of carbon dioxide per million Btu in Missouri, Iowa, and Nevada to more than 209 in Arizona, Arkansas, and Montana. About 16 percent of the 1992 coal output west of the Mississippi was bituminous coal, with production chiefly from Utah, Arizona, Colorado, and New Mexico.

Subbituminous coal is the predominant rank of coal produced west of the Mississippi River, accounting for 62 percent of the region's total coal output in 1992. Subbituminous coal in Wyoming's Powder River Basin, the principal source of this rank of coal, has an emission factor of 212.7 pounds of carbon dioxide per million Btu. This is the same as for subbituminous coal in Colorado, but slightly below that in Montana. The lowest emission factor for subbituminous coal is in Utah (207.1) and the highest is in Alaska (214.0).

The emission factor for lignite from the Gulf Coast Coal Region in Texas, Louisiana, and Arkansas is 213.5 pounds of carbon dioxide per million Btu. This is 1 to 3 percent lower than the emission factors for lignite in the Fort Union Coal Region in North Dakota, South Dakota, and Montana and for lignite in the Powder River Basin in Wyoming. The 1992 output of lignite accounted for 22 percent of coal production west of the Mississippi

River, with two-thirds from Texas and most of the balance from North Dakota.

All of EIA's carbon dioxide emission factors for coal by rank and State of origin should be considered as "fixed" for the foreseeable future. This is because detailed coal analysis data are not widely available annually, and because the EIA emission factors, as developed from the EIA Coal Analysis File, are considered to effectively represent the relationship between the carbon and heat content of the various U.S. coals. However, the basic emission factors will be reviewed when sufficient additional coal analysis data are accumulated.

Carbon Dioxide Emission Factors by Coal-Consuming Sector and State

Coal use among the consuming sectors and States varies in quantity as well as in rank and State of origin. Therefore, emission factors by consuming sector in each State were derived by weighting the emission factors by coal rank and State of origin by the respective amounts received by sector.(13),(14) For comparison, emission factors for 1980 and 1992 are reported in this article (Table FE5). It should be noted that the amount of coal received in a certain year may not equal the amount consumed during that year because of stock additions or withdrawals. Furthermore, because data on the origin and destination of coal are available only for coal distribution, EIA's emission factors for coal consumption by sector assume that the mix of coal received during a certain year was the same as that consumed in that year.

The emission factors for coal consumption involving combustion are based on the assumption that all of the carbon in coal is converted to carbon dioxide during combustion. Actually, a very small percentage of the carbon in coal is not oxidized during combustion. The emission factors in Table FE5 can be adjusted to reflect incomplete combustion.(15)

In coke plants, coal is carbonized, not combusted, to make coke, which is used in the manufacture of pig iron by the iron and steel industry. Although most of the carbon in the coal carbonized remains in the coke, a small amount is retained in byproducts, some of which are consumed as energy sources and others as non-energy raw materials.(16) Examination of historical data for coke plant operations indicates that about 10 percent of the carbon in coking coal remains in non- energy byproducts.(17) However, no allowances have been made in the emission factors for coke plants (Table FE5) for carbon retained in non-energy byproducts, leaving any adjustments to the user's stipulations.

Table FE5. Average Carbon Dioxide Emission Factors for Coal-Consuming Sector and State, 1980 and 1992

State	Sector									
	Electric Utilities		Industrial				Residential/ Commercial		State Average[b]	
			Coking Coal[a]		Other Coal					
	1980	1992	1980	1992	1980	1992	1980	1992	1980	1992
Alabama	205.0	205.3	205.5	206.1	205.5	205.7	205.4	205.5	205.1	205.4
Alaska	214.0	214.0	--	--	--	--	--	214.0	214.0	214.0
Arizona	208.0	207.7	--	--	209.2	206.7	--	208.6	208.1	207.6

Arkansas	212.7	212.7	--	--	201.4	205.2	205.3	222.3	210.7	212.5
California	--	--	208.7	--	205.6	204.2	204.5	204.1	207.5	204.1
Colorado	211.5	209.8	212.6	--	212.6	212.5	212.6	211.0	211.7	209.9
Connecticut	--	204.9	--	--	--	204.7	226.1	220.2	226.1	205.2
Delaware	206.0	206.9	--	--	205.9	207.4	221.8	221.1	206.0	207.0
District of Columbia	--	--	--	--	205.0	--	205.5	206.3	205.4	206.3
Florida	204.0	204.4	--	--	204.2	205.1	205.0	205.7	204.0	204.5
Georgia	204.3	204.8	--	--	204.9	204.9	204.7	204.9	204.3	204.8
Hawaii	--	--	--	--	--	204.4	--	--	--	204.4
Idaho	--	--	--	--	212.6	212.2	205.4	205.0	210.7	211.3
Illinois	207.1	206.2	205.2	206.5	204.2	203.7	203.9	203.9	206.7	205.9
Indiana	204.0	205.6	205.0	206.0	203.7	204.5	203.7	203.8	204.3	205.5
Iowa	207.2	211.1	--	--	205.7	208.3	205.1	204.2	207.0	210.7
Kansas	209.2	210.9	--	--	201.9	205.3	202.2	202.9	209.0	210.8
Kentucky	204.0	204.1	204.6	206.3	205.4	205.4	204.6	204.6	204.1	204.2
Louisiana	212.7	212.9	--	--	203.9	210.9	201.3	--	212.1	212.8
Maine	--	--	--	--	206.0	204.9	216.2	213.0	207.9	205.3
Maryland	206.6	207.0	205.9	--	206.1	208.4	210.6	211.7	206.3	207.1
Massachusetts	206.4	206.8	--	--	206.3	207.0	218.2	214.1	207.6	206.9
Michigan	206.0	208.9	205.5	--	204.8	205.3	205.0	205.0	205.7	208.5
Minnesota	212.9	213.0	--	--	211.6	211.8	208.6	212.3	212.7	212.9
Mississippi	204.7	204.5	--	--	204.0	204.6	202.6	227.4	204.7	204.5
Missouri	204.5	206.2	205.2	--	203.6	204.5	202.1	203.4	204.5	206.1
Montana	213.9	213.5	--	--	211.2	211.4	205.6	213.3	213.7	213.5
Nebraska	211.7	212.7	--	--	212.3	213.1	212.6	219.2	211.7	212.7
Nevada	208.2	208.4	--	--	204.5	204.1	208.4	204.1	208.1	208.3
New Hampshire	206.9	206.3	--	--	207.0	207.1	227.2	225.4	207.0	206.5
New Jersey	206.6	206.6	--	--	218.3	207.3	227.2	227.1	207.1	206.8
New Mexico	205.7	205.7	--	--	212.0	212.7	209.8	206.3	205.7	205.7
New York	205.7	206.1	205.5	206.1	206.9	207.0	218.9	218.0	206.3	206.5
North Carolina	205.6	205.8	--	--	204.8	205.7	204.9	206.2	205.6	205.8
North Dakota	218.8	218.8	--	--	218.8	218.3	218.5	216.8	218.8	218.6
Ohio	204.4	204.4	205.4	206.4	204.0	204.5	203.8	205.5	204.5	204.6
Oklahoma	210.5	212.6	--	--	202.2	207.5	205.7	207.0	210.0	212.3

Oregon	212.7	212.9	--	--	212.7	211.5	205.6	204.1	212.5	212.8
Pennsylvania	206.1	206.2	205.7	206.1	207.9	208.5	221.2	219.7	206.4	206.7
Rhode Island	--	--	--	--	210.0	--	223.9	227.4	217.2	227.4
South Carolina	204.9	205.0	--	--	205.0	205.3	204.8	205.3	204.9	205.0
South Dakota	218.1	218.8	--	--	210.5	212.7	212.0	212.8	217.6	217.9
Tennessee	204.0	204.0	210.2	--	204.8	205.5	204.5	204.6	204.1	204.2
Texas	213.0	212.9	209.8	--	212.3	212.3	213.7	211.0	212.8	212.9
Utah	204.1	204.3	210.8	205.6	205.2	204.1	204.1	204.1	205.7	204.4
Vermont	205.7	--	--	--	207.8	212.2	227.4	227.4	216.0	216.8
Virginia	205.9	206.0	206.2	206.2	205.1	206.2	205.0	206.3	205.7	206.1
Washington	208.7	209.3	--	--	206.3	205.8	204.3	206.9	208.3	209.1
West Virginia	206.9	207.0	205.3	206.7	205.4	206.6	205.0	210.2	206.6	207.0
Wisconsin	207.0	209.9	205.4	--	205.5	206.1	205.8	204.9	206.8	209.5
Wyoming	212.7	212.0	--	--	212.0	212.5	212.3	212.7	212.6	212.1
U.S. Average[b]	**206.7**	**207.7**	**205.8**	**206.2**	**205.9**	**207.1**	**210.6**	**211.2**	**206.5**	**207.6**

[a]No allowances have been made for carbon retained in non-energy coal chemical byproducts from the coal carbonization process.

[b]Weighted average. The weights used are consumption values by sector.

Source: Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels.

The mix of rank and origin of coal consumed in the United States has changed substantially in the past two decades, reflecting shifts to Western low-sulfur subbituminous coal and lignite, predominantly for electricity generation. Further changes are expected in the coming years, especially due to the Clean Air Act Amendments of 1990, which will encourage switches from high-sulfur Eastern bituminous coal to low-sulfur Western subbituminous coal.

The shift in the mix of coal ranks consumed becomes apparent when production by coal rank in 1980 is compared with that in 1992, as most production was for domestic consumption.(18) In 1980, bituminous coal comprised 76 percent of the total, but by 1992 its share dropped to 65 percent. By contrast, the share for subbituminous coal rose from 18 percent in 1980 to 25 percent in 1992, while the share for lignite grew from 6 percent to 9 percent. Anthracite's share was about 1 percent in both years. Because lower rank coals have relatively high carbon dioxide emission factors, increased use of these coals caused the national average carbon dioxide emission factor to rise from 206.5 pounds per million Btu in 1980 to 207.6 pounds per million Btu in 1992.

The change in mix of coal ranks produced reflects the large sectorial and regional shifts in coal consumption that have occurred in the past two decades. The electric utility sector dominates coal consumption, and its share has grown substantially. Of total coal consumption in 1992, electric utilities accounted for 87 percent, up from 81 percent in 1980, due mostly to increases in utility coal consumption west of the Mississippi River.(19) The share held by low-rank coals in the electric utility sector increased substantially.(20) Subbituminous coal rose from 24

percent in 1980 to 31 percent in 1992, and lignite grew from 7 to 10 percent during the period. In contrast, bituminous coal fell from 69 percent in 1980 to 58 percent in 1992. The share held by anthracite (about 1 percent) did not change.

Coal used to produce coke is virtually all bituminous in rank; less than 1 percent is anthracite. Only a few States, mostly in Appalachia, supply coking coal. The coke industry, which has been declining, accounted for only 4 percent of total coal consumption in 1992, down from 9 percent in 1980.

All ranks of coal are used by the other industrial and the residential/commercial sectors.(21) The other industrial sector accounted for 8 percent of total coal consumption in 1992, slightly less than in 1980. However, the emission factor for this sector increased sizably during the period, due mainly to the rising use of low-rank coals in the West, and contributed to the increase in emission factors for the overall national average. The residential/commercial sector is a relatively minor component of coal consumption, with about 1 percent of the total in 1980 and 1992.

As with coal consumption by sector, the amount of carbon dioxide emitted from total coal combustion in a particular State--and hence the carbon dioxide emission factor for that State--depends on the mix of coal consumed by various consuming sectors in that State during a particular year. When the total energy in Btu from coal consumption by State is known (with no breakdown by coal-consuming sector), the State average emission factors can be used to estimate the total amount of carbon dioxide emissions by State.

Publication of Carbon Dioxide Emission Factors

EIA's carbon dioxide emission factors by consuming sector and State will be updated periodically to reflect changes in the mix of U.S. coal consumption. EIA plans to report these updates in the *Quarterly Coal Report*, the *State Energy Data Report*, and the annual issue of *Emissions of Greenhouse Gases in the United States*.

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[1]Coal combustion emits almost twice as much carbon dioxide per unit of energy as does the combustion of natural gas, whereas the amount from crude oil combustion falls between coal and natural gas, according to Energy Information Administration, *Emissions of Greenhouse Gases in the United States 1985-1990*, DOE/EIA-0573 (Washington, DC, September 1993), p. 16.

[2]Examples of previously published emission factors include, in pounds of carbon dioxide per million Btu, single emission factors of 205.7 in "United States Emissions of Carbon Dioxide to the Earth's Atmosphere," *Energy Systems Policy*, Vol. 14, 1990, p. 323; 210.2 in *Changing by Degrees*, U.S. Congress, Office of Technology Assessment, February 1991, p. 333; 205.6 for bituminous coal in *Greenhouse Gases, Abatement and Control*, IEA Coal Research, June 1991, p. 24; and 183.4 in *Limiting Net Greenhouse Gas Emissions in the United States (Executive Summary)*, U.S. Department of Energy, Office of Environmental Analysis, September 1991, p. 37. EIA's first reported emission factors by coal rank, published in *Electric Power Annual 1990*, DOE/EIA-0348(90) (Washington, DC, January 1992), p. 124, were as follows: anthracite, 209; bituminous coal, 209; subbituminous coal, 219; and lignite, 213.

[3]U.S. Department of Energy, Pittsburgh Energy Technology Center, "A Coal Combustion Primer," *PETC Review*, Issue 2 (Pittsburgh, PA, September 1990), p. 17.

[4]The relationships of the various heat-producing components of coal are given in Dulong's formula, which provides a method for calculating the heating value of solid fuels. Dulong's formula is as follows: Btu per pound = 14,544C + 62,028 (H - O ÷ 8) + 4,050S. C is carbon, H is hydrogen, O is oxygen, and S is sulfur, all expressed in percent by weight. The coefficients represent the approximate heating values of the respective components in Btu per pound. The term O ÷ 8 for hydrogen is a correction applied to account for the portion of hydrogen combined with oxygen to form water. For a further discussion of Dulong's formula, see Babcock and Wilcox Co., *Steam/Its Generation and Use*, 40th edition, 1992, p. 9-9.

[5]Potential carbon dioxide emissions can be calculated by use of the following formula: percent carbon ÷ Btu per pound x 36,670 = pounds (lbs) of carbon dioxide per million (10^6) Btu. Multiply pounds of carbon dioxide per million Btu by 0.123706 to get million metric tons (MMT) of carbon per quadrillion (10^{15}) Btu.

[6]Ultimate analysis refers to the determination of carbon, hydrogen, sulfur, nitrogen, oxygen, and ash. By comparison, proximate analysis determines fixed carbon, volatile matter, moisture, and ash. Fixed carbon is principally carbon, but it may contain appreciable amounts of sulfur, hydrogen, nitrogen, and oxygen. Volatile matter comprises hydrogen, carbon dioxide, carbon monoxide, and various compounds of carbon and hydrogen.

[7]Modification of the emission factors for incomplete combustion is described on page 6 of this article under "Carbon Dioxide Emission Factors by Coal-Consuming Sector and State."

[8]For details, see "Analysis of the Relationship Between the Heat and Carbon Content of U.S. Coals," prepared for the Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, by Science Applications International Corp., September 1992.

[9]Because of the unbalanced nature of the data being analyzed (i.e., unequal numbers of observations for the different levels of the classification variables), the General Linear Models procedure in the Statistical Analysis System was used to perform the analyses.

[10]The EIA Coal Analysis File did not contain data for bituminous coal in Texas, subbituminous coal in Alaska and New Mexico, or lignite in Arkansas, California, and Louisiana. The emission factor for Alaska subbituminous coal was derived from information obtained from the sole producer of coal in Alaska. The others were assigned appropriate average factors for their coal ranks, as noted in Table FE4.

[11]For the coal analyzed in the EIA Coal Analysis File, the average hydrogen content was as follows, by weight (dry basis): anthracite, 2.5 percent; bituminous coal, 5.0 percent; subbituminous coal, 4.8 percent; and lignite, 4.4 percent.

[12]For information on States that produce coal, see Energy Information Administration, *Coal Production 1992*, DOE/EIA-0118(92) (Washington, DC, October 1993), and *State Coal Profiles*, DOE/EIA-0576 (Washington, DC, January 1994).

[13]The amount of coal distributed by State of origin and State of destination is reported on Form EIA-6, "Coal Distribution Report," for consuming sectors other than electric utilities, and on Federal Energy Regulatory Commission (FERC) Form 423, "Monthly Report of Cost and Quality of Fuels for Electric Plants," for utility coal by rank. The amount and energy content of coal consumption by State and sector are detailed in Energy Information Administration, *State Energy Data Report*, DOE/EIA-0214, published annually.

[14]Acknowledgement is due Albert D. Gerard, Energy Information Administration, Office of Coal, Nuclear, Electric and Alternate Fuels, for assistance in developing Table FE5.

[15]Adjustments can be made by multiplying the factors by the estimated percentage of carbon converted to carbon dioxide. This has been estimated as 99 percent by G. Marland and A. Pippin, "United States Emissions of Carbon Dioxide to the Earth's Atmosphere by Economic Activity," *Energy Systems and Policy*, Vol. 14, (1990), p. 323. EIA's *Emissions of Greenhouse Gases in the United States 1985-1990* (DOE/EIA-0573, September 1993) also assumed 99 percent combustion for carbon emission estimates.

[16]Byproducts include coke oven gas, benzene, creosote, and other hydrocarbons. See, for example, Energy Information Administration, *Coke and Coal Chemicals in 1980*, DOE/EIA-012(80) (Washington, DC, May 1981), for production and disposition of coal chemical materials.

[17]Another source, *Greenhouse Gas Inventory Reference Manual--IPCC Draft Guideline for National Greenhouse Gas Inventories* (IPCC/OECD Joint Programme, 1993), Volume 3, part 2, 1.29, states that on average 5.91 percent of coal going to coke plants ends up as light oil and crude tar, with 75 percent of the carbon in these products remaining unoxidized for long periods.

[18]Energy Information Administration, *Coal Production 1980*, DOE/EIA-0118(80) (Washington, DC, May 1982), p. 20; and *Coal Production 1992*, DOE/EIA-0118(92) (Washington, DC, October 1993), p. 30.

[19]Energy Information Administration, *Quarterly Coal Report July-September 1993*, DOE/EIA-0121(93/3Q) (Washington, DC, February 1994), p. 77; and *Quarterly Coal Report October-December 1987*, DOE/EIA-0121 (87/4Q) (Washington, DC, May 1988), p. 46.

[20]Energy Information Administration, *Cost and Quality of Fuels for Electric Utility Plants 1992*, DOE/EIA-019(92) (Washington, DC, August 1993), and *Cost and Quality of Fuels for Electric Utility Plants 1980 Annual*, DOE/EIA-0191 (80) (Washington, DC, June 1981).

[21]Information on the rank of coal distributed to the other industrial and residential/commercial sectors from States producing more than one rank is not available. Therefore, based on available EIA data, the following coal ranks were assigned to distributions of nonutility coal from the following coal-producing States: Arkansas, bituminous; Colorado, Montana, Washington, and Wyoming, subbituminous; Texas, lignite.

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DOE/ID-10430(NC)

U.S. Hydropower Resource Assessment for North Carolina

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Contract DE-AC07-94ID13223

ABSTRACT

The U.S. Department of Energy is developing an estimate of the undeveloped hydropower potential in the United States. The Hydropower Evaluation Software (HES) is a computer model that was developed by the Idaho National Engineering Laboratory[a] for this purpose. HES measures the undeveloped hydropower resources available in the United States, using uniform criteria for measurement. The software was developed and tested using hydropower information and data provided by the Southwestern Power Administration. It is a menu-driven program that allows the personal computer user to assign environmental attributes to potential hydropower sites, calculate development suitability factors for each site based on the environmental attributes present, and generate reports based on these suitability factors. This report describes the resource assessment results for the State of North Carolina.

a. In January 1997, the name of the Idaho National Engineering Laboratory (INEL) was changed to the Idaho National Engineering and Environmental Laboratory (INEEL). INEEL will be used throughout the text of the document, except where the use of INEL is historically important.

ACKNOWLEDGMENTS

The authors thank Peggy A. M. Brookshier and John V. Flynn of the U.S. Department of Energy for their active participation and timely comments.

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U.S. Hydropower Resource Assessment for North Carolina

INTRODUCTION

In June 1989, the U.S. Department of Energy initiated the development of a National Energy Strategy to identify the energy resources available to support the expanding demand for energy in the United States. Public hearings conducted as part of the strategy development process indicated that undeveloped hydropower resources were not well defined. As a result, the Department of Energy established an interagency Hydropower Resource Assessment Team to ascertain the undeveloped hydropower potential. In connection with these efforts by the Department of Energy, the Idaho National Engineering Laboratory designed the Hydropower Evaluation Software (HES), which has been used to perform a resource assessment of the undeveloped conventional hydropower potential in over 30 states. This report presents the results of the hydropower resource assessment for the State of North Carolina. Undeveloped pumped storage hydropower potential is not included.

The HES was developed as a tool to measure undeveloped hydropower potential regionally or by state. The software is not intended to provide precise development factors for individual sites, but to provide regional or state totals. Because the software was developed as a generic measurement tool encompassing national issues, regional and state totals must be considered judiciously; various local issues may skew undeveloped hydropower potential totals. The information for the resource assessment was compiled from the Federal Energy Regulatory Commission's Hydroelectric Power Resources Assessment database and several other sources. Refer to DOE/ID-10338, the *User's Manual* (Francfort, Matthews, Rinehart 1991) for the specifics of the software and to DOE/ID-10430.1, the *Status Report* (Conner, Francfort, Rinehart 1996) for an overview of all resource assessment activities to date.

Model Development

Hydropower Evaluation Software, both a probability-factor computer model and a database, is a menu-driven program that is intended to be user-friendly. Computer screens and report-generation capabilities were developed to meet the needs of users nationwide. The software uses environmental attribute data to generate an overall project environmental suitability factor (PESF) between 0.1 and 0.9, where 0.9 indicates the highest likelihood of development and 0.1 indicates the lowest likelihood of development. The suitability factors depend on the unique environmental attributes of each potential site. They reflect the considerations that (a) environmental concerns can make a potential site unacceptable, prohibiting its development (for a suitability factor of 0.1), or (b) if there are no environmental concerns, there is no negative effect on the likelihood of site development (for a suitability factor of 0.9). A combination of attributes can result in a lower suitability factor because multiple environmental considerations would reduce the likelihood that a site may be developed to its physical potential.

Model Goal

The goal of the HES is to assemble an accurate resource database of all sites with undeveloped hydropower potential in the United States for use as a planning tool to determine the viable national hydropower potential. Undeveloped hydropower potential is not limited to the development of new sites; it also includes the development of additional hydropower-generating capacity at sites that currently have hydropower, but are not developed to their full potential. This undeveloped hydropower potential is a source of nonpolluting, renewable energy available to meet the growing power needs of the United States. The HES should help make this goal obtainable and ensure a set of uniform criteria for national assessment.

Dam Status

The effects of environmental attributes vary by dam status. The dam status classifications used are as follows:

W = Developed hydropower site with current power generation, but the total hydropower potential has not been fully developed. Only the undeveloped hydropower potential is discussed in this report.

W/O = Developed site without current power generation. The site has some type of developed impoundment or diversion structure, but no developed hydropower generating capability.

U = Undeveloped site. The site does not have power generation capability nor a developed impoundment or diversion structure.

ASSESSMENT RESULTS

Summary Results

A total of 93 sites (Table 1) have been identified and assessed for their undeveloped hydropower potential. The HES results for individual site capacities range from 1 kilowatt (kW) to 76 megawatts (MW). The majority, or 77%, of the HES-modeled sites in North Carolina are less than 5 MW each (Figure 1).

The nonmodeled undeveloped hydropower potential total for North Carolina was identified as 1,458 MW. The HES results lowers this estimate about 65% to 508 MW. The greatest reduction in undeveloped hydropower potential, by MW, occurs at sites with no current power generation capability nor impoundment or diversion structure in place (undeveloped category [U]). These sites have an HES-modeled undeveloped hydropower potential of 125 MW, an 85% or 723-MW reduction in the estimated undeveloped hydropower potential (Figure 2). Figure 3 correlates the number of sites that have undeveloped hydropower potential with the total megawatts of HES-modeled undeveloped hydropower potential.

The 93 identified sites are located within eight major river basins. The number of sites per river basin ranges from 1 in the Kanawha River Basin to 30 in the Cape Fear River Basin (Figure 4). The Yadkin-Pee Dee River Basin has the most undeveloped hydropower potential (233 MW) of the North Carolina river basins. Forty-six percent of the HES-modeled undeveloped hydropower potential in the State of North Carolina is contained within the Yadkin-Pee Dee River Basin (Figure 5).

Table 1. Undeveloped hydropower potential summary for North Carolina. The table contains the nonmodeled undeveloped nameplate potential and the HES-modeled undeveloped potential totals.

	Number of projects	Nameplate potential (MW)	HES-modeled potential (MW)
With Power	6	16.2	14.3
W/O Power	57	594.2	369.0
Undeveloped	30	847.9	124.5
State Total	93	1,458.3	507.8

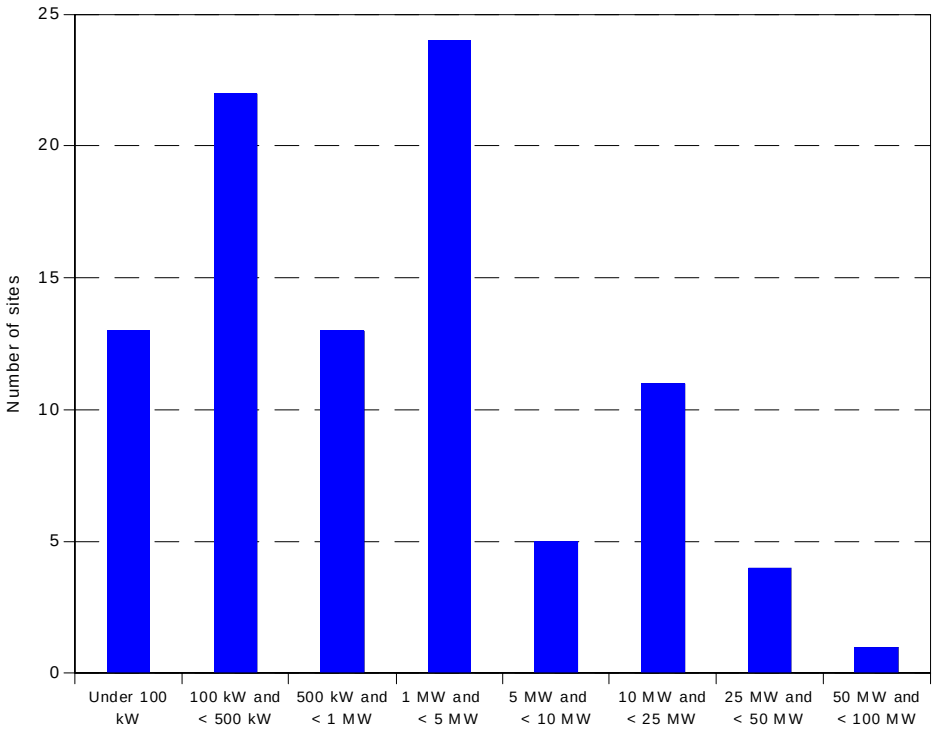

Figure 1. Number of sites, by capacity groups, with HES-modeled undeveloped hydropower potential.

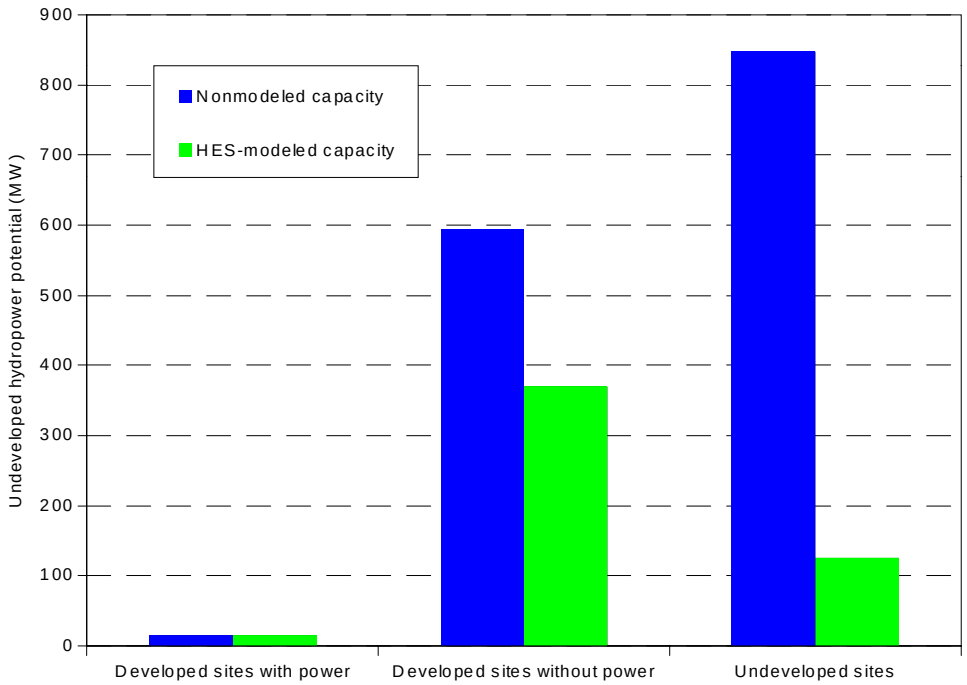

Figure 2. The nonmodeled and HES-modeled undeveloped hydropower potential.

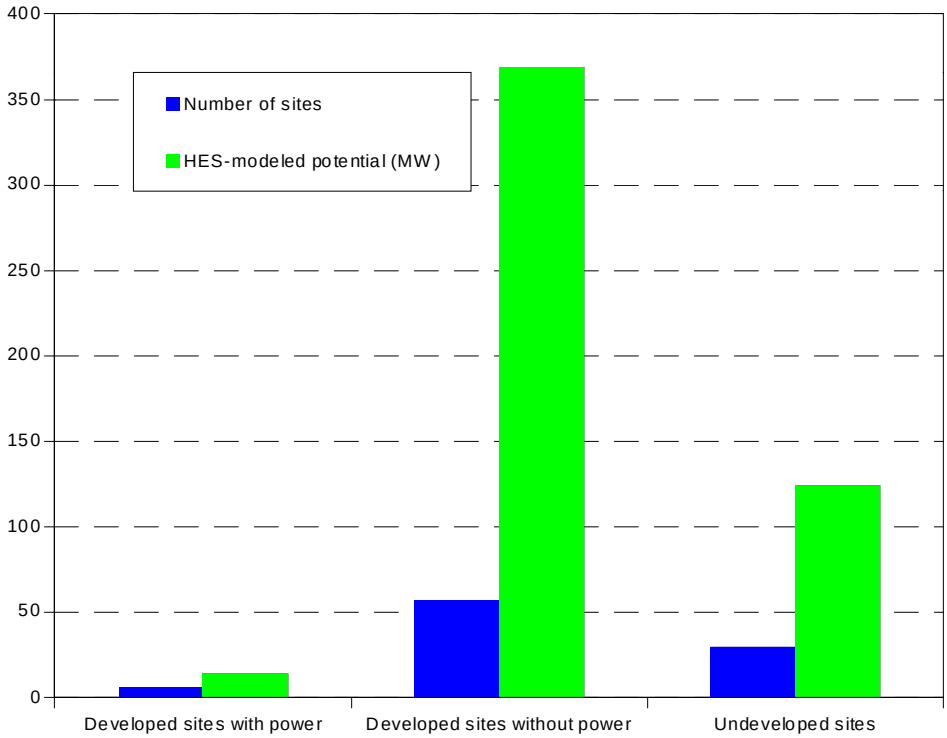

Figure 3. The number of sites with undeveloped hydropower potential and the total megawatts of HES-modeled undeveloped hydropower potential.

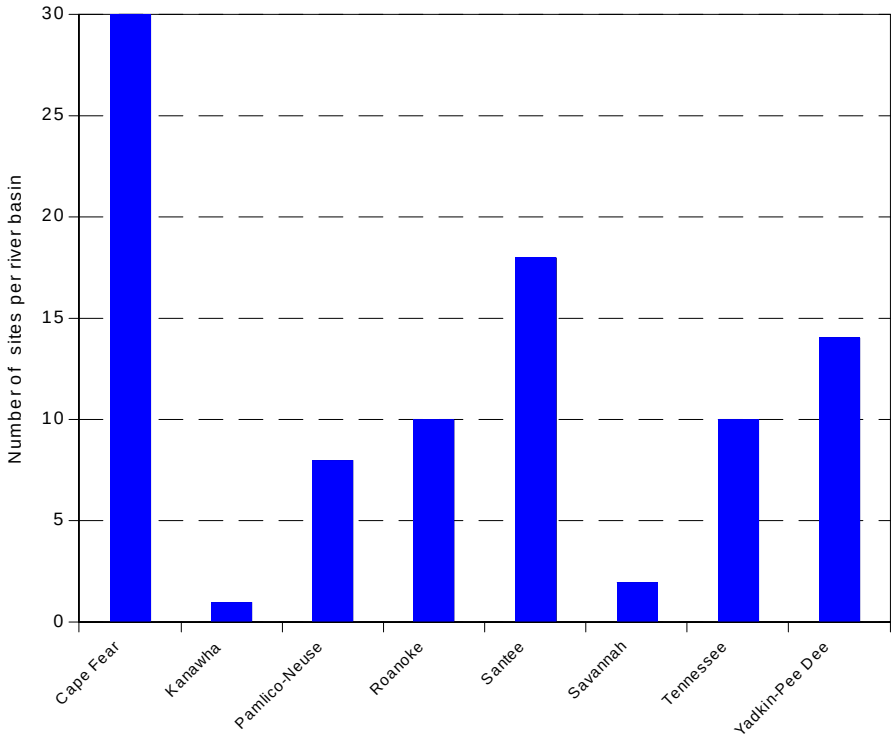

Figure 4. Number of sites with undeveloped hydropower potential in the North Carolina river basins.

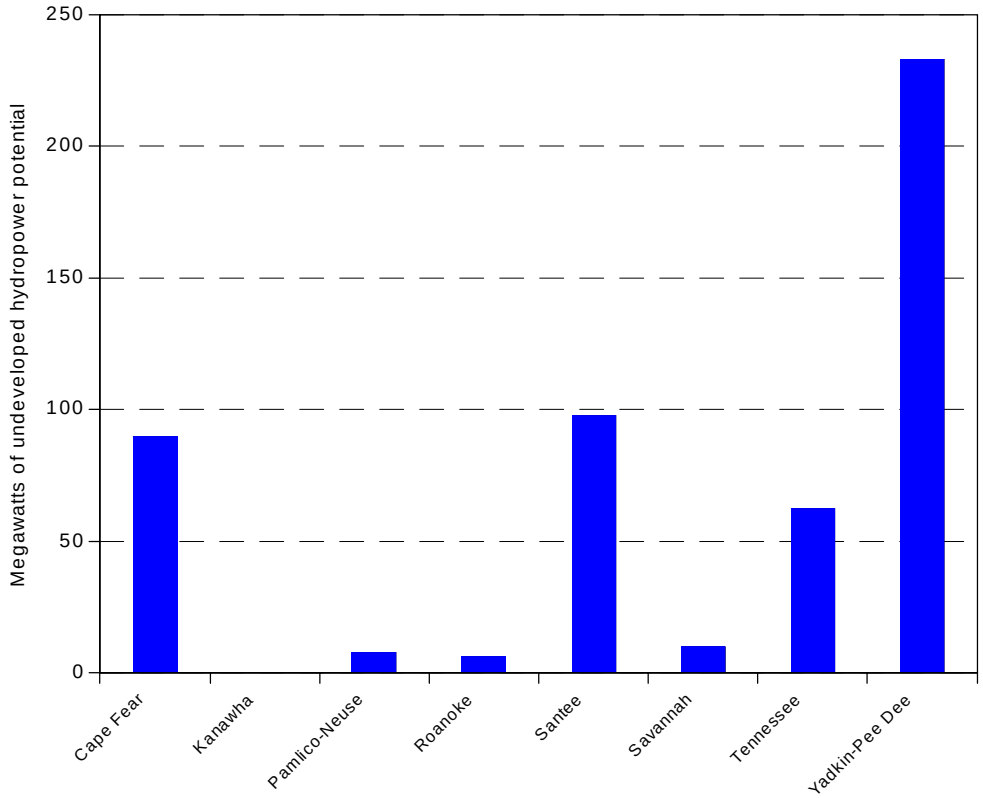

Figure 5. Megawatts of HES-modeled undeveloped hydropower potential in the North Carolina river basins.

Detailed Results

The appendices contain, in the form of HES-generated reports, detailed information about the undeveloped hydropower potential in North Carolina. The appendices contain the following information:

Appendix A summarizes the undeveloped hydropower potential by dam status groups. The number of sites, nonmodeled undeveloped hydropower potential, and HES-modeled undeveloped hydropower potential is provided based on the dam status.

Appendix B provides the hydropower resource assessment by river basin, which includes the project number, project name, stream name, dam status, nonmodeled undeveloped hydropower potential, and the HES-modeled undeveloped hydropower potential for each site. Subtotals are provided for each river basin.

Appendix C lists the project numbers, plant name, stream name, if a site is Federally owned, nonmodeled undeveloped hydropower potential, and HES-modeled undeveloped hydropower potential. The sites are grouped by dam status.

Appendix D contains a resource database list for the 93 sites in North Carolina. Information includes plant name, stream, state, county, river basin and owner names, project number, nameplate and HES-modeled undeveloped hydropower potential, the unit and plant types, dam status, latitude, longitude, and the environmental factors that the HES uses to determine the PESF.

OBTAINING INDIVIDUAL STATE INFORMATION

Additional copies of the hydropower resource assessment results for individual states are available and can be obtained by writing or calling the authors or the National Technical Information Service (NTIS).

Telephone Orders (703) 487-4650. NTIS sales desk and customer services are available between 8:30 a.m. and 5:00 p.m., Eastern Standard Time.

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ADDITIONAL HYDROPOWER EVALUATION SOFTWARE INFORMATION

Additional information concerning the HES can be obtained by contacting Ben Rinehart or Jim Francfort at the addresses provided below. Copies of the software and the User's Manual may also be obtained from these individuals.

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Conner, A. M., J. E. Francfort, and B. N. Rinehart, 1996, *Uniform Criteria for U.S. Hydropower Resource Assessment, Hydropower Evaluation Software Status Report-II*, DOE/ID 10430.1, Idaho National Engineering Laboratory, Idaho Falls, Idaho.

Francfort, J. E., S. D. Matthews, and B. N. Rinehart, 1991, *Hydropower Evaluation Software User's Manual*, DOE/ID-10338, Idaho National Engineering Laboratory, Idaho Falls, Idaho.

INTEGRATED WASTE SERVICES ASSOCIATION

Fact Sheet

Waste-to-Energy and the Production Tax Credit:

A tax credit for new, waste-to-energy facilities or new generating units at existing facilities continues the federal government's policy to encourage clean, renewable electricity, and promotes energy diversity while helping cities meet the challenge of trash disposal. Here is why the tax credit deserves your support.

- Waste-to-energy facilities produce electricity "with less environmental impact than almost any other source of electricity," according to the U.S. Environmental Protection Agency. The "outstanding performance" of waste-to-energy enables America "to continue to rely on municipal solid waste as a clean, reliable, renewable source of energy."

- Waste-to-energy facilities generate electricity and steam using municipal solid waste (garbage) as fuel. The garbage burns in specially designed boilers to ensure complete combustion, and facilities employ the most modern pollution control equipment available to scrub emissions. The result is clean, renewable energy.

- Nationwide, 89 waste-to-energy plants supply about 2700 megawatts of electricity to the grid. Plants operate 365-days-a-year, 24-hours a day. Facilities average greater than 90% availability of installed capacity. Waste-to-energy plants generally operate in or near an urban area, easing transmission to the customer.

- Facility revenues come from fees paid to dispose of the garbage and the price paid for electricity generated by waste-to-energy plants. New facilities or new generating units built at existing facilities require significant capital investment. The capital, and the operation and maintenance (O&M) costs at a facility equal about $100 for each ton of garbage processed at a facility. On an energy revenue basis, about 20 cents per kWh would be required for capital and O&M. For example, a facility that processes 2000 tons of trash each day into 60 MW of electricity would require about $200,000 in revenues daily, coming from either disposal fees or electricity revenues, or both.

- Waste-to-energy power must be sold as "base load" electricity and cannot be operated to supply "peak load" power simply because there is a constant need for trash disposal by combustion that keeps power generation steady and reliable.

- Similar to other alternative energy sources, waste-to-energy plants are qualified facilities (QFs) eligible under PURPA for mandatory power purchase at avoided cost. Most existing facilities have been financed based, in part, on long-term PURPA contracts that run commensurate with the facility debt.

- The biomass content of waste-to-energy's fuel, municipal solid waste, is about 75% on a Btu-output basis.

- The market price and disposal fee will, on average, not be sufficient to cover the cost of a new waste-to-energy unit. A tax credit is needed to encourage this form of clean, renewable electricity.

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Shearon Harris: Carolina's Best Bassin'

April means warmer water, submerged primrose, shallow bass and full livewells at Shearon Harris. Get in on the action now! (April 2007)

By Dan Kibler

Photo by Ron Sinfelt

The aquatic grass that gets the most credit for helping turn Shearon Harris Lake into a crackerjack bass-fishing lake is hydrilla.

However, the aquatic grass that will have the biggest impact on anglers' success this month is a viney, leafy mess called "primrose" that grows along the bank.

And to top it off, most of the primrose won't even be alive -- but it still attracts a great many big bass that are staging before the spawn.

"April is a good month; the best fishing really gets started in late February and March, but in April, they're going to be looking to spawn, and by the end of the month, they'll be in full spawn," said guide Phil Cable of Holly Springs.

"It's typically a shallow bite, and there are not many times when fishermen can throw just about anything they want to and catch fish. There aren't a lot of stumps; it's pretty much the old vine.

"The primrose will be greening up, but you can fish through it. They'll stage on the outside edge of the old vines, but they can be anywhere up underneath it."

Cable, whose Web Site is at PhilCableGuideService.com, said that fishing the primrose is one of two main patterns he likes to run in April on Shearon Harris. He's still partial to working a deep-diving crankbait on drops in the 8- to 10-foot range, looking for those pre-spawn fish that have not moved into the shallows. Harris is a bit of an unusual lake in that there aren't too many true "transition" sections -- a bass can go from 10 feet deep to 4 feet deep in a single move toward the shallows.

"Years ago, the early spring was when I was throwing a deep-diving crankbait and catching so many fish," said Cable, who once used a crankbait to win a spring team tournament on Harris with 10 bass that pushed the 60-pound mark -- not long before Dennis Reedy of Sanford and his partner won another tournament with a gargantuan 10-fish, 72-pound catch. "It's good to take a look for some of those fish; I wouldn't discount that bite. I look for it when I go, regardless of how good the shallow bite is. But I'm not in real deep water -- more like 8 to 10 feet."

Cable's favorite deep-diving plugs are Poe's Series 300 and 400 in the popular "homer" color -- chartreuse with a green back. But he's not nearly as likely to be filling out a big limit of bass these days with a lure that dives too deeply. Most of the time, he's probing water no deeper than 4 or 5 feet -- and often, much shallower. He fishes a spinnerbait in the vines and a shallow-running crankbait, lipless crankbait, jerkbait or Senko-type bait along the outside edges.

"I like to fish a Berkley Gulp Sinking Minnow in and around those old primrose vines, and a spinnerbait will also work real good," Cable said. "You can still fish a spinnerbait through and around the primrose. I just work it through the vines. I let it get down in there -- I don't work it on the surface. At that time of the year, all you'll have there are the (plant) stalks anyway."

Shearon Harris: Carolina's Best Bassin'

Cable favors a 1/2-ounce or larger Zone spinnerbait with tandem willow-leaf blades in sizes 4 and 4 1/2.

"A shallow-running crankbait is good, and a Rat-L-Trap-type bait, and there will probably be a decent jerkbait bite along with those," he said. "You can throw a lot of things. I throw a Lucky Craft Pointer 78 in natural colors, in golds and shads. I'll position my boat right up almost to the edge of the grass and cast parallel."

Cable said that the primrose will just be starting to leaf out in April; the vines will be spread out enough that it's not difficult to cast a spinnerbait back into the vines and get a good retrieve.

"You can fish through the primrose in April -- a month later, it will be too thick and you'll have to fish the edges; but in April, it be will be right through those old vines. And it's not a bad time to fish a frog, either."

Cable said that the primrose will rarely grow out in water that isn't shallow. Typically, he said, the primrose will start growing just off the bank and grow out to about 5 to 6 feet deep. When the hydrilla comes alive in the summer, it takes over in deeper water.

"Bass will stage on the outside edges of the primrose, but they can be all through it," he said. "There are enough vines that they can lie in there among them for protection, and they give them a good ambush spot -- but you can still fish a spinnerbait through the vines.

"When I'm fishing a Gulp minnow, I'll usually fish out in front of the grass with it. I will throw it in the primrose, but most of the time, I work it along the edge, casting parallel. I do like to work it on clear banks, too. The primrose isn't everywhere; it's in a lot of the pockets on the main creeks, but you can fish bare banks."

Cable said that Harris is small enough that fish don't stage at different times in different areas of the lake. He has seen many a spring in one area of the lake where the bite started earlier and was strong all spring, while other areas lagged.

"There have been springs where one end of the lake is better than the other -- but it's not always the same area every spring," he said. "I don't think it has to do with the water temperature -- there are just some areas that turn on earlier.

"What you'll find are stretches of bank that are real good. You can't go to any bank and expect to catch fish, but if you find a stretch of bank that's holding fish -- if you catch several fish on several hundred yards of a bank -- that bank will be good the whole spring."

Cable said that Shearon Harris is so full of bass that fish almost have to move shallow and spawn in different stages, even in the same area. Once a group of fish moves up, a second group will take its place out on the end of the flat in that 8- to 10-foot range. Then a group of fish will spawn, the deeper fish will move to the edges of the primrose, and another group of fish will pull up on the deep flats.

North Carolina GAME&FISH

Shearon Harris: Carolina's Best Bassin'

"They don't spawn all at once -- there will be fish caught over a period of several weeks," Cable said.

"You go to main-lake pockets, short pockets back off the creeks. You'll see (beds) where the primrose hasn't grown in solid, and you'll see them right up against the bank where there isn't any primrose."

Just about all of the lake's creeks can produce some very nice fish. Cable likes to fish Tomjack, White Oak and Buckhorn creeks and Cary Branch.

Harris has received quite a bit of attention -- and fishing pressure -- over the past 15 years, in part because of some of the enormous catches of bass. The N.C. Wildlife Resources Commission several years ago removed Harris from the list of reservoirs managed with a 14-inch size minimum. Biologists recommended, and the commission voted for, a 16- to 20-inch slot limit. Fishermen cannot creel or remove fish from the lake that measure between 16 and 20 inches long.

The aim was to identify Harris as a trophy fishery and hope that fishermen would understand that catch and release of

mature largemouths would have nothing if not a positive effect on the fishery.

"The slot has done a lot for this lake -- guys can't haul them off," Cable said. "You can catch a 5-pound fish that isn't 20 inches long.

"You see a lot of fish between 16 and 20 inches. I believe the biologists say that that's the best size range for spawning -- those 3- and 4- and 5-pound fish," he said. "And the best thing is, people have to put most of those fish back.

"The last couple of years, I've started to see a lot of fish in that range, and you can still catch big fish. You go to a comparable lake, and you'll have guys catching a lot of 1- and 2-pound fish. At Harris, those same fish are 3s, 4s and 5s."

Cable said that despite many local tournament circuits and bass clubs avoiding Harris because of the slot limit, fishing pressure is still pretty tough on the reservoir. "It's so much smaller than Jordan or Falls (of Neuse), and it comes with a huge amount of pressure," he said. "But the fishing is still great. You can really have some big days on Harris."

Find this article at:
http://www.ncgameandfish.com/fishing/bass-fishing/NC_0407_01

☐ Check the box to include the list of links referenced in the article.

WHO ARE THE LUMBEE?

The 40,000+ members of the Lumbee Tribe of North Carolina reside primarily in Robeson, Hoke,Cumberland and Scotland counties. The Lumbee Tribe is the largest tribe in North Carolina, the largest tribe east of the Mississippi River and the ninth largest in the nation. The Lumbee take their name from the Lumbee River which winds its way through Robeson County. Pembroke, North Carolina is the economic, cultural and political center of the tribe.

The ancestors of the Lumbee were mainly Cheraw and related Siouan-speaking Indians who have lived in the area of what is now Robeson County since the 1700s. The Lumbee people have been recognized by the state of North Carolina since 1885, and at the same time established a separate school system that would benefit tribal members. In 1887, the state established the Croatan Normal Indian School, which is today The University of North Carolina at Pembroke. In 1956 a bill was passed by the United States Congress which recognized the Lumbee as Indian, but denied the tribe full status as a federally recognized Indian tribe. Federal recognition for the tribe is currently being sought through federal legislation. For more information regarding Lumbee Federal Recognition, click here.

FINDING OF NO SIGNIFICANT IMPACT
AND ENVIRONMENTAL ASSESSMENT

TOWN OF HOLLY SPRINGS

EXPANSION OF THE UTLEY CREEK WASTEWATER TREATMENT PLANT

RESPONSIBLE AGENCY: NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

CONTACT: JOHN R. BLOWE, P.E., CHIEF
CONSTRUCTION GRANTS AND LOANS SECTION
DIVISION OF WATER QUALITY
1633 MAIL SERVICE CENTER
RALEIGH, NORTH CAROLINA 27699-1633
(919) 715-6212

February 16, 2007

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FINDING OF NO SIGNIFICANT IMPACT (FNSI)

Article I, Chapter 113A of the North Carolina General Statutes requires an action to be subject to the requirements of the North Carolina Environmental Policy Act (NCEPA) if it involves the expenditure of public funds and a potential impact is anticipated to the environment. The project has been evaluated for compliance with the NCEPA and determined to be a major agency action, which will affect the environment.

Project Applicant: Town of Holly Springs, North Carolina

Project Description: The Town of Holly Springs will expand the treatment capacity of the Utley Creek Wastewater Treatment Plant (WWTP) from 1.75 million gallons per day (MGD) to 6.0 MGD. The treatment train will be upgraded with a new headworks structure, two parallel activated sludge oxidation ditches, tertiary disc filters, and a low-high UV disinfection system.

Project Number: CS370722-02

Project Cost:	$22,371,000
State Revolving Fund Loan:	$15,000,000
Local Funding:	$ 7,371,000

The review process indicated that significant adverse environmental impacts should not occur if mitigative measures are implemented, and an environmental impact statement will not be required. The decision was based on information in the 201 Facilities Plan Amendment and reviews by governmental agencies. An environmental assessment supporting this action is attached. This FNSI completes the environmental review record, which is available for inspection at the State Clearinghouse.

No administrative action will be taken on the proposed project for at least thirty days after notification that the FNSI has been published in the North Carolina Environmental Bulletin.

Sincerely,

Alan W. Klimek, P.E., Director
Division of Water Quality

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ENVIRONMENTAL ASSESSMENT

A. Proposed Facilities and Actions

Figure 1 shows the location of the proposed upgrade and expansion of the Utley Creek WWTP.

Wastewater Treatment Facilities. The Town of Holly Springs proposes to upgrade and expand the current Utley Creek WWTP from 1.75 million gallons per day (MGD) to a capacity of 6.0 MGD. The expanded and upgraded WWTP will produce reuse quality effluent. The existing NPDES permit for the Utley Creek WWTP limits the discharge capacity to 2.4 MGD. However, the Town has elected to upgrade and expand the facility to be capable of treating 6.0 MGD. The proposed facilities improvements include abandoning the existing headworks and constructing new headworks consisting of a Parshall flume, two mechanical bar screens, one manually cleaned bar screen, two grit removal units, and an influent pump station that will also pump return activated sludge; modifying the existing 1.2 MG oxidation ditch and constructing two new 2.4 MG oxidation ditches to obtain a five-stage biological nutrient removal with a 6.0 MGD total capacity; constructing three new clarifiers; converting the existing clarifier and an existing 0.5 MGD extended aeration system for sludge treatment; replacing the existing traveling bridge effluent filters with disc filters; replacing the existing low-pressure/low-intensity ultraviolet disinfection system with a new low-pressure/high-intensity ultraviolet disinfection system; and replacing the existing aerobic digestion and liquid land application sludge disposal system with a solids reduction process, which consists of aerobic digestion, solids reduction, and disposal by landfill and land application of Class B sludge.

The *October 2005 Cape Fear River Basinwide Water Quality Plan* continues to recommend that the Town of Holly Springs remove its effluent discharge from Utley Creek, and the Division of Water Quality (DWQ) concurs with the need to eliminate this discharge. In a letter from the Town to the Deputy Director of the DWQ (Exhibit 1), the Town has committed to sending its treated effluent to the Western Wake Water Reclamation Facility (WWWRF) for discharge into the Cape Fear River below Buckhorn Dam when the WWWRF becomes operational. Any Authorizations to Construct or other necessary permits (orders, etc.) for expansion of the Utley Creek WWTP will include a condition stating that the treated effluent must be removed from Utley Creek by the date established in the *Certificate Authorizing the Towns of Cary, Apex, and Morrisville and Wake County to Increase Their Transfer of Water from the Haw River basin to the Neuse River basin under the Provisions of G.S. 143-215.221*.

B. Existing Environment

Topography and Soils. The Town of Holly Springs lies in the Piedmont physiographic province of North Carolina. The project service area lies within three major geologic regions: the Durham-Sanford Triassic Basin in the northwest, the Raleigh Belt in the northeast, and the Sandhills in the south. Elevations at the Utley Creek WWTP ranges from 305 to 360 feet. Predominant soils in the project area are the Mayodan-Granville-Creedmoor and Creedmoor-White Store associations. The Mayodan-Granville-Creedmoor association is a soil that is derived from sandstone, shale, and mudstone that is gently sloping to moderately steep, deep or moderately deep, well-drained and moderately well-drained soils that have a subsoil of friable sandy clay loam to firm clay. The Creedmoor-White Store association is a group of soils that are

also derived from sandstone, shale and mudstone that are gently sloping to hilly, deep and moderately deep, that are well drained and that have a very firm, clayey subsoil.

Surface Water. This project is located within the Cape Fear River Basin. Utley Creek forms the southern boundary of the WWTP site and varies in width from 10 to 20 feet. There is an unnamed stream which ranges in breadth from 2 to 8 feet that flows from north to south across to the WWTP site. The subbasin of Utley Creek (03-06-07) into which the WWTP discharges is classified as a Class C surface water and is not listed as impaired. Although this stretch of the creek is not listed as impaired, there have been numerous concerns regarding local water quality such as algal blooms and fish kills attributed to discharge from the Utley Creek facility that have led DWQ to recommend that Holly Springs ultimately remove its discharge from this water body.

Water Supply. The town of Holly Springs obtains its potable water from the city of Raleigh and Harnett County.

C. Existing Wastewater Facilities

Holly Springs' Utley Creek WWTP was constructed in the mid-1980s with a treatment capacity of 0.25 MGD and provided secondary treatment. The treatment process included a dual train rectangular package plant, each with its own bar screen, an aeration basin, and two hopper bottom clarifiers. The effluent was disinfected with chlorine prior to discharge.

In 1996, the facility increased capacity to 0.50 MGD with the addition of a circular package treatment unit that consisted of a singular circular steel tank with two aeration basins, two secondary clarifiers, and an aerobic digester. A traveling bridge-type filter and an ultraviolet disinfection system were also installed.

In 2000, an oxidation ditch and secondary clarifier were added that allowed the WWTP a total treatment capacity of 1.5 MGD. Also added at this time were an influent flume, a mechanical screen, an aerated grit removal system, an additional traveling bridge filter, and an updated low-pressure ultraviolet disinfection system. Biosolids at the WWTP are stabilized in 300,000 gallon holding tanks, and stabilization is accomplished via aerobic digestion. The town contracts with a private hauler for land application of the biosolids following the addition of lime prior to land application, per 40 CFR-Part 503 regulations. Utley Creek's collection system has been in service since 1985 and is comprised of approximately 71 miles of collection lines and 21 sewer lift stations. Most of the major force mains are made of ductile iron, and the smaller mains are made of PVC.

The NPDES permit limits for the Utley Creek WWTP are:

Parameter	Limit
Flow	2.4 MGD
BOD_5 (monthly average Summer-Winter)	5.0 mg/l and 10.0 mg/l
NH_3-N (monthly average Summer-Winter)	1.0 mg/l and 2.0 mg/l
TSS (monthly average)	30.0 mg/l
Fecal Coliform (monthly average)	200.0 Count 100 ML
Total Residual Chlorine	17 µg/L

Total Nitrogen	43,800 lbs/year
Total Phosphorus	3,653 lbs/year

D. Need for Proposed Facilities and Actions

Located in southwestern Wake County, the Town of Holly Springs has a population of approximately 15,000 persons. Currently, the Town is experiencing significant growth at a rate of over 10 percent a year and projects that the population in 2030 will be over 60,000 persons. This rate of growth strains the existing wastewater infrastructure and requires continued attention to its facilities.

In 2002, the Town, along with the Town of Cary, Town of Morrisville, Town of Apex, and Research Triangle Park (South) agreed to jointly participate in the planning for the WWWRF, which is anticipated to be operational by 2011. The WWWRF could provide an adequate, long-term solution to wastewater disposal needs for Holly Springs. However, it does not address Holly Springs' wastewater treatment in the short-term.

Due to the growth rate in Holly Springs, the need for more wastewater treatment capacity will outstrip the current capacity (1.75 MGD) of the Utley Creek WWTP by 2010 based on flow projections in the 201 Facilities Plan Amendment. The Town's 20-year flow need is 6.0 MGD. Therefore, the Town will expand the Utley Creek WWTP from the current 1.75 MGD to 6.0 MGD for use when the WWWRF eventually accepts its treated effluent. The Town will relocate the treated effluent discharge from the Utley Creek WWTP to the Cape Fear River (via the WWWRF) at such time that the regional project outfall to the Cape Fear River is available, as stated in the letter in Exhibit 1.

E. Alternatives Analysis

An alternatives analysis was performed on various ways to expand the capacity of the Town's wastewater treatment facilities. These alternatives were as follows: (1) No-Action Alternative, (2) Optimum Operation of Existing Facilities, (3) Land Application, (4) Harnett County Regional Interconnection, (5) Western Wake Regional Treatment, (6) Effluent Reuse, and (7) Utley Creek WWTP Expansion.

No-Action Alternative: This alternative would result in no improvements or expansions to the existing sewer system. Though the system is in good condition and will continue to operate, flow violations and capacity shortcomings will occur in the future as the Town's population outgrows the current capacity of the system. The No-Action Alternative was deemed infeasible because it does not provide the necessary capacity for future growth and does not eliminate the discharge to Utley Creek, which is one of the desired goals.

Optimum Operation of Existing Facilities Alternative: This alternative is essentially the same as the No-Action Alternative, as records indicate that the Utley Creek WWTP is operating efficiently. The required increase in wastewater treatment capacity cannot be met under this alternative. Furthermore, it does not eliminate the discharge into Utley Creek, which is one of the desired goals.

Land Application Alternative: Using spray irrigation as an alternative to surface water discharge was analyzed. Because the quantity of well-drained soils in the Holly Springs area is highly limited, the Town would have to purchase land outside of its jurisdiction. Furthermore, if the 5,200 acres that would eventually be needed to apply 6.0 MGD of effluent were available, the total capital cost (not including the needed WWTP expansion) for the land purchase and construction of the land application system would be a minimum of $104,000,000. Therefore, the high cost of land, limited suitability of area soils, and the cost of treatment facilities make this alternative not cost efficient.

Harnett County Regional Interconnection Alternative: Holly Springs has examined the option of a partnership with Harnett County in the Fuquay/North Harnett County Regional Project. As part of this alternative, the Town would expand the Utley Creek WWTP to the already-permitted capacity of 2.4 MGD and construct a raw wastewater transmission system to the proposed Harnett County WWTP at Lillington. This alternative would provide an interim solution until the WWWRF became operational. Substantial improvements to the Harnett County interceptor system would be required to handle the additional 3.5 MGD average flow, as would retrofits and enlargements to major pump stations and force mains in the Middle Creek watershed. Also, the Harnett County wastewater improvements have been designed and permitted with construction already underway. Therefore, this alternative was not deemed feasible due to timing and cost issues.

Western Wake Regional Treatment Alternative: When completed, the proposed WWWRF could provide Holly Springs with the additional wastewater capacity needed for continued growth. However, the WWWRF is not scheduled to be operational until 2011, and the Town will need additional capacity at the Utley Creek WWTP much sooner than that. Though full participation in the WWWRF remains a viable, long-term solution for the Town, it does not address the immediate needs of the Town and was therefore rejected as the Preferred Alternative.

Effluent Reuse Alternative: The Town would reuse the treated effluent as a way to relieve the quantity of wastewater discharged into Utley Creek. While the reuse water system will help the Town with the overall goal of reducing the volume of wastewater discharged to Utley Creek as well as annual pollutant loading of the receiving stream, its initial customer base will consist of only residential seasonal users and irrigation systems. Therefore, implementation of the Effluent Reuse Alternative will not alleviate the need for the WWTP expansion and increased NPDES discharge. It is not a viable alternative and remains a separate, independent project.

Utley Creek WWTP Expansion Alternative: Under this alternative, the Utley Creek WWTP would expand its capacity from 1.75 MGD to 6.0 MGD for use when the WWWRF eventually accepts its treated effluent. Expanding the existing facilities would occur on the existing plant site and disturb approximately nine acres. This alternative is the Preferred Alternative because it addresses the short-term wastewater treatment needs of Holly Springs in the most timely, cost-efficient manner.

F. Environmental Consequences and Mitigative Measures

Topography and Soils: The Utley Creek WWTP upgrade and expansion will occur entirely on the existing WWTP site and will not impact the topography of the site. The upgrade and expansion of the WWTP may impact portions of the 100-year floodplain. Sediment and erosion

control practices will be compliant with the *North Carolina Sedimentation and Erosion Control Planning and Design Manual*.

Land Use: The expansion and upgrade of the Utley Creek WWTP will not impact current or future land use patterns.

Wetlands: The project will affect a small perennial stream that has a length of 806 feet on the WWTP site. The stream will be rerouted to allow for the placement of facilities involved in the expansion and upgrade. This stream will be filled in, and the natural drainage will be redirected by a 60-inch storm drain that will relocate this tributary to Utley Creek. The U.S. Army Corps of Engineers (USACOE) will require a Section 404/401 Individual Permit (Action ID #200420744). The Town of Holly Springs has entered into an agreement with the North Carolina Department of Environment and Natural Resources Ecosystem Enhancement Program (EEP). The EEP will mitigate the stream impacts related to this project.

Important Farmlands: No prime or unique agricultural lands exist within the project area.

Public Lands, and Scenic, Recreational, and State Natural Areas: No public lands or scenic, recreational, or state natural areas will be impacted by the upgrade and expansion of the Utley Creek WWTP.

Cultural Resources: In a letter dated October 6, 2005, the North Carolina State Historic Preservation Office (SHPO) stated that no historic resources would be impacted by the proposed project (Project No. ER 05-2065).

Air Quality: The operation of the upgraded and expanded WWTP will not adversely impact air quality. However, there will be short-term construction impacts associated with dust and minor burning during site clearing. Construction will comply with local burning ordinances as well as dust control measures as prescribed in the *North Carolina Sedimentation and Erosion Control Planning and Design Manual*.

Noise Levels: Construction activities will temporarily increase noise levels, which should return to normal once construction is complete. The operation of heavy construction equipment will be limited to the hours specified in the Town's Noise Ordinance and other standards. Mufflers on all equipment will be checked to ensure that the noise generated is not excessive.

Water Resources: Groundwater resources will not be impacted due to the upgrade and expansion of the Utley Creek WWTP. According to modeling done by Tetra Tech, Inc., operation of the upgraded and expanded Utley Creek WWTP will not negatively impact water quality within Utley Creek in the interim before shifting its treated effluent to the WWWRF. Based on the recommendations made in the North Carolina Department of Environment and Natural Resources Division of Water Quality's *October 2005 Cape Fear Basinwide Water Quality Plan*, it is recommended that Holly Springs shift its wastewater discharge from Utley Creek to the WWWRF when it becomes operational, which will improve water quality. During construction, degradation of water quality will be minimized by the Section 404/401 permit, Sedimentation and Erosion Control permits, and local ordinances.

Forest Resources: The upgrade and expansion of the Utley Creek WWTP will impact 8.5 acres of pine/hardwood forest and 0.45 acre of scrub utility right-of-way. The North Carolina Department of Forest Resources did not comment on the project.

Shellfish or Fish and Their Habitat: The construction and operation of the Utley Creek WWTP expansion and upgrade will not impact shellfish or fish and their habitat. The eventual shifting of the effluent from the WWTP to the WWWRF will improve the habitat of fish and shellfish.

Wildlife and Natural Vegetation: No protected species, neither flora nor fauna, are expected to be impacted by the proposed upgrade and expansion of the Utley Creek WWTP.

Introduction of Toxic Substances: As part of the construction process, substances such as fuels, lubricants, antifreeze, etc. will be used and may be introduced into the environment through spillage or other events. All construction activity will be performed in accordance with Federal, State, and local rules and regulations to avoid environmental impacts.

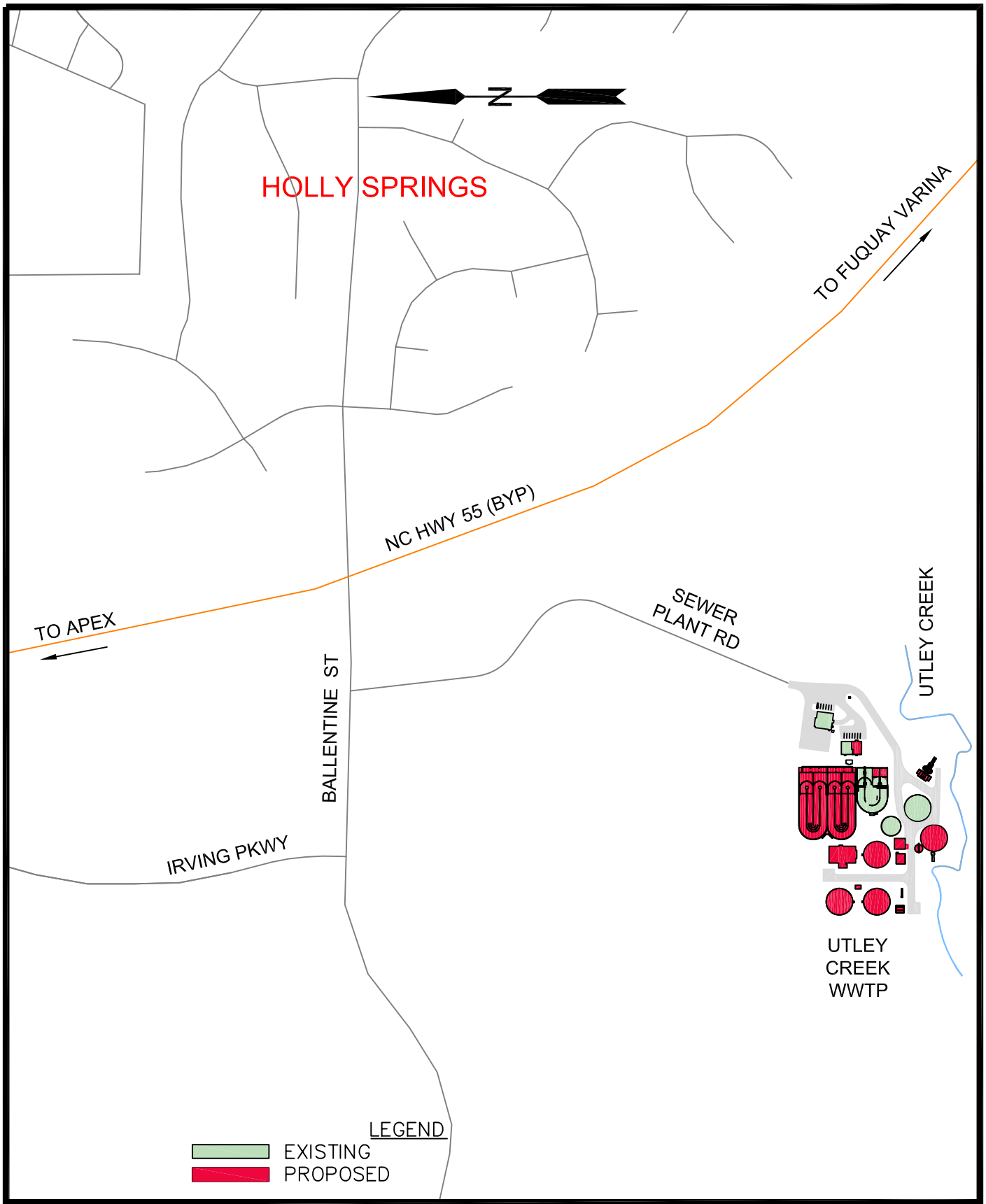
The U.S. Fish and Wildlife Service reviewed the proposed project and concluded that the requirements of Section 7(a)(2) of the Endangered Species Act have been fulfilled. The North Carolina Wildlife Resources Commission, the DWQ Raleigh Regional Office, the Division of Environmental Health, and the NPDES and PERCS Units concur with the proposed project. The North Carolina Department of Cultural Resources is not aware of any properties of architectural, historical, or archaeological significance that would be affected by the project. Other state agencies did not submit objections to this project

G. Public Participation, Sources Consulted

A public hearing was held on January 17, 2006 on the proposed project. The current user charge for in-town users for 5,000 gallons per month is $48.00. The proposed project will result in an increased charge of $7.85 for a total of $55.85 for 5,000 gallons per month for the typical user. No opposition to the plan was presented at the public hearing.

Sources consulted about this project for information or concurrence included:

1) The Town of Holly Springs
2) North Carolina Department of Environment and Natural Resources
   -Wildlife Resources Commission
   -DWQ Raleigh Regional Office – Surface Water Protection Section
   -NPDES Units
   -PERCs Unit
   -Legislative and Intergovernmental Affairs
3) North Carolina Department of Cultural Resources
4) North Carolina State Clearinghouse
5) U.S. Fish and Wildlife Service
6) U.S. Army Corps of Engineers



THE TOWN OF Holly Springs NORTH CAROLINA

FIGURE 1
PROPOSED UTLEY CREEK WWTP

1" = 500 FT

DRAWING NAME: P:\PROJECT\HollySprings\E3464\201 EXHIBIT\WWTP-SP FIGURES.dwg - Fig 1 Feb 09, 2007 - 2:34pm

Exhibit 1

THE TOWN OF
Holly
Springs

February 6, 2007

Ms. Colleen Sullins, Deputy Director
NCDENR
1617 Mail Service Center
Raleigh, NC 27699-1617

REF: Holly Springs Utley Creek Wastewater Treatment Expansion
TOHS Project # 04-003

Dear Ms. Sullins:

As follow up to my conversation with Melba McGee last Friday, and at your request, please accept this letter as confirmation from the Town of Holly Springs that we will relocate the treated effluent discharge from the Utley Creek Wastewater Treatment Plant to the Cape Fear River (via the Western Wake Regional Project) at such time that the regional project outfall to the Cape Fear River is available.

Please feel free to contact me at 919-557-3902 if you should have any questions or need further information form us. We greatly appreciate your assistance with this matter.

Sincerely,

Carl G. Dean
Town Manager

cc: Stephanie L. Sudano, P.E., Director of Engineering
Mayor & Town Council Members
Leo Green P.E., Green Engineering
Ed Powell P.E., Davis, Martin & Powell
Correspondence 12871

CGD/SLS/jcb

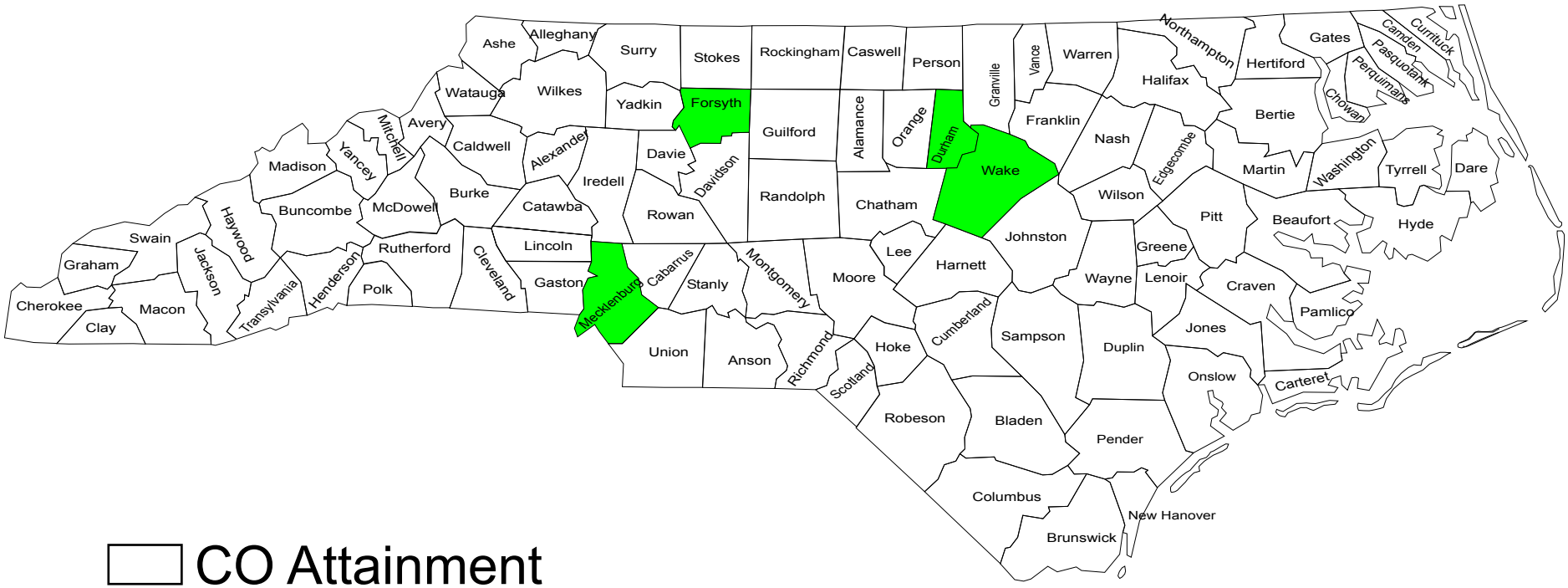
P.O. Box 8
128 S. Main Street
Holly Springs, N.C. 27540
www.hollyspringsnc.us

(919) 552-6221

Fax: (919) 552-5569

Mayor's Office Fax:
(919) 552-0654

North Carolina CO Maintenance Areas



CO Attainment

Maintenance

Forsyth County was Redesignated Nov, 1994

Redesignation was projected Sept. 18, 1995 for Mecklenburg, Durham and Wake Counties

Note: Not to Scale
April 6, 2004

North Carolina Department of Environment and Natural Resources

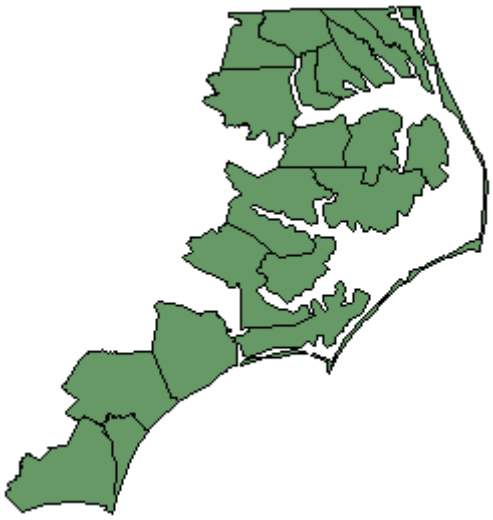
Division of Coastal Management

CAMA Counties

The following counties are subject to the rules and policies of the Coastal Resources Commission, which administers the Coastal Area Management Act. If you are planning to develop in one of these counties, check to see whether your project is also in an Area of Environmental Concern. If it is, you may need a CAMA permit.

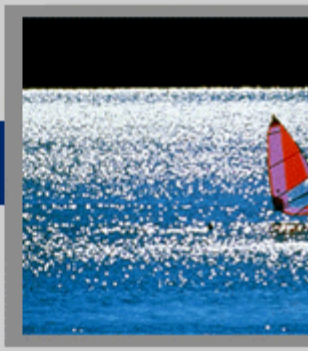
CAMA Counties

Beaufort	Hertford
Bertie	Hyde
Brunswick	New Hanover
Camden	Onslow
Carteret	Pamlico
Chowan	Pasquotank
Craven	Pender
Currituck	Perquimans
Dare	Tyrrell
Gates	Washington



Last Modified: May 02, 2002

NCDENR . Division of Coastal Management . 1638 Mail Service Center . Raleigh, NC 27699-1638 . 919-733-2293 . 1-888-4RCOAST . E-mail Us



280 State Park Road, Apex, NC 27523
(919) 362-0586
jordan.lake@ncmail.net

Ecological information

Jordan Lake State Recreation Area is one of the largest summertime homes of the bald eagle, the symbol of the United States for more than 200 years. The population of eagles in the Jordan Lake area has increased dramatically since the flooding of the reservoir in 1983.

Vast, undisturbed areas provide the perfect home for the bald eagle; there's plenty of fish to eat and a mature forest for roosting. Although protection efforts have increased the numbers of this mighty bird, it still remains a rare species. Interpretive programs about the bald eagle are conducted throughout the year at Jordan Lake, usually during warm-weather months. Join one of our programs or bird watch on your own.

The eagles congregate at the north end of the lake and can be seen best from either the NC 751 bridge crossing Northeast Creek or the Wildlife Resources Commission's Wildlife Observation Deck. The observation deck is located five miles south of I-40 on NC 751, 6.5 miles north of US 64.

Characteristics of the 100 Largest Public Elementary and Secondary School Districts in the United States: 2000-2001

TOC Discussion Tables and Figures Methodology References & Related Data Appendices

Rankings: 1-70 71-140 141-210 211-280 281-350 351-420 421-490 491-500

Appendix A.-The 500 largest public school districts in the United States and jurisdictions: School year 2000-01: 1-70

Rank	Students	Agency name	Mailing address	City	ST	ZIP	Schools	Telephone
1	1,066,516	New York City Public Schools	110 Livingston St	Brooklyn	NY	11201	1,213	718-935-2794
2	721,346	Los Angeles Unified	450 N Grand Ave	Los Angeles	CA	90012	659	323-625-6251
3	612,725	Puerto Rico Department of Educ	PO Box 190759	San Juan	PR	00919	1,543	787-759-2000
4	435,261	City of Chicago School Dist 29	125 S Clark	Chicago	IL	60603	602	773-553-1000
5	368,625	Dade County School District	1450 NE 2nd Ave, #912	Miami	FL	33132	356	305-995-1428
6	251,129	Broward County School District	600 SE 3rd Ave	Fort Lauderdale	FL	33301	243	954-765-6271
7	231,655	Clark County School District	2832 E Flamingo	Las Vegas	NV	89121	259	702-799-5310
8	208,462	Houston ISD	3830 Richmond Ave	Houston	TX	77027	289	713-892-6000
9	201,190	Philadelphia City SD	Parkway at 21st St	Philadelphia	PA	19103	261	215-299-7000
10	184,360	Hawaii Department of Education	PO Box 2360	Honolulu	HI	96804	261	808-837-8012
11	164,311	Hillsborough County School Dis	PO Box 3408	Tampa	FL	33601	210	813-272-4050
12	162,194	Detroit City School District	5057 Woodward Ave	Detroit	MI	48202	263	313-494-1075
13	161,548	Dallas ISD	3700 Ross Ave	Dallas	TX	75204	221	972-925-3700
14	156,412	Fairfax County Public Schools	10700 Page Ave	Fairfax	VA	22030	195	703-246-2631
15	153,871	Palm Beach County School Distr	3340 Forest Hill Blvd	West Palm Beach	FL	33406	177	561-434-8200
16	150,681	Orange County School District	PO Box 271	Orlando	FL	32802	174	407-317-3202
17	141,804	San Diego City Unified	4100 Normal St	San Diego	CA	92103	180	619-293-8686
18	134,180	Montgomery County Public Schls	850 Hungerford Dr	Rockville	MD	20850	192	301-279-3383
19	133,723	Prince Georges County Pub Schs	14201 School Ln	Upper Marlboro	MD	20772	194	301-952-6008
20	125,846	Duval County School District	1701 Prudential Dr	Jacksonville	FL	32207	179	904-390-2115

21	113,730	Memphis City School District	2597 Avery Ave	Memphis	TN	38112	164	901-325-5300
22	113,027	Pinellas County School Distric	301 4th St SW	Largo	FL	33770	164	727-588-6011
23	110,075	Gwinnett County	PO Box 343	Lawrenceville	GA	30046	85	770-963-8651
24	106,898	Baltimore County Public Schls	6901 N Charles St	Towson	MD	21204	169	410-887-4281
25	103,336	Charlotte-Mecklenburg Schools	PO Box 30035	Charlotte	NC	28230	135	704-379-7000
26	99,859	Baltimore City Pub Sch System	200 E North Ave	Baltimore	MD	21202	183	410-396-8803
27	98,950	Wake County Schools	PO Box 28041	Raleigh	NC	27611	120	919-850-1600
28	97,985	Milwaukee	PO Box 2181	Milwaukee	WI	53201	206	414-475-8001
29	96,860	Jefferson Co	PO Box 34020	Louisville	KY	40232	174	502-485-3114
30	95,958	Dekalb County	3770 N Decatur Rd	Decatur	GA	30032	123	404-297-2300
31	95,781	Cobb County	514 Glover St	Marietta	GA	30061	94	770-426-3300
32	93,694	Long Beach Unified	1515 Hughes Way	Long Beach	CA	90810	89	562-997-8000
33	87,703	Jefferson County R-1	PO Box 4001	Golden	CO	80401	161	303-982-6500
34	85,276	Albuquerque Public Schools	PO Box 25704	Albuquerque	NM	87125	131	505-842-8211
35	79,661	Fort Worth ISD	100 N University Dr	Fort Worth	TX	76107	141	817-871-2000
36	79,477	Polk County School District	PO Box 391	Bartow	FL	33831	137	863-534-0521
37	79,007	Fresno Unified	Ed. Cntr., Tulare & M Sts	Fresno	CA	93721	99	559-457-3000
38	77,816	Austin ISD	1111 W 6th St	Austin	TX	78703	109	512-414-1700
39	77,610	Orleans Parish School Board	3510 General Degaulle Dr	New Orleans	LA	70114	128	504-365-8730
40	76,586	Virginia Beach City Public Sch	PO Box 6038	Virginia Beach	VA	23456	84	757-427-4326
41	75,684	Cleveland Municipal SD	1380 E 6th St	Cleveland	OH	44114	125	216-574-8000
42	74,491	Anne Arundel County Pub Schls	2644 Riva Rd	Annapolis	MD	21401	119	410-222-5304
43	73,587	Mesa Unified District	549 N Stapley Dr	Mesa	AZ	85203	86	480-472-0000
44	73,158	Jordan School District	9361 S 300 E	Sandy	UT	84070	81	801-567-8100
45	71,328	Granite School District	340 E 3545 S	Salt Lake City	UT	84115	98	801-263-6100
46	70,847	Denver County 1	900 Grant St	Denver	CO	80203	129	303-764-3200
47	70,597	Brevard County School District	2700 Judge Fran	Viera	FL	32940	108	321-631-1911
48	68,925	District of Columbia Pub Schls	825 N Capitol St, NE	Washington	DC	20003	165	202-442-5885
49	68,583	Fulton County	786 Cleveland Ave, SW	Atlanta	GA	30315	71	404-768-3600

50	67,669	Nashville-Davidson County SD	2601 Bransford Ave	Nashville	TN	37204	125	615-259-8419
51	64,976	Mobile County Sch Dist	PO Box 1327	Mobile	AL	36633	100	334-690-8227
52	64,511	Columbus City SD	270 E State St	Columbus	OH	43215	146	614-365-5000
53	63,739	Northside ISD	5900 Evers Rd	San Antonio	TX	78238	84	210-706-8770
54	63,497	Cypress-Fairbanks ISD	PO Box 692003	Houston	TX	77269	54	281-897-4000
55	63,417	Guilford County Schools	PO Box 880	Greensboro	NC	27402	98	336-370-8100
56	63,024	Boston	26 Court St	Boston	MA	02108	131	617-635-9050
57	62,325	El Paso ISD	PO Box 20100	El Paso	TX	79998	86	915-779-3781
58	61,869	Tucson Unified District	PO Box 40400	Tucson	AZ	85717	123	520-617-7336
59	61,517	Volusia County School District	PO Box 2118	Deland	FL	32721	92	904-734-7190
60	60,869	Seminole County School Distric	400 E Lake Mary Blvd	Sanford	FL	32773	68	407-320-0006
61	60,643	Santa Ana Unified	1601 E Chestnut Ave	Santa Ana	CA	92701	53	714-558-5501
62	59,979	San Francisco Unified	135 Van Ness Ave	San Francisco	CA	94102	116	415-241-6000
63	59,875	Greenville County School Distr	PO Box 2848	Greenville	SC	29602	93	864-241-3457
64	59,578	Davis School District	45 E State St	Farmington	UT	84025	83	801-402-5261
65	58,866	Arlington ISD	1203 W Pioneer Pkwy	Arlington	TX	76013	71	817-460-4611
66	58,401	Lee County School District	2055 Central Ave	Fort Myers	FL	33901	75	941-337-8301
67	58,230	Atlanta City	210 Pryor St, SW	Atlanta	GA	30335	98	404-827-8075
68	57,273	San Antonio ISD	141 Lavaca St	San Antonio	TX	78210	104	210-299-5500
69	56,268	Washoe County School District	425 E Ninth	Reno	NV	89520	92	702-348-0200
70	54,863	Oakland Unified	1025 Second Ave	Oakland	CA	94606	96	510-879-8100
NOTE: The universe for this table includes outlying areas, Bureau of Indian Affairs, and Department of Defense schools.								
SOURCE: U.S. Department of Education, National Center for Education Statistics, Common Core of Data, "Public Elementary/ Secondary School Universe Survey," 2000-01, and "Local Education Agency Universe Survey," 2000-01.								

Executive Summary

An Inventory of Significant Natural Areas in Wake County, North Carolina

North Carolina Natural Heritage Program

Funding provided by:
Wake County
North Carolina Natural Heritage Trust Fund

2003

SIGNIFICANT NATURAL HERITAGE SITES OF WAKE COUNTY

Wake County is located in east-central North Carolina within the Piedmont province, though the extreme southern tip is often considered to be in the Coastal Plain. The diversity of community types found within Wake County can partly be attributed to its highly varied geology. The terrain is gently rolling, with steeper areas along creeks, where the banks can rise up to 100 feet above the stream channel. The elevation in Wake County ranges from 160 feet above sea level along the southeast border to 540 feet in the northwest portion of the county. Raleigh is situated in the geographic center of the county, at an average elevation of approximately 350 feet.

Eighty-five percent of Wake County lies within the Neuse River Basin; however, the southwestern corner of the county lies within the Cape Fear River Basin. Most of the waterways that cross the county flow in a southeasterly direction; this includes the Neuse River and its tributaries. There are no natural lakes in Wake County, but there are several large reservoirs, notably Harris Lake on Buckthorn Creek and Falls Lake on the Neuse River. Falls Lake provides drinking water for local communities and recreational opportunities for area residents. There are also several smaller, artificially created lakes and ponds throughout the county.

Wake County is the second most populous in North Carolina and is decidedly urban in character. From 1992 to 2002, the population of Wake County increased by 45.8%, making it the fastest-growing county in the state. Raleigh is the county seat as well as the state capital. In the past, much of the county was cleared for agriculture, but as the economy of the area changed from an agrarian one to a largely high-tech one, previously cultivated land was allowed to revert to forest. As recently as 1990, approximately half of the land area in Wake County was forested. However, within the last decade explosive development around Raleigh, Cary, and along the I-40 and US 70 corridors has resulted in the increasing conversion of these forested areas, as well as the remaining agricultural land, to commercial and residential developments. This expansion has been fueled by the growing concentration of biotechnology, biomedical, and computer and software companies in Wake County and neighboring Durham County. Today, only 17% of the land area of Wake County is used for agriculture.

Wake County has a fairly large number of high-quality Significant Natural Heritage Areas. This high number of significant sites attests to the great diversity of habitats still remaining in the county which include granitic flatrocks, steep slopes and bluffs, and “coastal plain” features such as longleaf pine stands and a stream with bald-cypress. A good number of the these significant sites is already in conservation ownership in the county in part due to the active land trust and conservation community.

Conducted by Harry LeGrand, Jr., with assistance from Christine Wiecek, and published in 2003, the Wake County inventory identified 48 Significant Natural Heritage Areas. As of 2005, a total of 59 Significant Natural Heritage Areas are documented in the county. Three natural areas are considered of national significance, 8 are of state significance, 12 are of regional significance, and 36 are of local significance. All aquatic habitats are North Carolina Public Waters.

For more information on the Wake County Inventory please contact the North Carolina Natural Heritage Program at 1601 MSC, Raleigh, NC 27699, (919) 715-8687 or visit our website at http://www.ncnhp.org.

SITES OF *NATIONAL, STATE, AND REGIONAL* SIGNIFICANCE IN WAKE COUNTY

Aquatic Habitats

Little River Aquatic Habitat. The Little River is one of the largest tributaries of the Neuse River, and it supports an outstanding population of the Federal and State Endangered Dwarf wedgemussel (*Alasmidonta heterodon*), as well as a small population of the Federal and State Endangered Tar River spinymussel (*Elliptio steinstansana*). Other rare mussel species include the Federal Species of Concern/State Endangered Green Floater (*Lasmigona subviridis*), Atlantic Pigtoe (*Fusconaia masoni*), and Yellow Lampmussel (*Lampsilis cariosa*); the Federal Species of Concern/State Threatened Yellow Lance (*Elliptio lanceolata*); the State Threatened Triangle Floater (*Alasmidonta undulata*); and the State Special Concern Notched Rainbow (*Villosa constricta*). Other rare animals include the Neuse River Waterdog (*Necturus lewisi*), Least Brook Lamprey (*Lampetra aepyptera*), Carolina Madtom (*Noturus furiosus*), and Roanoke Bass (*Ambloplites cavifrons*).

Middle Creek Aquatic Habitat supports several rare animal species. Among the rare species found here are Atlantic Pigtoe, Yellow Lance, Triangle Floater, Eastern Lampmussel (*Lampsilis radiata radiata*), Roanoke Slabshell (*Elliptio roanokensis*), Carolina Madtom and the North Carolina Spiny Crayfish (*Orconectes carolinensis*).

Moccasin Creek Aquatic Habitat is significant due to its rare freshwater mollusks. Rare animals found here include the Dwarf Wedgemussel, Atlantic Pigtoe, Triangle Floater, the Creeper (*Strophitus undulata*), the Notched Rainbow, and the Neuse River Waterdog.

Swift Creek Aquatic Habitat is significant because it supports a number of rare mussel species. Rare mussels include the Dwarf Wedgemussel, Green Floater, Triangle Floater, Yellow Lance, Creeper, Atlantic Pigtoe, and Notched Rainbow, as well as the State Threatened Cape Fear Spike (*Elliptio marsupiobesa*) and Roanoke Slabshell (*Elliptio roanokensis*) and the uncommon Eastern Lampmussel (*Lampsilis radiata radiata*). Rare fish found here include the Carolina Madtom.

Granitic Flatrocks

Adam Mountain has significance due to its Ultramafic Outcrop Barren natural community community. While this is a marginally-developed example, it is the only example known from the North Carolina Piedmont. The State Threatened Low wild-petunia (*Ruellia humilis*) occurs here. The site is a Registered Heritage Area owned by the U.S. Army Corps of Engineers at Falls Lake.

Mitchell's Millpond State Natural Area contains what may be the largest expanse of excellent quality Granitic Flatrock natural communities in North Carolina. These support the State Threatened Small's portulaca (*Portulaca smallii*) and Piedmont quillwort (*Isoetes piedmontana*). Most of the site is owned by the North Carolina Division of Parks and Recreation; this is a Registered Heritage Area. The remainder is owned by Wake County or is privately owned.

Southwest Rolesville Granitic Outcrops is significant, as it is one of the largest clusters of flatrocks in the eastern Piedmont. This site is privately owned.

Temple Rock (or Temple Flat Rock) contains a good quality Granitic Flatrock natural community. The rare Small's portulaca grows at this site. The Triangle Land Conservancy owns this site.

The Rocks has one of the largest extents of a good quality Granitic Flatrock natural community in the state. The rare plant, Small's Portulaca, occurs here. Part of the site is owned by Wake County; the remainder is owned by Triangle Land Conservancy and is a Registered Heritage Area.

Mafic Areas

Swift Creek Bluffs contains a very mature Basic Mesic Forest natural community, as well as good quality Piedmont/Low Mountain Alluvial Forest and Floodplain Pool natural communities. Most of the site is by the Triangle Land Conservancy; the rest is privately owned.

Upper Barton Creek Bluffs and Ravine is significant because its soapstone outcrops help support an extensive and mature Basic Mesic Forest natural community. This is a Registered Heritage Area owned by the U.S. Army Corps of Engineers at Falls Lake.

Floodplains, Bluffs, and Uplands

Blue Pond Salamander Site (Sunset Lake) consists of 2 small wooded ponds that are seasonally inundated and are one of the most important amphibian breeding sites in the county, despite their location in the middle of a residential development. Seventeen amphibian species were encountered during the inventory, but their long-term population viability is unknown. A portion of the site is protected by the North Carolina Museum of Natural Sciences; the remainder is privately owned.

Hemlock Bluffs State Natural Area contains steep, 80-foot-high, north-facing bluffs that support a disjunct population of eastern hemlock (*Tsuga canadensis*) 200 miles from its normal range in the mountains. The natural communities are small but good quality Piedmont/Coastal Plain Acidic Cliff and Piedmont Monadnock Forest types. Part of the site is owned by the North Carolina Division of Parks and Recreation; this is a Registered Heritage Area. The rest of the site is owned by the Town of Cary.

Middle Creek Bluffs and Floodplain is a segment of wide floodplain and slopes that support extensive mature Mesic Mixed Hardwood Forest natural community and areas of good quality Piedmont/Low Mountain Alluvial Forest communities. This site is privately owned.

Robertson's Millpond and Buffalo Creek Floodplain is significant because of its Coastal Plain Semipermanent Impoundment natural community, which features an abundance of the locally rare bald-cypress (*Taxodium distichum*). A portion of this privately owned site is a Registered Heritage Area.

Shearon Harris Longleaf Pine Forest has a remnant Piedmont Longleaf Pine Forest natural community. This is the only example of this community in the region. The privately owned site is leased for research by the NC State University Forestry School.

Upper Neuse River Floodplain Floodplain contains well-developed natural levee with an associated Piedmont/Mountain Levee Forest natural community and a few floodplain pools. An abandoned oxbow is also present. The City of Raleigh owns a portion of this site; the remainder is privately owned.

Utley Creek Slopes contains an extensive Dry Oak-Hickory Forest natural community. Other notable features include rock outcrops, with "caves" along Utley Creek, exposing sedimentary rock. The rare Virginia spiderwort (*Tradescantia virginiana*) is found here. This site is privately owned.

Walnut Creek Sumac Site is significant, as its mowed roadbanks support one of the state's best known populations of the Federal and State Endangered Michaux's sumac (*Rhus michauxii*). Parts of the site are owned by the North Carolina Department of Transportation, private landowners, and the City of Raleigh. A portion of the site is a Registered Heritage Area.

White Oak Creek Floodplain is a fairly broad floodplain, with a good quality hardwood forest and the Piedmont/Low Mountain Alluvial Forest natural community, dominated by white oak (*Quercus alba*). The site also has one of the best examples in the region of the Floodplain Pools natural community. The rare Lewis's heartleaf (*Hexastylis lewisii*) is found within this site. This site is owned by the U.S. Army Corps of Engineers.

Wild Cat Hollow contains small caves in the openings of weathered granite boulders. Such a feature is quite rare in eastern North Carolina. Part of this privately owned site is a Registered Heritage Area.

William B. Umstead State Park is a 5400-acre, unbroken expanse of diverse forests that provide important wildlife habitat. Rare plants found here include Michaux's sumac. Rare animals include the State Special Concern Neuse River Waterdog and Four-toed Salamander (*Hemidactylium scutatum*). The park is owned by the North Carolina Division of Parks and Recreation.

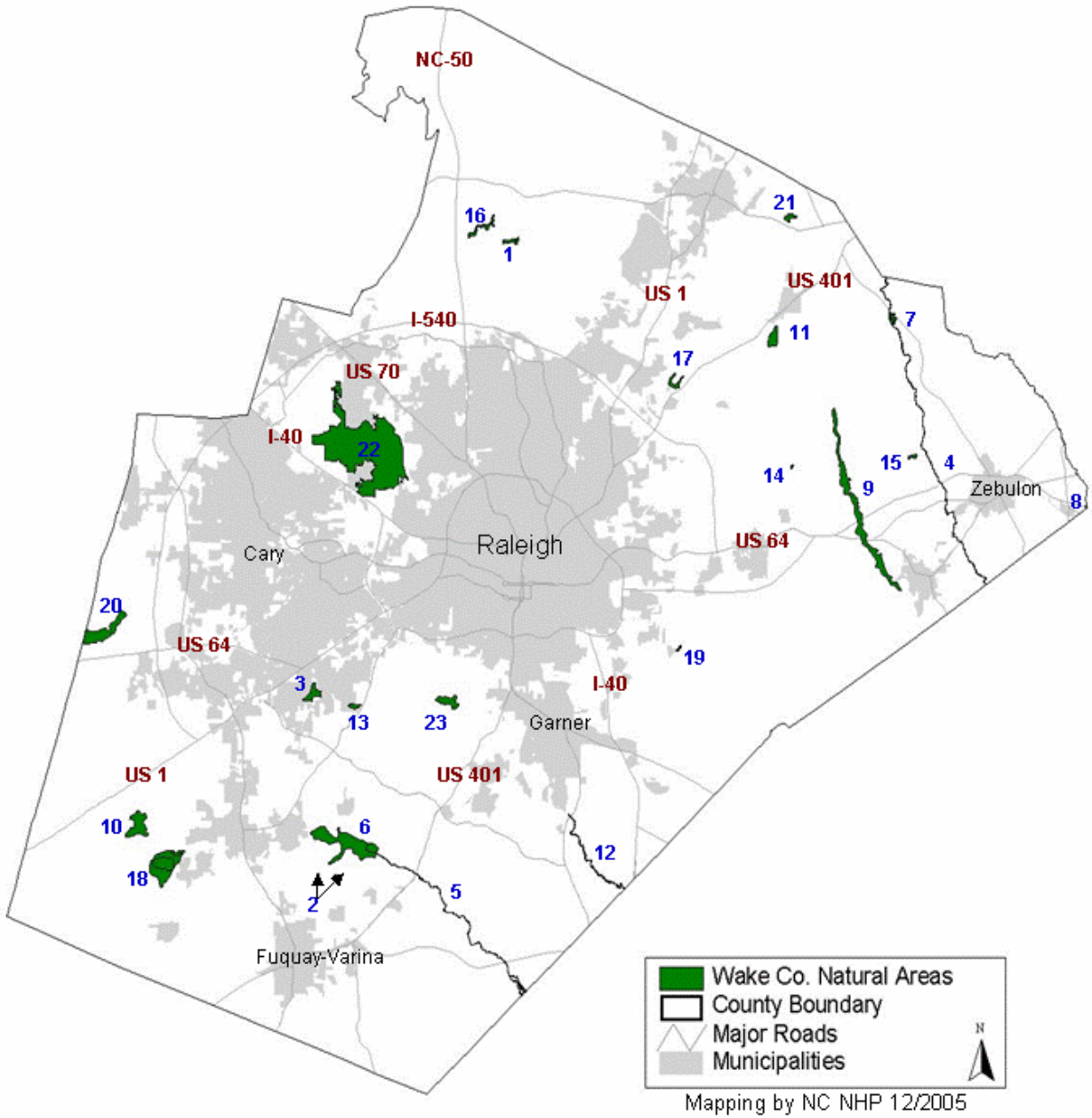
Yates Millpond is an old millpond with a floodplain above it, and some of the floodplain has been impounded by beavers. A large population of the rare Carolina least trillium (*Trillium pusillum* var. *pusillum*) is found here. This site is partly owned by Wake County and NC State University; the remainder is privately owned.

Additional References

Oakley, S.C., H.E. LeGrand, Jr., and M.P. Schafale. 1995. An Inventory of Mafic Natural Areas in the North Carolina Piedmont. NC Natural Heritage Program, Division of Parks and Recreation, Raleigh, NC.

LeGrand, H.E., Jr. 1987. Inventory of the Natural Areas of Wake County. Report prepared for Triangle Land Conservancy and N.C. Natural Heritage Program.

Significant Natural Heritage Areas in Wake County, North Carolina.



Key to Wake County Significant Natural Heritage Areas:

1 Adam Mountain
2 Blue Pond (Sunset Lake)
3 Hemlock Bluffs State Natural Area
4 Little River Aquatic Habitat
5 Middle Creek Aquatic Habitat
6 Middle Creek Bluffs and Floodplain
7 Mitchells Mill State Natural Area
8 Moccasin Creek Aquatic Habitat
9 Robertsons Pond and Buffalo Creek Floodplain
10 Shearon Harris Longleaf Pine Forest
11 Southwest Rolesville Granitic Outcrops
12 Swift Creek Aquatic Habitat
13 Swift Creek Bluffs
14 Temple Rock
15 The Rocks
16 Upper Barton Creek Bluffs and Ravine
17 Upper Neuse River Floodplain
18 Utley Creek Slopes
19 Walnut Creek Sumac Site
20 White Oak Creek Floodplain
21 Wild Cat Hollow
22 William B Umstead State Park
23 Yates Millpond

NC NHP County Element Search Results

New Search

Returned Elements: 89 using: WAKE ALL
[Animal Assemblage 1] [Invertebrate Animal 16] [Natural Community 18] [Nonvascular Plant 3] [Vascular Plant 37] [Vertebrate Animal 14]

Major Group	Scientific Name	Common Name	State Status	Federal Status	State Rank	Global Rank	County - Status	Map - Habitat
Animal Assemblage	*Colonial Wading Bird Colony*	None	None	None	S3	GNR	Wake - Current	Link
Invertebrate Animal	*Alasmidonta heterodon*	Dwarf Wedgemussel	E	E	S1	G1G2	Wake - Current	Link
Invertebrate Animal	*Alasmidonta undulata*	Triangle Floater	T	None	S2	G4	Wake - Current	Link
Invertebrate Animal	*Cambarus davidi*	Carolina Ladle Crayfish	SR	None	S2S3	G2G3	Wake - Current	Link
Invertebrate Animal	*Dibusa angata*	A Caddisfly	SR	None	S3	G5	Wake - Current	Link
Invertebrate Animal	*Elliptio lanceolata*	Yellow Lance	E	FSC	S1	G2G3	Wake - Current	Link
Invertebrate Animal	*Elliptio roanokensis*	Roanoke Slabshell	T	None	S1	G3	Wake - Current	Link
Invertebrate Animal	*Erynnis martialis*	Mottled Duskywing	SR	None	S3	G3G4	Wake - Obscure	Link
Invertebrate Animal	*Fusconaia masoni*	Atlantic Pigtoe	E	FSC	S1	G2	Wake - Current	Link
Invertebrate Animal	*Lampsilis radiata radiata*	Eastern Lampmussel	T	None	S1S2	G5T5	Wake - Current	Link
Invertebrate Animal	*Lasmigona subviridis*	Green Floater	E	FSC	S1	G3	Wake - Current	Link
Invertebrate Animal	*Lithophane lemmeri*	Lemmer's Pinion	SR	None	S1S3	G3G4	Wake - Obscure	Link
Invertebrate Animal	*Orconectes carolinensis*	North Carolina Spiny Crayfish	SC	None	S3	G3	Wake - Historical	Link
Invertebrate Animal	*Papilio cresphontes*	Giant Swallowtail	SR	None	S2	G5	Wake - Obscure	Link
Invertebrate Animal	*Schizura sp. 1*	A New Prominent Moth	SR	None	S1S3	G3G4	Wake - Obscure	Link
Invertebrate Animal	*Strophitus undulatus*	Creeper	T	None	S2	G5	Wake - Current	Link
Invertebrate Animal	*Villosa constricta*	Notched Rainbow	SC	None	S3	G3	Wake - Current	Link
Natural Community	*Basic mesic forest (piedmont subtype)*	None	None	None	S2	G5T3	Wake - Current	Link
Natural Community	*Coastal plain semipermanent impoundment*	None	None	None	S4	G5	Wake - Current	Link
Natural Community	*Coastal plain small stream swamp (brownwater subtype)*	None	None	None	S2S3	G5T3T4	Wake - Current	Link
Natural Community	*Dry oak--hickory forest*	None	None	None	S4	G5	Wake - Current	Link
Natural Community	*Dry-mesic oak--hickory forest*	None	None	None	S5	G5	Wake - Current	Link
Natural Community	*Floodplain pool*	None	None	None	S2S3	G3?	Wake - Current	Link
Natural Community	*Granitic flatrock*	None	None	None	S2	G3	Wake - Current	Link
Natural Community	*Low elevation seep*	None	None	None	S3	G4?	Wake - Current	Link
Natural Community	*Mesic mixed hardwood forest (piedmont subtype)*	None	None	None	S4	G5T5	Wake - Current	Link
Natural Community	*Piedmont longleaf pine forest*	None	None	None	S1	G1?	Wake - Current	Link
Natural Community	*Piedmont monadnock forest*	None	None	None	S4	G5	Wake - Current	Link
Natural Community	*Piedmont/coastal plain acidic cliff*	None	None	None	S2?	G4	Wake - Current	Link

Natural Community	*Piedmont/coastal plain heath bluff*	None	None	None	S3	G4?	Wake - Current	Link
Natural Community	*Piedmont/low mountain alluvial forest*	None	None	None	S5	G5	Wake - Current	Link
Natural Community	*Piedmont/mountain bottomland forest*	None	None	None	S3?	G5	Wake - Current	Link
Natural Community	*Piedmont/mountain levee forest*	None	None	None	S3?	G5	Wake - Current	Link
Natural Community	*Piedmont/mountain semipermanent impoundment*	None	None	None	S4	G5	Wake - Current	Link
Natural Community	*Ultramafic outcrop barren*	None	None	None	S1	G1	Wake - Current	Link
Nonvascular Plant	*Campylopus oerstedianus*	Oersted's Campylopus	SR-D	None	S1	G1G3	Wake - Historical	Link
Nonvascular Plant	*Sphagnum subsecundum*	Orange Peatmoss	SR-P	None	S1	G5	Wake - Historical	Link
Nonvascular Plant	*Tortula plinthobia*	A Chain-teeth Moss	SR-O	None	S1?	G4G5	Wake - Historical	Link
Vascular Plant	*Buchnera americana*	American Bluehearts	SR-P	None	SH	G5?	Wake - Historical	Link
Vascular Plant	*Cardamine douglassii*	Douglass's Bittercress	SR-P	None	S2	G5	Wake - Current	Link
Vascular Plant	*Carex reniformis*	Kidney Sedge	SR-P	None	SH	G4?	Wake - Historical	Link
Vascular Plant	*Carex tetanica*	Rigid Sedge	SR-P	None	S1	G4G5	Wake - Historical	Link
Vascular Plant	*Cirsium carolinianum*	Carolina Thistle	SR-P	None	S2	G5	Wake - Historical	Link
Vascular Plant	*Cyperus granitophilus*	Granite Flatsedge	SR-T	None	S2	G3G4Q	Wake - Current	Link
Vascular Plant	*Dichanthelium annulum*	A Witch Grass	SR-P	None	SH	GNR	Wake - Historical	Link
Vascular Plant	*Dichanthelium sp. 9*	A Witch Grass	SR-L	None	S2	G2G3	Wake - Historical	Link
Vascular Plant	*Didiplis diandra*	Water Purslane	SR-P	None	S1	G5	Wake - Current	Link
Vascular Plant	*Eupatorium godfreyanum*	Godfrey's Thoroughwort	SR-P	None	S2	G4	Wake - Historical	Link
Vascular Plant	*Fothergilla major*	Large Witch-alder	SR-T	None	S3	G3	Wake - Current	Link
Vascular Plant	*Gillenia stipulata*	Indian Physic	SR-P	None	S2	G5	Wake - Current	Link
Vascular Plant	*Helenium brevifolium*	Littleleaf Sneezeweed	E	None	S2	G4	Wake - Historical	Link
Vascular Plant	*Isoetes piedmontana*	Piedmont Quillwort	T	None	S2	G3	Wake - Current	Link
Vascular Plant	*Liatris squarrulosa*	Earle's Blazing-star	SR-P	None	S2	G4G5	Wake - Current	Link
Vascular Plant	*Lindera subcoriacea*	Bog Spicebush	T	FSC	S2	G2	Wake - Current	Link
Vascular Plant	*Magnolia macrophylla*	Bigleaf Magnolia	SR-P	None	S2	G5	Wake - Current	Link
Vascular Plant	*Matelea decipiens*	Glade Milkvine	SR-P	None	S2	G5	Wake - Current	Link
Vascular Plant	*Monotropsis odorata*	Sweet Pinesap	SR-T	FSC	S3	G3	Wake - Historical	Link
Vascular Plant	*Polygala senega*	Seneca Snakeroot	SR-D	None	S2	G4G5	Wake - Current	Link
Vascular Plant	*Portulaca smallii*	Small's Portulaca	T	None	S2	G3	Wake - Current	Link
Vascular Plant	*Pseudognaphalium helleri*	Heller's Rabbit-Tobacco	SR-P	None	S3	G3G4	Wake - Current	Link
Vascular Plant	*Pycnanthemum virginianum*	Virginia Mountain-mint	SR-P	None	S1?	G5	Wake - Current	Link
Vascular Plant	*Rhus michauxii*	Michaux's Sumac	E-SC	E	S2	G2G3	Wake - Current	Link
Vascular Plant	*Ruellia humilis*	Low Wild-petunia	T	None	S1	G5	Wake - Historical	Link

Vascular Plant	*Ruellia purshiana*	Pursh's Wild-petunia	SR-O	None	S2	G3	Wake - Current	Link
Vascular Plant	*Sagittaria weatherbiana*	Grassleaf Arrowhead	SR-T	FSC	S2	G5T2	Wake - Historical	Link
Vascular Plant	*Saxifraga pensylvanica*	Swamp Saxifrage	SR-P	None	S1	G5	Wake - Current	Link
Vascular Plant	*Scutellaria australis*	Southern Skullcap	SR-P	None	S1	G4?Q	Wake - Historical	Link
Vascular Plant	*Scutellaria nervosa*	Veined Skullcap	SR-P	None	S1	G5	Wake - Historical	Link
Vascular Plant	*Silphium terebinthinaceum*	Prairie Dock	SR-P	None	S2	G4G5	Wake - Historical	Link
Vascular Plant	*Solidago radula*	Western Rough Goldenrod	SR-P	None	S1	G5?	Wake - Historical	Link
Vascular Plant	*Symphyotrichum laeve var. concinnum*	Narrow-leaf Aster	SR-P	None	S2	G5T4	Wake - Historical	Link
Vascular Plant	*Thermopsis mollis*	Appalachian Golden-banner	SR-P	None	S2	G3G4	Wake - Current	Link
Vascular Plant	*Tradescantia virginiana*	Virginia Spiderwort	SR-P	None	S1	G5	Wake - Current	Link
Vascular Plant	*Trifolium reflexum*	Buffalo Clover	SR-T	None	S1S2	G3G4	Wake - Current	Link
Vascular Plant	*Trillium pusillum var. virginianum*	Virginia Least Trillium	E	FSC	S1	G3T2	Wake - Current	Link
Vertebrate Animal	*Aimophila aestivalis*	Bachman's Sparrow	SC	FSC	S3B,S2N	G3	Wake - Historical	Link
Vertebrate Animal	*Ambloplites cavifrons*	Roanoke Bass	SR	FSC	S2	G3	Wake - Current	Link
Vertebrate Animal	*Ambystoma tigrinum*	Eastern Tiger Salamander	T	None	S2	G5	Wake - Current	Link
Vertebrate Animal	*Condylura cristata pop. 1*	Star-nosed Mole - Coastal Plain Population	SC	None	S2	G5T2Q	Wake - Current	Link
Vertebrate Animal	*Haliaeetus leucocephalus*	Bald Eagle	T	T	S3B,S3N	G5	Wake - Current	Link
Vertebrate Animal	*Hemidactylium scutatum*	Four-toed Salamander	SC	None	S3	G5	Wake - Current	Link
Vertebrate Animal	*Heterodon simus*	Southern Hognose Snake	SC	FSC	S2	G2	Wake - Obscure	Link
Vertebrate Animal	*Lampetra aepyptera*	Least Brook Lamprey	T	None	S2	G5	Wake - Current	Link
Vertebrate Animal	*Lanius ludovicianus*	Loggerhead Shrike	SC	None	S3B,S3N	G4	Wake - Obscure	Link
Vertebrate Animal	*Myotis austroriparius*	Southeastern Myotis	SC	FSC	S3	G3G4	Wake - Historical	Link
Vertebrate Animal	*Myotis septentrionalis*	Northern Long-eared Myotis	SC	None	S3	G4	Wake - Historical	Link
Vertebrate Animal	*Necturus lewisi*	Neuse River Waterdog	SC	None	S3	G3	Wake - Current	Link
Vertebrate Animal	*Noturus furiosus*	Carolina Madtom	SC (PT)	FSC	S2	G2	Wake - Current	Link
Vertebrate Animal	*Picoides borealis*	Red-cockaded Woodpecker	E	E	S2	G3	Wake - Historical	Link

NC NHP database updated on Monday, July 2nd, 2007.
Search performed on Monday, 10 September 2007 @ 14:54:42 EDST
Explanation of Codes

NC NHP County Element Search Results

New Search

Returned Elements: 57 using: CHATHAM ALL
[Animal Assemblage 1] [Invertebrate Animal 14] [Natural Community 18] [Vascular Plant 14] [Vertebrate Animal 10]

Major Group	Scientific Name	Common Name	State Status	Federal Status	State Rank	Global Rank	County - Status	Map - Habitat
Animal Assemblage	*Colonial Wading Bird Colony*	None	None	None	S3	GNR	Chatham - Current	Link
Invertebrate Animal	*Alasmidonta undulata*	Triangle Floater	T	None	S2	G4	Chatham - Current	Link
Invertebrate Animal	*Alasmidonta varicosa*	Brook Floater	E	FSC	S1	G3	Chatham - Historical	Link
Invertebrate Animal	*Cambarus davidi*	Carolina Ladle Crayfish	SR	None	S2S3	G2G3	Chatham - Current	Link
Invertebrate Animal	*Choroterpes basalis*	A Mayfly	SR	None	S2	G5	Chatham - Current	Link
Invertebrate Animal	*Fusconaia masoni*	Atlantic Pigtoe	E	FSC	S1	G2	Chatham - Current	Link
Invertebrate Animal	*Gomphus abbreviatus*	Spine-crowned Clubtail	SR	None	S3?	G3G4	Chatham - Obscure	Link
Invertebrate Animal	*Gomphus quadricolor*	Rapids Clubtail	SR	None	S1S2	G3G4	Chatham - Obscure	Link
Invertebrate Animal	*Gomphus septima*	Septima's Clubtail	SR	FSC	S1S3	G2	Chatham - Current	Link
Invertebrate Animal	*Lampsilis cariosa*	Yellow Lampmussel	E	FSC	S1	G3G4	Chatham - Current	Link
Invertebrate Animal	*Neurocordulia virginiensis*	Cinnamon Shadowdragon	SR	None	S2S3	G4	Chatham - Obscure	Link
Invertebrate Animal	*Strophitus undulatus*	Creeper	T	None	S2	G5	Chatham - Current	Link
Invertebrate Animal	*Villosa constricta*	Notched Rainbow	SC	None	S3	G3	Chatham - Current	Link
Invertebrate Animal	*Villosa delumbis*	Eastern Creekshell	SR	None	S3	G4	Chatham - Current	Link
Invertebrate Animal	*Villosa vaughaniana*	Carolina Creekshell	E	FSC	S2	G2	Chatham - Current	Link
Natural Community	*Basic mesic forest (piedmont subtype)*	None	None	None	S2	G5T3	Chatham - Current	Link
Natural Community	*Basic oak--hickory forest*	None	None	None	S3	G4	Chatham - Current	Link
Natural Community	*Dry oak--hickory forest*	None	None	None	S4	G5	Chatham - Current	Link
Natural Community	*Dry-mesic oak--hickory forest*	None	None	None	S5	G5	Chatham - Current	Link
Natural Community	*Floodplain pool*	None	None	None	S2S3	G3?	Chatham - Current	Link
Natural Community	*Hillside seepage bog*	None	None	None	S2	G2	Chatham - Current	Link
Natural Community	*Mesic mixed hardwood forest (piedmont subtype)*	None	None	None	S4	G5T5	Chatham - Current	Link
Natural Community	*Piedmont longleaf pine forest*	None	None	None	S1	G1?	Chatham - Current	Link
Natural Community	*Piedmont/coastal plain heath bluff*	None	None	None	S3	G4?	Chatham - Current	Link
Natural Community	*Piedmont/low mountain alluvial forest*	None	None	None	S5	G5	Chatham - Current	Link
Natural Community	*Piedmont/mountain bottomland forest*	None	None	None	S3?	G5	Chatham - Current	Link
Natural Community	*Piedmont/mountain levee forest*	None	None	None	S3?	G5	Chatham - Current	Link
Natural Community	*Piedmont/mountain semipermanent impoundment*	None	None	None	S4	G5	Chatham - Current	Link
Natural Community	*Piedmont/mountain swamp forest*	None	None	None	S1S2	G2	Chatham - Current	Link

Natural Community	*Rocky bar and shore*	None	None	None	S5	G5	Chatham - Current	Link
Natural Community	*Upland depression swamp forest*	None	None	None	S3	G3	Chatham - Current	Link
Natural Community	*Upland pool*	None	None	None	S1	G1	Chatham - Current	Link
Natural Community	*Xeric hardpan forest*	None	None	None	S3	G3G4	Chatham - Current	Link
Vascular Plant	*Allium cuthbertii*	Striped Garlic	SR-T	None	S2	G4	Chatham - Historical	Link
Vascular Plant	*Baptisia albescens*	Thin-pod White Wild Indigo	SR-P	None	S2	G4	Chatham - Historical	Link
Vascular Plant	*Collinsonia tuberosa*	Piedmont Horsebalm	SR-P	None	S1	G3G4	Chatham - Current	Link
Vascular Plant	*Dichanthelium annulum*	A Witch Grass	SR-P	None	SH	GNR	Chatham - Historical	Link
Vascular Plant	*Fothergilla major*	Large Witch-alder	SR-T	None	S3	G3	Chatham - Current	Link
Vascular Plant	*Gillenia stipulata*	Indian Physic	SR-P	None	S2	G5	Chatham - Historical	Link
Vascular Plant	*Isoetes virginica*	Virginia Quillwort	SR-L	FSC	S1	G1	Chatham - Historical	Link
Vascular Plant	*Monotropsis odorata*	Sweet Pinesap	SR-T	FSC	S3	G3	Chatham - Current	Link
Vascular Plant	*Paspalum fluitans*	Horsetail Crown Grass	SR-D	None	S1	G5	Chatham - Historical	Link
Vascular Plant	*Phacelia covillei*	Buttercup Phacelia	SR-T	FSC	S3	G3	Chatham - Current	Link
Vascular Plant	*Ptilimnium nodosum*	Harperella	E	E	S1	G2	Chatham - Current	Link
Vascular Plant	*Scutellaria nervosa*	Veined Skullcap	SR-P	None	S1	G5	Chatham - Historical	Link
Vascular Plant	*Thermopsis mollis*	Appalachian Golden-banner	SR-P	None	S2	G3G4	Chatham - Historical	Link
Vascular Plant	*Trifolium reflexum*	Buffalo Clover	SR-T	None	S1S2	G3G4	Chatham - Historical	Link
Vertebrate Animal	*Aimophila aestivalis*	Bachman's Sparrow	SC	FSC	S3B,S2N	G3	Chatham - Current	Link
Vertebrate Animal	*Anhinga anhinga*	Anhinga	SR	None	S2B	G5	Chatham - Current	Link
Vertebrate Animal	*Etheostoma collis pop. 2*	Carolina Darter - Eastern Piedmont Population	SC	FSC	S2	G3T3Q	Chatham - Current	Link
Vertebrate Animal	*Haliaeetus leucocephalus*	Bald Eagle	T	T	S3B,S3N	G5	Chatham - Current	Link
Vertebrate Animal	*Hemidactylium scutatum*	Four-toed Salamander	SC	None	S3	G5	Chatham - Current	Link
Vertebrate Animal	*Lanius ludovicianus*	Loggerhead Shrike	SC	None	S3B,S3N	G4	Chatham - Current	Link
Vertebrate Animal	*Moxostoma sp. 3*	Carolina Redhorse	SR (PE)	FSC	S1	G1G2Q	Chatham - Current	Link
Vertebrate Animal	*Notropis mekistocholas*	Cape Fear Shiner	E	E	S1	G1	Chatham - Current	Link
Vertebrate Animal	*Phalacrocorax auritus*	Double-crested Cormorant	SR	None	S1B,S5N	G5	Chatham - Current	Link
Vertebrate Animal	*Picoides borealis*	Red-cockaded Woodpecker	E	E	S2	G3	Chatham - Historical	Link

NC NHP database updated on Monday, July 2nd, 2007.
Search performed on Monday, 10 September 2007 @ 14:56:14 EDST
Explanation of Codes

Invasive Exotic Plants in NC 2006

Compiled by Misty Franklin with review and input from biologists in the following agencies: NC Natural Heritage Program, NC DENR Aquatic Weed Control Program, NC Exotic Pest Plant Council, US Fish &Wildlife Service, The Nature Conservancy, NC Zoo, NC Botanical Garden, and UNC Herbarium.

This is the first edition of the NC Native Plant Society Invasive Exotic Plant list. The intent of the list is to rank exotic (alien, foreign, introduced, and non-indigenous) plants based on their invasive characteristics, to educate the public and resource managers, and to encourage early detection of invasive exotic species so that a rapid response can be implemented when needed. We hope this list will help eliminate the use of invasive exotic plants in landscaping and restoration projects. The 2004 Tennessee Exotic Pest Plant Council Invasive Exotic Plant list was used as a model for organization of this list, but species listed and ranks assigned here are applicable to North Carolina. The NC Native Plant Society Invasive Exotic Plant List is considered a work in progress, and will be evaluated and updated as new information is gathered about these and other species. Please send your comments:

North Carolina Native Plant Society
C/O North Carolina Botanical Garden
Totten Center 3375,
Chapel Hill, NC 27599-3375

Background: Many introduced plants have become naturalized in North Carolina and some are replacing our native plant species. Not all exotic species are considered harmful. Invasive plants are usually characterized by fast growth rates, high fruit production, rapid vegetative spread and efficient seed dispersal and germination. Not being native to NC, they lack the natural predators and diseases which would naturally control them in their native habitats. The rapid growth and reproduction of invasive plants allows them to overwhelm and displace existing vegetation and, in some cases, form dense one-species stands. Invasive species are especially problematic in areas that have been disturbed by human activities such as road building, residential development, forest clearing, logging, grazing, mining, ditching, mowing, erosion control, and fire control activities.

Invasive exotic plants disrupt the ecology of natural ecosystems, displace native plant and animal species, and degrade our biological resources. Aggressive invaders reduce the amount of light, water, nutrients and space available to native species. Some cause increased erosion along stream banks, shorelines and roadsides. Some exotics hybridize with related native plant species, resulting in changes to a population's genetic makeup; others have been found to harbor plant pathogens that can affect both native and non-native plants, including ornamentals. Others contain toxins that may be lethal humans and other animals. Some invasive plants compete with and replace rare and endangered species and encroach upon their limited habitat. Other problems include disruption of native plant-pollinator relationships, tree and shrub mortality due to girdling, reduced establishment of native tree and shrub seedlings, reduction in the amount of space, water, sunlight and nutrients that would be available to native species, and altered fire regimes. Invasive plants also cause economic losses and expenditures each year for agriculture, forestry, and roadside management.

Our native fauna, including insects, birds, mammals, reptiles, fish and other animals, is dependent on native plants for food and shelter. While some animals can feed on a wide number of plant species, others are highly specialized and may be restricted to feeding on several or a single plant species. As exotic plants replace our native flora, fewer host plants are available to provide the necessary nutrition for our native wildlife. In some cases, invasive plants replace nutritious native plant foods with lower quality sources. Each exotic plant is one less native host plant for our native insects, vertebrates and other organisms that are dependent upon them.

It is important to document the spread of invasive exotic plants into natural areas. When invaders are found outside of landscape plantings, they should be recorded and voucher specimens should be collected for donation to a herbarium.

To reduce invasive plant invasions, we must approach the problem in a variety of ways: stop planting them, prevent accidental introductions, manage existing infestations, minimize disturbance to forests, wetlands, and other natural communities, and learn to work with (rather than against) natural systems and cycles.

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Rank 1 - Severe Threat

Exotic plant species that have invasive characteristics and spread readily into native plant communities, displacing native vegetation.

Scientific name	Common name
Ailanthus altissima (Mill.) Swingle	Tree of Heaven
Albizia julibrissin Durz.	Mimosa
Alliaria petiolata (Bieb.) Cavara & Grande	Garlic-mustard
Alternanthera philoxeroides (Mart.) Griseb.	Alligatorweed
Celastrus orbiculatus Thunb.	Asian bittersweet
Elaeagnus angustifolia L.	Russian olive
Elaeagnus umbellata Thunb.	Autumn olive
Hedera helix L.	English ivy
Hydrilla verticillata (L.f.) Royle	Hydrilla
Lespedeza bicolor	Bicolor lespedeza
Lespedeza cuneata (Dum.-Cours.) G. Don	Sericea lespedeza
Ligustrum sinense Lour.	Chinese privet
Lonicera fragrantissima Lindl. & Paxton	Fragrant honeysuckle
Lonicera japonica Thunb.	Japanese honeysuckle
Microstegium vimineum (Trin.) A. Camus	Japanese stilt-grass
Murdannia keisak (Hassk.) Hand.-Mazz.	Asian spiderwort
Myriophyllum aquaticum (Vell.) Verdc.	Parrotfeather
Paulownia tomentosa (Thunb.) Sieb.&Zucc. ex Steud.	Princess tree
Phragmites australis (Cav.) Trin. ssp. australis	Common reed
Polygonum cuspidatum Seib. & Zucc.	Japanese knotweed
Pueraria montana (Lour.) Merr.	Kudzu
Rosa multiflora Thunb.	Multiflora rose
Salvinia molesta Mitchell	Aquarium water-moss

Vitex rotundifolia L.f.	Beach vitex
Wisteria sinensis (Sims) DC	Chinese wisteria
return to top	

Rank 2 - Significant Threat

Exotic plant species that display some invasive characteristics, but do not appear to present as great a threat native communities in NC as the species listed in Rank 1.

Scientific name	Common name
Ampelopsis brevipedunculata (Maxim.) Trautv.	Porcelain-berry
Arthraxon hispidus (Thunb.) Makino	Hairy jointgrass
Bambusa spp.	Exotic bamboo
Berberis thunbergii DC	Japanese barberry
Broussonetia papyrifera (L.) L'Her. ex Vent.	Paper mulberry
Centaurea biebersteinii DC	Spotted knapweed
Clematis terniflora DC (=C. dioscoreifolia)	Leatherleaf clematis
Conium maculatum L.	Poison hemlock
Coronilla varia L.	Crown vetch
Dioscorea oppositifolia L.	Air-potato
Eichhornia crassipes (Mart.) Solms	Water-hyacinth
Euonymus alata (Thunb.) Sieb.	Burning bush
Euonymus fortunei (Turcz.) Hand. - Mazz	Winter creeper
Glechoma hederacea L.	Gill-over-the-ground, ground ivy
Humulus japonicus	Japanese Hops
Lamium purpureum L.	Henbit
Lespedeza bicolor Turcz.	Bicolor lespedeza, shrubby bushclover
Ligustrum japonicum Thunb.	Japanese privet
Ligustrum vulgare L.	Common privet
Lonicera maackii (Rupr.) Maxim.	Amur bush honeysuckle
Lonicera morrowii A. Gray	Morrow's bush honeysuckle
Lonicera standishii Jaques	Standish's Honeysuckle
Lonicera ×bella [morrowii × tatarica]	Hybrid Bush Honeysuckle
Ludwigia uruguayensis (Camb.) Hara	Creeping waterprimrose
Lygodium japonicum (Thunb. ex Murr.) Sw.	Japanese climbing fern
Lythrum salicaria L.	Purple loosestrife
Mahonia beali (Fortune) Carriere	Oregon grape
Miscanthus sinensis Andersson	Chinese silver grass
Morus alba L.	White mulberry
Myriophyllum spicatum Komarov	Eurasian watermilfoil
Nandina domestica Thunb.	Nandina
Persicaria longiseta (de Bruijn) Moldenke	Oriental ladies-thumb

(=Polygonum caespitosum Blume)	
Persicaria maculata (Rafinesque) S.F. Gray (=Polygonum persicaria L.)	Lady's thumb
Phyllostachys spp.	Exotic bamboo
Poncirus trifoliata (L.) Raf.	Hardy-Orange
Pseudosasa japonica (Sieb. & Zucc. ex Steud.) Makino ex Nakai	Arrow bamboo
Pyrus calleryana Decne.	Bradford pear
Rhodotypos scandens (Thunb.)	Makino jetbead
Rubus phoenicolasius Maxim.	Wineberry
Solanum viarum Dunal	Tropical soda apple
Sorghum halepense (L.) Pers.	Johnson grass
Spiraea japonica L.f.	Japanese spiraea
Stellaria media (L.) Vill.	Common chickweed
Veronica hederifolia L.	Ivyleaf speedwell
Vinca major L.	Bigleaf periwinkle
Vinca minor L.	Common periwinkle
Wisteria floribunda (Willd.) DC	Japanese wisteria
Xanthium strumarium L.	Common cocklebur
Youngia japonica (L.) DC.	Oriental false hawksbeard
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Rank 3 - Lesser Threat

Exotic plant species that spread into or around disturbed areas, and are presently considered a low threat to native plant communities in NC.

Scientific name	**Common name**
Ajuga reptans L.	Bugleweed
Allium vineale L.	Field garlic
Artemisia vulgaris L.	Mugwort, common wormwood
Arundo donax L.	Giant reed
*Baccharis halimifolia L.**	Silverling, groundsel tree
Bromus catharticus Vahl	Bromegrass, rescue grass
Bromus commutatus Schrad.	Meadow brome
Bromus japonicus Thunb. ex Murray	Japanese bromegrass
Bromus secalinus L.	Rye brome
Bromus tectorum L.	Thatch bromegrass, cheat grass
Buddleia davidii Franch	Butterfly bush
Chicorium intybus L.	Chicory
Chrysanthemum leucanthemum L.	Ox-eye daisy
Cirsium vulgare (Savi) Ten.	Bull thistle
Daucus carota L.	Wild carrot, Queen Anne's-lace
Dipsacus fullonum L.	Fuller's teasle
Egeria densa Planch.	Brazilian elodea, Brazilian water-

	weed
Fatoua villosa (Thunb.) Nakai	Hairy crabweed
Festuca pratensis Huds.	Meadow fescue
Ipomoea quamoclit L.	Cypressvine morningglory
Kummerowia stipulacea (Maxim.)	Makino Korean clover
Kummerowia striata (Thunb.) Schindl	Japanese clover
Lysimachia nummularia L.	Moneywort, creeping Jenny
Melilotus albus Medik.	White sweet clover
Melilotus officinalis (L.) Lam.	Yellow sweet clover
Najas minor All.	Brittle naiad
Pastinaca sativa L.	Wild parsnip
Perilla frutescens (L.) Britt.	Beefsteakplant
Populus alba L.	White poplar
Senecio vulgaris L.	Ragwort
Setaria faberi R.A.W. Herrm.	Nodding foxtail-grass
Triadica sebifera (L.) Small	Chinese tallowtree
Tussilago farfara L.	Coltsfoot
Vicia sativa L.	Garden vetch
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* *Baccharis halimifolia* is native to marshes and marsh borders on the outer Coastal Plain in NC, but has spread along road corridors to invade disturbed areas in the Piedmont, which is not considered its native habitat.

Watch List A

Exotic plants that naturalize and may become a problem in the future; includes species that are or could become widespread in North Carolina. At this time, more information is needed.

Scientific name	**Common name**
Arum italicum P. Mill.	Italian lords and ladies
Buglossoides arvensis (L.) I.M. Johnston (L.) I.M.	Corn gromwell
Bupleurum rotundifolium L.	Hound's-ear, hare's ear
Centaurea cyanus L.	cornflower
Echium vulgare L.	Viper’s bugloss
Elaeagnus pungens Thunb	Thorny olive
Hibiscus syriacus L.	Rose of Sharon
Hypericum perforatum L.	St. John’s-wort
Ornithogalum umbellatum L.	Star of Bethlehem
Solanum dulcamara L.	Climbing nightshade
Verbascum thapsus L.	Common mullein
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Watch List B

Exotic plant species that cause problems in adjacent states but have not yet been reported to cause problems in NC.

Scientific name	Common name
Acer platanoides L.	Norway maple
Akebia quinata (Houtt.) Dcne.	Fiveleaf akebia
Bromus inermis Leyss.	Smooth bromegrass
Cardiospermum halicacabum L.	Balloonvine
Carduus nutans L.	Musk thistle
Cirsium arvense (L.) Scop.	Canada thistle
Commelina benghalensis L.	Bengal dayflower
Elaeagnus pungens Thunb.	Thorny-olive
Hesperis matronalis L.	Dame's rocket
Iris pseudoacorus L.	Pale-yellow iris
Lonicera tatarica L.	Tartarian honeysuckle
Melia azedarach L.	Chinaberry
Persicaria perfoliata (Linnaeus) H. Gross (=Polygonum perfoliatum L.)	Mile-a-minute vine
Pistia stratiotes L.	Watter-lettuce
Potamogeton crispus L.	Curly pondweed
Quercus acutissima Carruthers	Sawtooth oak
Rhamnus cathartica L.	European buckthorn
Setaria italica (L.) P. Beauv.	Foxtail-millet
Setaria verticillata (L.) Beauv.	Bur-foxtail
Setaria viridis (L.) P. Beauv.	Green millet
Stachys floridana Shuttlw. ex Benth.	Florida Hedge nettle
Torilis arvensis (Huds.) Link	Spreading hedge-parsley
Tragopogon dubius Scop.	Yellow goat's-beard
Trapa natans L.	Water Chestnut
Tribulus terrestris L.	Puncturevine
Xanthium spinosum L.	Spiny cocklebur
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References

NatureServe Explorer has a new U.S. invasive species assessments on their web site
http://www.natureserve.org/explorer/

NC Botanical Gardens, Invasive Exotic Plants: Publications and Resources
http://ncbg.unc.edu/pages/12/

USDA National Agricultural Library
http://www.invasivespeciesinfo.gov/plants/main.shtml

Ecology and Management of Invasive Plants Program

http://www.invasiveplants.net/

Center for Invasive Plant Management
http://www.weedcenter.org/

Invasive and Exotic Species
http://www.invasive.org/

Invasive Plants, Changing the Landscape of America
https://www.denix.osd.mil/denix/Public/ES-Programs/Conservation/Invasive/intro.html

Guidelines for Riparian Buffer Restoration
http://h2o.enr.state.nc.us/wrp/pdf/buffers.pdf

Alien Plant Invaders of Natural Areas - Fact Sheets
http://www.nps.gov/plants/alien/factmain.htm

North Carolina Exotic Pest Plant Council
http://www.se-eppc.org/northcarolina/

Landscaping with Native Plants
NC Native Plant Society Table of Contents

August 2006

Population Overview: 2000-2030

Source - http://demog.state.nc.us/demog/pop0030.html

	.....Population.....						
County	**April 2000**	**July 2005**	**April 2010**	**July 2015**	**April 2020**	**July 2025**	**April 2030**
ALAMANCE	130,794	138,364	146,085	156,242	165,911	176,990	187,203
ALEXANDER	33,609	35,818	37,839	39,765	41,509	43,361	44,976
ALLEGHANY	10,680	10,877	11,320	11,621	11,869	12,094	12,266
ANSON	25,275	25,672	24,729	24,521	24,303	24,047	23,748
ASHE	24,384	25,420	26,808	27,701	28,450	29,171	29,780
AVERY	17,167	17,906	18,366	18,689	18,920	18,922	18,846
BEAUFORT	44,958	45,896	47,510	48,441	49,158	49,770	50,207
BERTIE	19,757	19,526	18,889	18,505	18,079	17,589	17,066
BLADEN	32,279	32,805	33,320	34,145	34,822	35,528	36,130
BRUNSWICK	73,141	89,481	110,374	125,107	138,169	151,959	164,165
BUNCOMBE	206,299	216,271	234,697	249,468	262,838	277,262	289,908
BURKE	89,145	88,266	90,108	92,126	94,021	96,040	97,626
CABARRUS	131,030	150,228	176,774	200,025	221,997	247,329	271,194
CALDWELL	77,710	78,664	81,057	82,536	83,830	85,073	85,966
CAMDEN	6,885	9,020	10,488	11,996	13,378	14,875	16,241
CARTERET	59,383	62,900	66,222	68,874	70,997	72,828	74,116
CASWELL	23,501	23,674	23,605	24,185	24,700	25,201	25,603
CATAWBA	141,677	148,797	158,468	168,180	177,187	187,259	196,363
CHATHAM	49,334	56,123	62,772	69,411	75,557	82,390	88,671
CHEROKEE	24,298	26,113	28,505	30,201	31,636	33,022	34,177
CHOWAN	14,150	14,411	15,192	15,506	15,745	15,923	16,028
CLAY	8,775	9,865	10,928	11,765	12,470	13,142	13,709
CLEVELAND	96,284	96,817	97,155	99,204	101,157	103,263	104,933
COLUMBUS	54,749	54,248	55,581	56,303	56,869	57,434	57,823
CRAVEN	91,523	94,207	99,151	102,212	104,667	106,823	108,411

	.....Population.....						
County	**April 2000**	**July 2005**	**April 2010**	**July 2015**	**April 2020**	**July 2025**	**April 2030**
CUMBERLAND	302,962	304,380	311,777	321,941	330,759	340,035	347,460
CURRITUCK	18,190	22,976	26,311	30,125	33,599	37,332	40,689
DARE	29,967	34,576	36,432	40,359	43,892	47,535	50,831
DAVIDSON	147,269	154,179	160,499	168,440	175,834	183,898	191,080
DAVIE	34,835	38,814	43,165	47,156	50,846	54,953	58,682
DUPLIN	49,063	51,788	55,665	59,831	63,742	68,336	72,638
DURHAM	223,306	241,680	262,256	281,608	299,410	319,361	337,743
EDGECOMBE	55,606	52,890	51,273	49,397	47,514	45,539	43,534
FORSYTH	306,044	325,724	350,784	373,508	394,528	418,295	439,967
FRANKLIN	47,260	54,005	59,951	66,673	72,951	79,927	86,324
GASTON	190,310	193,770	205,489	211,178	216,097	221,056	224,946
GATES	10,516	11,188	12,517	13,289	13,981	14,689	15,301
GRAHAM	7,993	8,048	8,257	8,412	8,534	8,632	8,699
GRANVILLE	48,498	53,196	56,645	61,080	65,137	69,503	73,388
GREENE	18,974	20,186	21,579	22,973	24,261	25,658	26,929
GUILFORD	421,048	440,913	474,605	505,100	533,495	565,249	593,830
HALIFAX	57,370	55,959	54,591	53,933	53,206	52,328	51,328
HARNETT	91,062	101,486	111,676	123,734	135,012	147,679	159,155
HAYWOOD	54,034	56,249	58,137	60,633	62,890	65,180	67,144
HENDERSON	89,204	97,751	107,680	117,283	126,163	135,956	144,989
HERTFORD	22,977	23,780	24,097	23,949	23,704	23,381	23,013
HOKE	33,646	40,428	48,162	55,781	63,034	71,430	79,427
HYDE	5,826	5,562	5,412	5,352	5,281	5,181	5,073
IREDELL	122,664	139,419	161,561	180,694	198,632	218,890	237,564
JACKSON	33,120	35,649	38,084	39,738	41,153	42,526	43,697
JOHNSTON	121,900	146,221	170,388	196,719	221,636	250,340	277,292
JONES	10,398	10,224	10,524	10,621	10,691	10,756	10,768

	.....Population.....						
County	**April 2000**	**July 2005**	**April 2010**	**July 2015**	**April 2020**	**July 2025**	**April 2030**
LEE	49,172	54,152	59,180	64,251	68,948	74,250	79,148
LENOIR	59,619	58,209	58,032	57,517	56,966	56,337	55,594
LINCOLN	63,780	69,437	76,958	83,669	89,825	96,557	102,567
MCDOWELL	42,151	43,119	45,143	47,036	48,747	50,571	52,144
MACON	29,806	32,373	35,452	38,358	41,008	43,816	46,345
MADISON	19,635	20,259	21,144	21,952	22,676	23,408	24,022
MARTIN	25,546	24,458	24,024	23,444	22,878	22,276	21,657
MECKLENBURG	695,427	795,361	925,084	1,042,399	1,151,640	1,275,869	1,391,703
MITCHELL	15,687	15,851	15,992	16,254	16,467	16,629	16,736
MONTGOMERY	26,836	27,342	28,222	29,300	30,299	31,449	32,486
MOORE	74,770	80,628	87,816	94,585	100,824	107,561	113,638
NASH	87,385	91,392	95,503	99,895	103,873	108,100	111,706
NEW HANOVER	160,327	179,944	200,401	219,531	236,605	254,874	271,030
NORTHAMPTON	22,086	21,488	21,522	21,427	21,312	21,166	20,973
ONSLOW	150,355	157,760	166,769	167,389	167,661	167,165	166,283
ORANGE	115,537	122,052	129,313	137,210	144,237	151,500	157,806
PAMLICO	12,934	13,068	13,279	13,538	13,733	13,867	13,942
PASQUOTANK	34,897	38,760	43,373	46,435	49,087	51,787	54,141
PENDER	41,082	46,599	54,884	61,200	66,926	73,046	78,479
PERQUIMANS	11,368	12,148	13,352	14,043	14,633	15,206	15,700
PERSON	35,623	37,125	38,679	40,696	42,520	44,446	46,117
PITT	133,719	143,125	156,000	167,164	177,289	188,335	198,152
POLK	18,324	18,950	19,721	20,878	21,982	23,174	24,223
RANDOLPH	130,470	137,122	144,643	153,688	162,178	171,604	180,076
RICHMOND	46,551	46,586	47,046	47,060	47,019	46,955	46,757
ROBESON	123,241	127,644	134,001	139,883	145,133	150,812	155,753
ROCKINGHAM	91,928	91,737	92,222	92,944	93,526	94,125	94,430

	.....Population.....						
County	**April 2000**	**July 2005**	**April 2010**	**July 2015**	**April 2020**	**July 2025**	**April 2030**
ROWAN	130,348	133,156	138,931	145,719	152,160	159,290	165,647
RUTHERFORD	62,901	63,185	63,610	64,650	65,571	66,496	67,149
SAMPSON	60,160	63,403	67,207	72,272	77,039	82,545	87,624
SCOTLAND	35,998	36,761	37,569	37,672	37,670	37,603	37,392
STANLY	58,100	58,854	60,134	61,854	63,401	64,981	66,247
STOKES	44,707	46,156	47,515	49,483	51,279	53,154	54,723
SURRY	71,227	72,877	74,629	77,162	79,594	82,376	84,859
SWAIN	12,973	13,650	14,765	15,602	16,374	17,164	17,871
TRANSYLVANIA	29,334	29,846	31,574	32,463	33,178	33,787	34,219
TYRRELL	4,149	4,205	4,341	4,374	4,386	4,385	4,377
UNION	123,738	161,260	203,527	239,852	274,147	313,635	350,928
VANCE	42,954	43,478	44,890	46,210	47,395	48,732	49,857
WAKE	627,865	755,967	900,072	1,041,590	1,173,840	1,324,216	1,464,029
WARREN	19,972	20,088	19,975	20,420	20,814	21,177	21,457
WASHINGTON	13,723	13,414	13,200	12,879	12,535	12,152	11,759
WATAUGA	42,693	42,854	44,433	45,302	45,984	46,510	46,866
WAYNE	113,329	115,328	116,693	119,731	122,376	125,155	127,537
WILKES	65,624	66,682	67,778	69,257	70,564	71,897	72,983
WILSON	73,811	76,730	80,063	83,352	86,301	89,542	92,348
YADKIN	36,348	37,408	39,341	41,337	43,234	45,357	47,243
YANCEY	17,774	18,143	19,032	19,644	20,173	20,672	21,063

Total

NORTH CAROLINA	**April 2000**	**July 2005**	**April 2010**	**July 2015**	**April 2020**	**July 2025**	**April 2030**
	8,046,813	8,672,544	9,450,494	10,178,807	10,850,228	11,596,651	12,274,433

County Population Growth 2000 - 2010

(to open/download as Excel Spreadsheet, click here)

...go to 2000-2010 Growth Map

..go to state	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2000	2010	Amount	%	Births	Deaths	Growth	Amount	%
ALAMANCE	130,794	146,085	15,291	11.7	18,688	12,965	5,723	9,568	7.3
ALEXANDER	33,609	37,839	4,230	12.6	4,191	2,963	1,228	3,002	8.9
ALLEGHANY	10,680	11,320	640	6.0	1,005	1,353	-347	987	9.2
ANSON	25,275	24,729	-546	-2.2	3,135	2,706	429	-975	-3.9
ASHE	24,384	26,808	2,424	9.9	2,587	3,010	-423	2,847	11.7
AVERY	17,167	18,366	1,199	7.0	1,649	1,934	-285	1,484	8.6
BEAUFORT	44,958	47,510	2,552	5.7	5,974	5,612	362	2,190	4.9
BERTIE	19,757	18,889	-868	-4.4	2,393	2,553	-160	-708	-3.6
BLADEN	32,279	33,320	1,041	3.2	4,504	3,748	756	285	0.9
BRUNSWICK	73,141	110,374	37,233	50.9	9,562	9,307	255	36,978	50.6
..go to state	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2000	2010	Amount	%	Births	Deaths	Growth	Amount	%
BUNCOMBE	206,299	234,697	28,398	13.8	26,199	22,567	3,632	24,766	12.0
BURKE	89,145	90,108	963	1.1	10,238	8,292	1,945	-982	-1.1
CABARRUS	131,030	176,774	45,744	34.9	23,674	11,698	11,976	33,768	25.8
CALDWELL	77,710	81,057	3,347	4.3	9,405	7,518	1,888	1,459	1.9
CAMDEN	6,885	10,488	3,603	52.3	992	765	227	3,376	49.0
CARTERET	59,383	66,222	6,839	11.5	6,247	7,250	-1,004	7,843	13.2
CASWELL	23,501	23,605	104	0.4	2,467	2,286	181	-77	-0.3
CATAWBA	141,677	158,468	16,791	11.9	20,551	13,114	7,437	9,354	6.6
CHATHAM	49,334	62,772	13,438	27.2	7,325	5,307	2,019	11,419	23.1
CHEROKEE	24,298	28,505	4,207	17.3	2,688	3,161	-473	4,680	19.3
..go to state	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2000	2010	Amount	%	Births	Deaths	Growth	Amount	%
CHOWAN	14,150	15,192	1,042	7.4	1,807	1,868	-61	1,103	7.8
CLAY	8,775	10,928	2,153	24.5	858	1,234	-376	2,529	28.8
CLEVELAND	96,284	97,155	871	0.9	12,108	9,778	2,330	-1,459	-1.5
COLUMBUS	54,749	55,581	832	1.5	7,562	6,079	1,483	-651	-1.2
CRAVEN	91,523	99,151	7,628	8.3	15,535	8,832	6,703	925	1.0
CUMBERLAND	302,962	311,777	8,815	2.9	54,262	20,387	33,875	-25,060	-8.3
CURRITUCK	18,190	26,311	8,121	44.6	2,551	1,993	558	7,563	41.6
DARE	29,967	36,432	6,465	21.6	4,287	2,636	1,651	4,814	16.1
DAVIDSON	147,269	160,499	13,230	9.0	19,354	13,428	5,926	7,304	5.0
DAVIE	34,835	43,165	8,330	23.9	4,537	3,522	1,014	7,316	21.0

..go to state	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2000	2010	Amount	%	Births	Deaths	Growth	Amount	%
DUPLIN	49,063	55,665	6,602	13.5	8,096	5,203	2,892	3,710	7.6
DURHAM	223,306	262,256	38,950	17.4	39,843	18,487	21,355	17,595	7.9
EDGECOMBE	55,606	51,273	-4,333	-7.8	7,413	5,869	1,544	-5,877	-10.6
FORSYTH	306,044	350,784	44,740	14.6	47,240	28,897	18,343	26,397	8.6
FRANKLIN	47,260	59,951	12,691	26.9	7,007	4,394	2,613	10,078	21.3
GASTON	190,310	205,489	15,179	8.0	25,777	19,204	6,573	8,606	4.5
GATES	10,516	12,517	2,001	19.0	1,188	1,238	-51	2,052	19.5
GRAHAM	7,993	8,257	264	3.3	992	1,019	-27	291	3.6
GRANVILLE	48,498	56,645	8,147	16.8	6,242	4,589	1,652	6,495	13.4
GREENE	18,974	21,579	2,605	13.7	2,563	1,729	835	1,770	9.3
..go to state	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2000	2010	Amount	%	Births	Deaths	Growth	Amount	%
GUILFORD	421,048	474,605	53,557	12.7	60,238	37,123	23,115	30,442	7.2
HALIFAX	57,370	54,591	-2,779	-4.8	7,243	6,709	534	-3,313	-5.8
HARNETT	91,062	111,676	20,614	22.6	15,057	7,732	7,325	13,289	14.6
HAYWOOD	54,034	58,137	4,103	7.6	5,697	6,506	-810	4,913	9.1
HENDERSON	89,204	107,680	18,476	20.7	11,555	11,816	-261	18,737	21.0
HERTFORD	22,977	24,097	1,120	4.9	2,976	2,841	135	985	4.3
HOKE	33,646	48,162	14,516	43.1	7,465	2,520	4,945	9,571	28.4
HYDE	5,826	5,412	-414	-7.1	560	693	-133	-281	-4.8
IREDELL	122,664	161,561	38,897	31.7	19,457	11,835	7,622	31,275	25.5
JACKSON	33,120	38,084	4,964	15.0	3,726	3,121	605	4,359	13.2
..go to state	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2000	2010	Amount	%	Births	Deaths	Growth	Amount	%
JOHNSTON	121,900	170,388	48,488	39.8	23,108	10,737	12,371	36,117	29.6
JONES	10,398	10,524	126	1.2	920	1,181	-261	387	3.7
LEE	49,172	59,180	10,008	20.4	8,591	5,008	3,583	6,425	13.1
LENOIR	59,619	58,032	-1,587	-2.7	7,840	6,933	907	-2,494	-4.2
LINCOLN	63,780	76,958	13,178	20.7	8,976	5,703	3,274	9,904	15.5
MCDOWELL	42,151	45,143	2,992	7.1	5,142	4,200	942	2,050	4.9
MACON	29,806	35,452	5,646	18.9	3,371	3,922	-550	6,196	20.8
MADISON	19,635	21,144	1,509	7.7	2,128	2,186	-58	1,567	8.0
MARTIN	25,546	24,024	-1,522	-6.0	2,999	2,929	70	-1,592	-6.2
MECKLENBURG	695,427	925,084	229,657	33.0	132,855	51,860	80,995	148,662	21.4
..go to state	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2000	2010	Amount	%	Births	Deaths	Growth	Amount	%
MITCHELL	15,687	15,992	305	1.9	1,616	1,930	-314	619	3.9
MONTGOMERY	26,836	28,222	1,386	5.2	3,911	2,629	1,282	104	0.4
MOORE	74,770	87,816	13,046	17.4	9,538	9,411	127	12,919	17.3
NASH	87,385	95,503	8,118	9.3	12,234	8,857	3,376	4,742	5.4

NEW HANOVER	160,327	200,401	40,074	25.0	22,125	15,566	6,560	33,514	20.9
NORTHAMPTON	22,086	21,522	-564	-2.6	2,375	2,748	-373	-191	-0.9
ONSLOW	150,355	166,769	16,414	10.9	32,836	7,972	24,864	-8,450	-5.6
ORANGE	115,537	129,313	13,776	11.9	13,509	7,204	6,305	7,471	6.5
PAMLICO	12,934	13,279	345	2.7	1,070	1,537	-467	812	6.3
PASQUOTANK	34,897	43,373	8,476	24.3	5,188	4,031	1,157	7,319	21.0
..go to state	**Pop.**	**Pop.**	**Growth**				**Natural**	**Net Migr.**	
County	**2000**	**2010**	**Amount**	**%**	**Births**	**Deaths**	**Growth**	**Amount**	**%**
PENDER	41,082	54,884	13,802	33.6	5,110	4,364	746	13,056	31.8
PERQUIMANS	11,368	13,352	1,984	17.5	1,279	1,523	-244	2,228	19.6
PERSON	35,623	38,679	3,056	8.6	4,590	3,524	1,065	1,991	5.6
PITT	133,719	156,000	22,281	16.7	20,616	11,289	9,328	12,953	9.7
POLK	18,324	19,721	1,397	7.6	1,745	2,674	-928	2,325	12.7
RANDOLPH	130,470	144,643	14,173	10.9	18,200	11,106	7,094	7,079	5.4
RICHMOND	46,551	47,046	495	1.1	6,259	5,086	1,173	-678	-1.5
ROBESON	123,241	134,001	10,760	8.7	20,604	11,322	9,282	1,478	1.2
ROCKINGHAM	91,928	92,222	294	0.3	10,982	9,992	990	-696	-0.8
ROWAN	130,348	138,931	8,583	6.6	16,759	13,246	3,513	5,070	3.9
..go to state	**Pop.**	**Pop.**	**Growth**				**Natural**	**Net Migr.**	
County	**2000**	**2010**	**Amount**	**%**	**Births**	**Deaths**	**Growth**	**Amount**	**%**
RUTHERFORD	62,901	63,610	709	1.1	7,726	7,159	567	142	0.2
SAMPSON	60,160	67,207	7,047	11.7	9,194	6,148	3,047	4,000	6.6
SCOTLAND	35,998	37,569	1,571	4.4	4,858	3,673	1,185	386	1.1
STANLY	58,100	60,134	2,034	3.5	7,358	5,944	1,413	621	1.1
STOKES	44,707	47,515	2,808	6.3	4,905	4,035	870	1,938	4.3
SURRY	71,227	74,629	3,402	4.8	9,044	7,727	1,316	2,086	2.9
SWAIN	12,973	14,765	1,792	13.8	1,841	1,588	253	1,539	11.9
TRANSYLVANIA	29,334	31,574	2,240	7.6	2,750	3,649	-899	3,139	10.7
TYRRELL	4,149	4,341	192	4.6	443	446	-3	195	4.7
UNION	123,738	203,527	79,789	64.5	26,077	10,412	15,665	64,124	51.8
..go to state	**Pop.**	**Pop.**	**Growth**				**Natural**	**Net Migr.**	
County	**2000**	**2010**	**Amount**	**%**	**Births**	**Deaths**	**Growth**	**Amount**	**%**
VANCE	42,954	44,890	1,936	4.5	6,869	4,669	2,200	-264	-0.6
WAKE	627,865	900,072	272,207	43.4	120,458	40,104	80,354	191,853	30.6
WARREN	19,972	19,975	3	0.0	2,008	2,203	-195	198	1.0
WASHINGTON	13,723	13,200	-523	-3.8	1,677	1,620	57	-580	-4.2
WATAUGA	42,693	44,433	1,740	4.1	3,519	2,899	620	1,120	2.6
WAYNE	113,329	116,693	3,364	3.0	17,521	10,594	6,927	-3,563	-3.1
WILKES	65,624	67,778	2,154	3.3	8,232	6,470	1,762	392	0.6
WILSON	73,811	80,063	6,252	8.5	10,686	8,161	2,525	3,727	5.0
YADKIN	36,348	39,341	2,993	8.2	4,723	3,486	1,237	1,756	4.8
YANCEY	17,774	19,032	1,258	7.1	1,824	1,899	-76	1,334	7.5

	Pop.	Pop.	Growth				Natural	Net Migr.	
NORTH	2000	2010	Amount	%	Births	Deaths	Growth	Amount	%
CAROLINA	8,046,813	9,450,494	1,403,681	17.4	1,224,856	742,949	481,907	921,774	11.5

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...go to County/State Projections

Last Update: June 20, 2007

County Population Growth 2010 - 2020

(to open/download as Excel Spreadsheet, click here)

...go to 2010-2020 Growth Map

..go to state	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2010	2020	Amount	%	Births	Deaths	Growth	Amount	%
ALAMANCE	146,085	165,911	19,826	13.6	21,061	13,376	7,686	12,140	8.3
ALEXANDER	37,839	41,509	3,670	9.7	4,472	3,389	1,083	2,587	6.8
ALLEGHANY	11,320	11,869	549	4.8	982	1,428	-446	995	8.8
ANSON	24,729	24,303	-426	-1.7	2,866	2,562	304	-730	-3.0
ASHE	26,808	28,450	1,642	6.1	2,503	3,297	-793	2,435	9.1
AVERY	18,366	18,920	554	3.0	1,511	2,116	-605	1,159	6.3
BEAUFORT	47,510	49,158	1,648	3.5	5,752	6,000	-248	1,896	4.0
BERTIE	18,889	18,079	-810	-4.3	2,060	2,515	-455	-355	-1.9
BLADEN	33,320	34,822	1,502	4.5	4,278	3,840	438	1,064	3.2
BRUNSWICK	110,374	138,169	27,795	25.2	12,585	13,630	-1,044	28,839	26.1
..go to state	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2010	2020	Amount	%	Births	Deaths	Growth	Amount	%
BUNCOMBE	234,697	262,838	28,141	12.0	28,959	24,479	4,480	23,661	10.1
BURKE	90,108	94,021	3,913	4.3	10,571	8,485	2,086	1,827	2.0
CABARRUS	176,774	221,997	45,223	25.6	29,934	13,947	15,987	29,236	16.5
CALDWELL	81,057	83,830	2,773	3.4	9,414	8,116	1,298	1,475	1.8
CAMDEN	10,488	13,378	2,890	27.6	1,384	1,024	359	2,531	24.1
CARTERET	66,222	70,997	4,775	7.2	6,525	8,723	-2,199	6,974	10.5
CASWELL	23,605	24,700	1,095	4.6	2,473	2,274	199	896	3.8
CATAWBA	158,468	177,187	18,719	11.8	22,436	14,422	8,014	10,705	6.8
CHATHAM	62,772	75,557	12,785	20.4	8,942	6,402	2,540	10,245	16.3
CHEROKEE	28,505	31,636	3,131	11.0	2,764	3,738	-974	4,105	14.4
..go to state	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2010	2020	Amount	%	Births	Deaths	Growth	Amount	%
CHOWAN	15,192	15,745	553	3.6	1,811	1,982	-171	724	4.8
CLAY	10,928	12,470	1,542	14.1	901	1,533	-633	2,175	19.9
CLEVELAND	97,155	101,157	4,002	4.1	12,449	9,816	2,633	1,369	1.4
COLUMBUS	55,581	56,869	1,288	2.3	7,234	6,167	1,067	221	0.4
CRAVEN	99,151	104,667	5,516	5.6	15,612	10,317	5,295	221	0.2
CUMBERLAND	311,777	330,759	18,982	6.1	56,224	22,568	33,656	-14,674	-4.7
CURRITUCK	26,311	33,599	7,288	27.7	3,438	2,674	764	6,524	24.8
DARE	36,432	43,892	7,460	20.5	5,077	3,337	1,740	5,720	15.7
DAVIDSON	160,499	175,834	15,335	9.6	20,915	14,704	6,210	9,125	5.7
DAVIE	43,165	50,846	7,681	17.8	5,358	4,202	1,156	6,525	15.1

..go to state	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2010	2020	Amount	%	Births	Deaths	Growth	Amount	%
DUPLIN	55,665	63,742	8,077	14.5	8,930	5,412	3,518	4,559	8.2
DURHAM	262,256	299,410	37,154	14.2	44,083	20,681	23,402	13,752	5.2
EDGECOMBE	51,273	47,514	-3,759	-7.3	6,495	5,591	905	-4,664	-9.1
FORSYTH	350,784	394,528	43,744	12.5	53,270	32,064	21,206	22,538	6.4
FRANKLIN	59,951	72,951	13,000	21.7	8,539	5,089	3,450	9,550	15.9
GASTON	205,489	216,097	10,608	5.2	26,332	20,742	5,590	5,018	2.4
GATES	12,517	13,981	1,464	11.7	1,371	1,383	-12	1,476	11.8
GRAHAM	8,257	8,534	277	3.4	983	1,095	-112	389	4.7
GRANVILLE	56,645	65,137	8,492	15.0	7,039	5,148	1,891	6,601	11.7
GREENE	21,579	24,261	2,682	12.4	2,827	1,861	966	1,716	8.0
..go to state	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2010	2020	Amount	%	Births	Deaths	Growth	Amount	%
GUILFORD	474,605	533,495	58,890	12.4	66,951	40,337	26,614	32,276	6.8
HALIFAX	54,591	53,206	-1,385	-2.5	6,645	6,519	126	-1,511	-2.8
HARNETT	111,676	135,012	23,336	20.9	18,024	8,808	9,215	14,121	12.6
HAYWOOD	58,137	62,890	4,753	8.2	6,042	7,006	-963	5,716	9.8
HENDERSON	107,680	126,163	18,483	17.2	13,441	13,352	88	18,395	17.1
HERTFORD	24,097	23,704	-393	-1.6	2,836	2,928	-93	-300	-1.2
HOKE	48,162	63,034	14,872	30.9	9,648	3,168	6,480	8,392	17.4
HYDE	5,412	5,281	-131	-2.4	466	646	-180	49	0.9
IREDELL	161,561	198,632	37,071	22.9	24,424	14,376	10,048	27,023	16.7
JACKSON	38,084	41,153	3,069	8.1	3,847	3,554	292	2,777	7.3
..go to state	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2010	2020	Amount	%	Births	Deaths	Growth	Amount	%
JOHNSTON	170,388	221,636	51,248	30.1	29,643	13,206	16,437	34,811	20.4
JONES	10,524	10,691	167	1.6	917	1,216	-299	466	4.4
LEE	59,180	68,948	9,768	16.5	9,815	5,627	4,188	5,580	9.4
LENOIR	58,032	56,966	-1,066	-1.8	7,318	6,904	415	-1,481	-2.6
LINCOLN	76,958	89,825	12,867	16.7	10,342	6,755	3,588	9,279	12.1
MCDOWELL	45,143	48,747	3,604	8.0	5,298	4,447	851	2,753	6.1
MACON	35,452	41,008	5,556	15.7	3,975	4,444	-469	6,025	17.0
MADISON	21,144	22,676	1,532	7.2	2,137	2,292	-155	1,687	8.0
MARTIN	24,024	22,878	-1,146	-4.8	2,717	2,818	-101	-1,045	-4.3
MECKLENBURG	925,084	1,151,640	226,556	24.5	161,325	64,285	97,041	129,515	14.0
..go to state	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2010	2020	Amount	%	Births	Deaths	Growth	Amount	%
MITCHELL	15,992	16,467	475	3.0	1,600	1,992	-392	867	5.4
MONTGOMERY	28,222	30,299	2,077	7.4	4,094	2,767	1,327	750	2.7
MOORE	87,816	100,824	13,008	14.8	10,975	10,618	357	12,651	14.4
NASH	95,503	103,873	8,370	8.8	13,041	9,605	3,436	4,934	5.2

NEW HANOVER	200,401	236,605	36,204	18.1	25,169	19,130	6,039	30,165	15.1
NORTHAMPTON	21,522	21,312	-210	-1.0	2,266	2,697	-431	221	1.0
ONSLOW	166,769	167,661	892	0.5	34,405	9,141	25,264	-24,372	-14.6
ORANGE	129,313	144,237	14,924	11.5	14,579	8,224	6,355	8,569	6.6
PAMLICO	13,279	13,733	454	3.4	1,008	1,642	-634	1,088	8.2
PASQUOTANK	43,373	49,087	5,714	13.2	5,780	4,733	1,047	4,667	10.8
..go to state	**Pop.**	**Pop.**	**Growth**				**Natural**	**Net Migr.**	
County	**2010**	**2020**	**Amount**	**%**	**Births**	**Deaths**	**Growth**	**Amount**	**%**
PENDER	54,884	66,926	12,042	21.9	6,394	5,582	811	11,231	20.5
PERQUIMANS	13,352	14,633	1,281	9.6	1,370	1,741	-371	1,652	12.4
PERSON	38,679	42,520	3,841	9.9	4,891	3,749	1,142	2,699	7.0
PITT	156,000	177,289	21,289	13.6	22,849	12,963	9,886	11,403	7.3
POLK	19,721	21,982	2,261	11.5	1,962	2,718	-756	3,017	15.3
RANDOLPH	144,643	162,178	17,535	12.1	19,953	12,110	7,843	9,692	6.7
RICHMOND	47,046	47,019	-27	-0.1	6,036	5,000	1,036	-1,063	-2.3
ROBESON	134,001	145,133	11,132	8.3	21,181	12,030	9,151	1,981	1.5
ROCKINGHAM	92,222	93,526	1,304	1.4	10,721	10,068	653	651	0.7
ROWAN	138,931	152,160	13,229	9.5	18,176	13,140	5,036	8,193	5.9
..go to state	**Pop.**	**Pop.**	**Growth**				**Natural**	**Net Migr.**	
County	**2010**	**2020**	**Amount**	**%**	**Births**	**Deaths**	**Growth**	**Amount**	**%**
RUTHERFORD	63,610	65,571	1,961	3.1	7,664	7,245	419	1,542	2.4
SAMPSON	67,207	77,039	9,832	14.6	10,079	6,316	3,762	6,070	9.0
SCOTLAND	37,569	37,670	101	0.3	4,846	3,892	954	-853	-2.3
STANLY	60,134	63,401	3,267	5.4	7,626	5,950	1,676	1,591	2.6
STOKES	47,515	51,279	3,764	7.9	5,116	4,427	690	3,074	6.5
SURRY	74,629	79,594	4,965	6.7	9,312	7,956	1,356	3,609	4.8
SWAIN	14,765	16,374	1,609	10.9	2,109	1,746	363	1,246	8.4
TRANSYLVANIA	31,574	33,178	1,604	5.1	2,838	4,112	-1,274	2,878	9.1
TYRRELL	4,341	4,386	45	1.0	366	430	-64	109	2.5
UNION	203,527	274,147	70,620	34.7	36,358	15,206	21,152	49,468	24.3
..go to state	**Pop.**	**Pop.**	**Growth**				**Natural**	**Net Migr.**	
County	**2010**	**2020**	**Amount**	**%**	**Births**	**Deaths**	**Growth**	**Amount**	**%**
VANCE	44,890	47,395	2,505	5.6	7,064	4,740	2,324	181	0.4
WAKE	900,072	1,173,840	273,768	30.4	156,324	54,883	101,441	172,327	19.1
WARREN	19,975	20,814	839	4.2	2,024	2,149	-125	964	4.8
WASHINGTON	13,200	12,535	-665	-5.0	1,471	1,644	-173	-492	-3.7
WATAUGA	44,433	45,984	1,551	3.5	3,464	3,160	304	1,247	2.8
WAYNE	116,693	122,376	5,683	4.9	18,102	11,180	6,922	-1,239	-1.1
WILKES	67,778	70,564	2,786	4.1	8,172	6,874	1,299	1,487	2.2
WILSON	80,063	86,301	6,238	7.8	11,161	8,706	2,455	3,783	4.7
YADKIN	39,341	43,234	3,893	9.9	5,154	3,612	1,542	2,351	6.0
YANCEY	19,032	20,173	1,141	6.0	1,837	2,066	-229	1,370	7.2

	Pop.	Pop.	Growth				Natural	Net Migr.	
NORTH	2010	2020	Amount	%	Births	Deaths	Growth	Amount	%
CAROLINA	9,450,494	10,850,228	1,399,734	14.8	1,383,709	838,760	544,948	854,786	9.0

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Last Update: June 21, 2007

County Population Growth 2020 - 2030

(to open/download as Excel Spreadsheet, click here)

...go to 2020-2030 Growth Map

..go to state	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2020	2030	Amount	%	Births	Deaths	Growth	Amount	%
ALAMANCE	165,911	187,203	21,292	12.8	23,907	14,476	9,431	11,860	7.1
ALEXANDER	41,509	44,976	3,467	8.4	4,901	3,899	1,002	2,466	5.9
ALLEGHANY	11,869	12,266	397	3.3	1,009	1,559	-550	948	8.0
ANSON	24,303	23,748	-555	-2.3	2,669	2,584	85	-640	-2.6
ASHE	28,450	29,780	1,330	4.7	2,604	3,646	-1,042	2,372	8.3
AVERY	18,920	18,846	-74	-0.4	1,408	2,325	-917	843	4.5
BEAUFORT	49,158	50,207	1,049	2.1	5,739	6,540	-801	1,850	3.8
BERTIE	18,079	17,066	-1,013	-5.6	1,758	2,580	-822	-191	-1.1
BLADEN	34,822	36,130	1,308	3.8	4,380	4,109	271	1,036	3.0
BRUNSWICK	138,169	164,165	25,996	18.8	14,996	17,472	-2,476	28,472	20.6
	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2020	2030	Amount	%	Births	Deaths	Growth	Amount	%
BUNCOMBE	262,838	289,908	27,070	10.3	31,021	27,404	3,618	23,452	8.9
BURKE	94,021	97,626	3,605	3.8	10,989	9,088	1,901	1,705	1.8
CABARRUS	221,997	271,194	49,197	22.2	37,194	16,970	20,224	28,973	13.1
CALDWELL	83,830	85,966	2,136	2.5	9,643	8,902	741	1,395	1.7
CAMDEN	13,378	16,241	2,863	21.4	1,729	1,288	440	2,423	18.1
CARTERET	70,997	74,116	3,119	4.4	6,389	10,143	-3,754	6,873	9.7
CASWELL	24,700	25,603	903	3.7	2,515	2,432	83	820	3.3
CATAWBA	177,187	196,363	19,176	10.8	25,002	16,248	8,754	10,422	5.9
CHATHAM	75,557	88,671	13,114	17.4	10,531	7,561	2,970	10,144	13.4
CHEROKEE	31,636	34,177	2,541	8.0	2,898	4,324	-1,426	3,968	12.5
	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2020	2030	Amount	%	Births	Deaths	Growth	Amount	%
CHOWAN	15,745	16,028	283	1.8	1,693	2,090	-397	680	4.3
CLAY	12,470	13,709	1,239	9.9	958	1,818	-860	2,100	16.8
CLEVELAND	101,157	104,933	3,776	3.7	12,838	10,423	2,414	1,361	1.3
COLUMBUS	56,869	57,823	954	1.7	7,255	6,509	746	208	0.4
CRAVEN	104,667	108,411	3,744	3.6	15,449	11,684	3,766	-21	0.0
CUMBERLAND	330,759	347,460	16,701	5.0	56,586	25,213	31,373	-14,672	-4.4
CURRITUCK	33,599	40,689	7,090	21.1	4,147	3,456	691	6,399	19.0
DARE	43,892	50,831	6,939	15.8	5,846	4,193	1,654	5,285	12.0
DAVIDSON	175,834	191,080	15,246	8.7	22,985	16,541	6,445	8,802	5.0
DAVIE	50,846	58,682	7,836	15.4	6,375	4,971	1,404	6,432	12.6

	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2020	2030	Amount	%	Births	Deaths	Growth	Amount	%
DUPLIN	63,742	72,638	8,896	14.0	10,350	5,968	4,382	4,514	7.1
DURHAM	299,410	337,743	38,333	12.8	48,826	23,812	25,013	13,319	4.4
EDGECOMBE	47,514	43,534	-3,980	-8.4	5,531	5,587	-56	-3,925	-8.3
FORSYTH	394,528	439,967	45,439	11.5	59,170	35,850	23,319	22,120	5.6
FRANKLIN	72,951	86,324	13,373	18.3	10,231	6,164	4,067	9,306	12.8
GASTON	216,097	224,946	8,849	4.1	26,760	22,726	4,034	4,815	2.2
GATES	13,981	15,301	1,320	9.4	1,458	1,538	-80	1,400	10.0
GRAHAM	8,534	8,699	165	1.9	1,016	1,190	-174	339	4.0
GRANVILLE	65,137	73,388	8,251	12.7	7,839	6,021	1,818	6,433	9.9
GREENE	24,261	26,929	2,668	11.0	3,151	2,056	1,094	1,573	6.5
	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2020	2030	Amount	%	Births	Deaths	Growth	Amount	%
GUILFORD	533,495	593,830	60,335	11.3	73,735	45,106	28,628	31,706	5.9
HALIFAX	53,206	51,328	-1,878	-3.5	5,957	6,640	-683	-1,195	-2.2
HARNETT	135,012	159,155	24,143	17.9	20,736	10,503	10,233	13,910	10.3
HAYWOOD	62,890	67,144	4,254	6.8	6,392	7,663	-1,272	5,525	8.8
HENDERSON	126,163	144,989	18,826	14.9	15,832	15,065	768	18,058	14.3
HERTFORD	23,704	23,013	-691	-2.9	2,492	2,998	-506	-185	-0.8
HOKE	63,034	79,427	16,393	26.0	12,238	3,995	8,243	8,150	12.9
HYDE	5,281	5,073	-208	-3.9	407	663	-256	48	0.9
IREDELL	198,632	237,564	38,932	19.6	29,593	17,473	12,120	26,812	13.5
JACKSON	41,153	43,697	2,544	6.2	4,071	4,063	8	2,536	6.2
	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2020	2030	Amount	%	Births	Deaths	Growth	Amount	%
JOHNSTON	221,636	277,292	55,656	25.1	37,991	16,850	21,141	34,515	15.6
JONES	10,691	10,768	77	0.7	859	1,292	-433	510	4.8
LEE	68,948	79,148	10,200	14.8	11,220	6,409	4,811	5,389	7.8
LENOIR	56,966	55,594	-1,372	-2.4	6,973	7,106	-133	-1,240	-2.2
LINCOLN	89,825	102,567	12,742	14.2	11,760	8,108	3,652	9,090	10.1
MCDOWELL	48,747	52,144	3,397	7.0	5,702	4,923	779	2,618	5.4
MACON	41,008	46,345	5,337	13.0	4,575	5,038	-463	5,800	14.1
MADISON	22,676	24,022	1,346	5.9	2,291	2,543	-252	1,598	7.0
MARTIN	22,878	21,657	-1,221	-5.3	2,480	2,841	-362	-860	-3.8
MECKLENBURG	1,151,640	1,391,703	240,063	20.8	192,611	80,203	112,409	127,655	11.1
	Pop.	Pop.	Growth				Natural	Net Migr.	
County	2020	2030	Amount	%	Births	Deaths	Growth	Amount	%
MITCHELL	16,467	16,736	269	1.6	1,560	2,122	-562	831	5.0
MONTGOMERY	30,299	32,486	2,187	7.2	4,502	3,027	1,475	712	2.3
MOORE	100,824	113,638	12,814	12.7	12,260	11,781	479	12,336	12.2
NASH	103,873	111,706	7,833	7.5	13,743	10,711	3,031	4,801	4.6

NEW HANOVER	236,605	271,030	34,425	14.5	27,750	23,188	4,561	29,864	12.6
NORTHAMPTON	21,312	20,973	-339	-1.6	2,080	2,730	-650	311	1.5
ONSLOW	167,661	166,283	-1,378	-0.8	33,256	9,946	23,309	-24,687	-14.7
ORANGE	144,237	157,806	13,569	9.4	15,479	9,861	5,618	7,951	5.5
PAMLICO	13,733	13,942	209	1.5	961	1,781	-820	1,029	7.5
PASQUOTANK	49,087	54,141	5,054	10.3	5,884	5,385	499	4,556	9.3
	Pop.	**Pop.**	**Growth**				**Natural**	**Net Migr.**	
County	**2020**	**2030**	**Amount**	**%**	**Births**	**Deaths**	**Growth**	**Amount**	**%**
PENDER	66,926	78,479	11,553	17.3	7,370	6,877	493	11,060	16.5
PERQUIMANS	14,633	15,700	1,067	7.3	1,409	1,930	-521	1,587	10.8
PERSON	42,520	46,117	3,597	8.5	5,226	4,199	1,027	2,569	6.0
PITT	177,289	198,152	20,863	11.8	24,927	15,144	9,783	11,080	6.2
POLK	21,982	24,223	2,241	10.2	2,166	2,911	-744	2,985	13.6
RANDOLPH	162,178	180,076	17,898	11.0	22,431	13,793	8,638	9,260	5.7
RICHMOND	47,019	46,757	-262	-0.6	5,832	5,079	753	-1,015	-2.2
ROBESON	145,133	155,753	10,620	7.3	22,174	13,256	8,917	1,703	1.2
ROCKINGHAM	93,526	94,430	904	1.0	10,668	10,560	108	796	0.9
ROWAN	152,160	165,647	13,487	8.9	19,562	14,014	5,547	7,940	5.2
	Pop.	**Pop.**	**Growth**				**Natural**	**Net Migr.**	
County	**2020**	**2030**	**Amount**	**%**	**Births**	**Deaths**	**Growth**	**Amount**	**%**
RUTHERFORD	65,571	67,149	1,578	2.4	7,723	7,705	18	1,560	2.4
SAMPSON	77,039	87,624	10,585	13.7	11,652	7,013	4,639	5,946	7.7
SCOTLAND	37,670	37,392	-278	-0.7	4,564	4,146	418	-696	-1.8
STANLY	63,401	66,247	2,846	4.5	7,690	6,317	1,373	1,473	2.3
STOKES	51,279	54,723	3,444	6.7	5,542	5,078	465	2,980	5.8
SURRY	79,594	84,859	5,265	6.6	10,216	8,502	1,714	3,551	4.5
SWAIN	16,374	17,871	1,497	9.1	2,302	1,943	359	1,138	7.0
TRANSYLVANIA	33,178	34,219	1,041	3.1	2,784	4,523	-1,739	2,780	8.4
TYRRELL	4,386	4,377	-9	-0.2	336	436	-100	91	2.1
UNION	274,147	350,928	76,781	28.0	48,105	20,616	27,489	49,292	18.0
	Pop.	**Pop.**	**Growth**				**Natural**	**Net Migr.**	
County	**2020**	**2030**	**Amount**	**%**	**Births**	**Deaths**	**Growth**	**Amount**	**%**
VANCE	47,395	49,857	2,462	5.2	7,431	5,043	2,388	74	0.2
WAKE	1,173,840	1,464,029	290,189	24.7	192,939	73,997	118,942	171,247	14.6
WARREN	20,814	21,457	643	3.1	1,960	2,226	-267	910	4.4
WASHINGTON	12,535	11,759	-776	-6.2	1,298	1,697	-399	-377	-3.0
WATAUGA	45,984	46,866	882	1.9	3,395	3,547	-151	1,033	2.2
WAYNE	122,376	127,537	5,161	4.2	18,620	12,001	6,619	-1,458	-1.2
WILKES	70,564	72,983	2,419	3.4	8,647	7,571	1,075	1,344	1.9
WILSON	86,301	92,348	6,047	7.0	11,863	9,509	2,354	3,693	4.3
YADKIN	43,234	47,243	4,009	9.3	5,741	3,941	1,800	2,209	5.1
YANCEY	20,173	21,063	890	4.4	1,880	2,281	-401	1,290	6.4

	Pop.	Pop.	Growth				Natural	Net Migr.	
NORTH	2020	2030	Amount	%	Births	Deaths	Growth	Amount	%
CAROLINA	10,850,228	12,274,433	1,424,205	13.1	1,551,585	967,229	584,355	839,849	7.7

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Last Update: June 21, 2007

BALD EAGLE

NORTH CAROLINA WILDLIFE RESOURCES COMMISSION *fact sheet, 2005*

Found throughout North America, the bald eagle has been a symbol of pride and freedom for the United States for many decades. This magnificent bird has a wing span that reaches approximately eight feet as an adult, and it can weigh more than 15 pounds. The bald eagle prefers to live in areas near a source of water because it feeds primarily on fish. The American bald eagle forms life-long pair bonds and will usually return to the same nesting area every year. With a relatively long life span of up to 40 years, the bald eagle does not need to produce very many offspring per year—a female bald eagle will lay one to three eggs every year.

POPULATION DECLINE

Due to large-scale deforestation over past decades, trapping and shooting by early settlers, and poor water quality, bald eagle populations plummeted through the 1950s, '60s and '70s. In the early 1970s, agricultural pesticides such as DDT and PCBs had alarming effects on eagle populations. These pesticides washed into streams, exposing fish and other wildlife to harmful chemicals. When bald eagles ate the toxic prey, they too ingested the harmful chemicals, which caused them to lay soft-shelled eggs that crushed under the weight of the nesting female. Starting in 1972, Congress passed a series of bills banning DDT and providing protection for these and other raptors.

ESTABLISHING A NEW POPULATION

In 1982, the N.C. Wildlife Resources Commission began the North Carolina Bald Eagle Project. One of the first objectives of this project was a "hacking" program, which involved raising eagles in captivity and reintroducing them into the wild. Young eagles were released from artificial nests near Lake Mattamuskeet in Hyde County. Commission biologists released 29 juvenile bald eagles near the lake from 1983 through 1988. These juveniles were monitored intensely around the lake. In 1984, North Carolina's first post-DDT wild bald eagle nest was documented just seven miles from Lake Mattamuskeet. Today, biologists monitor over 80 eagle nesting territories in the state.

A mature bald eagle lands on its nest.

SURVEYS AND MONITORING

Other objectives of the Bald Eagle Project include identifying the location of new bald eagle nests, monitoring activity and productivity of known eagle nests, and providing technical guidance to landowners about how to help

Bald eagle nests are very large and high of the ground.

protect bald eagles and their nesting sites in North Carolina. Commission biologists conduct annual aerial and ground surveys to monitor known bald eagle nests and territorial areas. The number of fledglings are recorded and compiled on an annual basis.

PROVIDING TECHNICAL GUIDANCE

Commission biologists also meet with landowners and timber companies to discuss logging operations around eagle nests. In most circumstances, biologists are able to work with these landowners to protect the eagle nesting sites without substantially interfering with the landowner's objectives.

CURRENT STATUS AND EAGLE RECOVERY

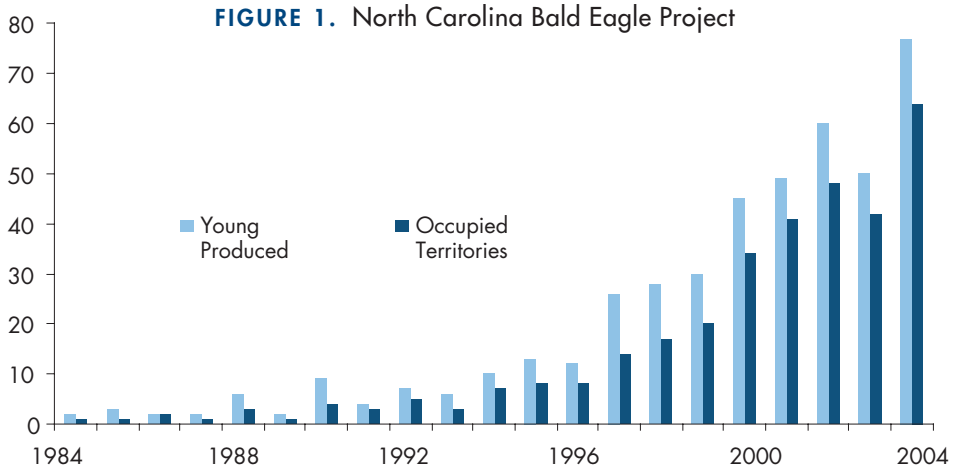
In 1990, the Commission implemented wildlife habitat management practices at Jordan Lake and Falls Lake to provide roosting and nesting habitats for bald eagles. Eagle observation data has shown that eagles prefer large dominant pine trees with an open flight path for roosting and nesting. The Commission created and maintains several of these eagle habitats at both lakes by thinning the timber and allowing individual pine trees to get very large. Eagles have also been enticed to use the Gull Rock and Goose Creek Gamelands.

The recovery of the American bald eagle has certainly been a success story for our state. In 2004, at least 60 active nesting territories had been established and at least 80 eagles fledged in from these nests in North Carolina. With current population trends and continued protection, biologists hope to see many more bald eagles nesting and reproducing across the United States., which should soon lead the delisting of the bald eagle from the federal list of threatened and endangered species.

Immature bald eagles lack the distinctive coloration of their parents.

This hacking site was used to release bald eagles at Lake Mattamuskeet.

FIGURE 1. North Carolina Bald Eagle Project



HOW YOU CAN HELP

1. Limit the use of pesticides and herbicides whenever possible to reduce the risk of water pollution.
2. Educate yourself and others on bald eagle biology and conservation efforts.
3. Join a conservation organization to help support eagle conservation in the state.
4. Donate to the N.C. Nongame and Endangered Wildlife Fund.

NORTH CAROLINA WILDLIFE RESOURCES COMMISSION

1722 Mail Service Center
Raleigh, N.C. 27699-1722
(919) 707-0050

www.ncwildlife.org

Species Information and Status

WILDLIFE SPECIES & CONSERVATION

dwarf wedgemussel *Alasmidonta heterodon* (I. Lea, 1830)

(interior)

(exterior)

*Please Note: Red text is defined in the **Glossary***

Description

Go to Shell Anatomy

In 1830, Isaac Lea (see Conrad illustration) described the dwarf wedgemussel. The name is appropriate as shells rarely exceed 45 mm in length. Clean young shells are usually greenish-brown with green rays. As the animal ages, the shell color becomes obscured by diatoms or mineral deposits and appears black or brown. The shell is thin but does thicken somewhat with age, especially toward the anterior end. The anterior end is rounded while the posterior end is angular forming a point near the posterio-ventral margin. The ventral margin is only slightly curved. The nacre is bluish-white, appearing whiter in the thickened anterior end. The most distinctive shell character of the dwarf wedgemussel is the arrangement of the lateral teeth. There are two lateral teeth in the right valve and one in the left valve. The typical arrangement for most freshwater mussel species consists of two lateral teeth in the left valve and one in the right valve. The incurrent and excurrent apertures and their associated papillae are usually white. The foot and other organs are also white.

Distribution (see map)

The dwarf wedgemussel was once found in rivers and streams from New Brunswick, Canada to North Carolina. Some of the known populations are found in the Nottoway River of Virginia, Neversink River in New York, and the Ashuelot River of New Hamshire. The largest known population is found in the Connecticut River in Vermont and New Hampshire. North Carolina supports the greatest number of known sites: Neuse River Basin: Orange Co. (Eno River Subbasin), Wake Co. (Swift Cr. and Little River subbasins), Johnston Co. (Swift Cr., Middle Cr., Little River, and Moccasin Cr. subbasins), Wilson Co. (Moccasin Cr. and Turkey Cr. subbasins), Nash Co. (Turkey Cr. and Moccasin Cr. subbasins); Tar River Basin: Person Co. (Tar River Subbasin - support waters for downriver population in Granville Co.), Granville Co. (Cub Cr., Shelton Cr., and Tar River subbasins), Vance Co. (Ruin Cr. Subbasin), Franklin Co. (Cedar Cr., Crooked Cr., Shocco Cr., and Fox Cr. subbasins), Warren Co. (Shocco Cr., Long Br., and Maple Br. subbasins), Halifax Co. (Rocky Swamp subbasin), Nash Co. (Stony Cr. Subbasin). Unfortunately, most of these populations are very small and isolated. Based upon recent surveys, the Eno River, Middle Creek, Cedar Creek, Rocky Swamp, Fox Creek, and Stony Creek populations may be extirpated. *NOTE: All headwater areas that flow into these occupied habitats should receive special management.*

Habitat Preferences

Individual dwarf wedgemussels are found in large rivers and small streams, often burrowed into clay banks among the root systems of trees. They may also be found associated with mixed substrates of cobble, gravel, and sand. Occasionally they may be found in very soft silt substrates. Stream banks are stable with extensive root system holding soils in place. The associated landscape is largely

wooded, especially near streams. Trees near the stream are relatively mature and tend to form a closed canopy over smaller streams, creeks, and headwater river habitats. Water quality is good to excellent.

Life History
Maximum age for the dwarf wedgemussel is around twelve years. The species is a bradytictic breeder. Females become gravid in the early fall and glochidia are released by mid-spring. Fish hosts include the tessellated and johnny darters in North Carolina (Michaelson 1993).

Return to Top of Page
Return to Species List
Return to Mussel Atlas home page

OCEAN & COASTAL RESOURCE MANAGEMENT

Back

Ocean and Coastal Management in North Carolina

North Carolina's Coastal State Program

The North Carolina Coastal Management Program was approved by NOAA in 1981. The lead agency is the Division of Coastal Management within the Department of Environment and Natural Resources that implements and supervises all the various Coastal Zone Management programs in the state. North Carolina's coastal zone includes 20 coastal counties that in whole or in part are adjacent to, adjoining, intersected or bounded by the Atlantic Ocean or any coastal sound.

State Facts

Miles of Coast: 3,375

Coastal Population (2000): 826,019

Lead Coastal Management Agency: Department of Environment and Natural Resources, Division of Coastal Management

Approval Date: 1981

In recent years, housing development along North Carolina's coastlines has significantly increased. Through development permits and setback laws, the state tries to ensure that new buildings are out of harms way during storms.

Some of the greatest challenges facing North Carolina's coastal zone are the impacts from population growth and coastal development, including loss of sensitive coastal habitats and increased risks to life and property from coastal hazards. The Coastal Program is designed to address these issues along with others, such as public access to beaches and other shore fronts, conservation and restoration of wetlands, and management of beach erosion.

North Carolina's National Estuarine Research Reserve

The North Carolina National Estuarine Research Reserve comprises four sites, including Corolla (Currituck Banks), Beaufort (Rachel Carson) and Wilmington (Masonboro Island and Zeke's Island). The estuarine system is the fourth largest in the nation and encompasses about two million acres.

The Reserve provides educational opportunities for students and teachers including Estuary Live, a program held twice a year, which allows students to explore the Reserve through internet field trips. The Reserve's research activities include studying what management measures are most effective at reducing the impact of golf course runoff and studying fish habitat in the surf zone and the impact of dredge spoil on surf fishes.

Program Highlights

North Carolina Pier Litter Project

Cross Agency Collaboration for Reducing Development Impacts in North Carolina

North Carolina Coastal Habitat Protection Plan

Links

North Carolina Coastal Program — The website provides information on the program's activities, including wetland restoration, public access, and hazards.

North Carolina National Estuarine Research Reserve — The website provides information on the Reserve's many research, education, and stewardship activities.

Marine Protected Areas in North Carolina — A summary of marine protected areas and programs in the state.

Marine Protected Areas - Search for marine protected areas by state, region, or topic area.

North Carolina Coastal Nonpoint Program Conditional and Final Approval Documents — The Coastal Nonpoint Pollution Control Program encourages better coordination between state coastal zone managers and water quality experts to reduce polluted runoff in the coastal zone. The state has a fully approved program.

North Carolina's Coastal Program Evaluation (2006) — The Office of Ocean and Coastal Resource Management conducts periodic performance reviews of federally approved state coastal management programs.

North Carolina National Estuarine Research Reserve Evaluation (2005) — The Office of Ocean and Coastal Resource Management conducts periodic performance review of estuarine research reserves.

Contact Information for North Carolina's Programs

North Carolina Division of Coastal Management
400 Commerce Avenue
Morehead City, NC 28557
1 (888) 4RCOAST

North Carolina Department of Environment and Natural Resources and
North Carolina National Estuarine Research Reserve
1 Marvin Moss Lane
Wilmington, NC 28409
(910) 962-2470

(top)

NEW YORK STATE DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Eastern Tiger Salamander Fact Sheet

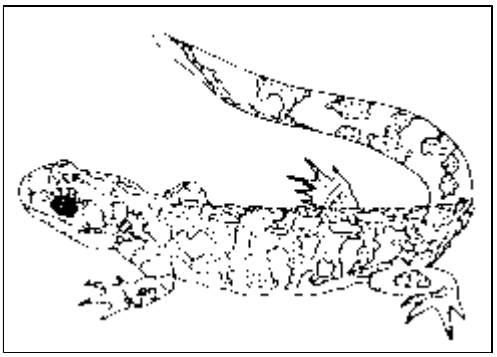
Eastern Tiger Salamander

Ambystoma tigrinum

New York Status: Endangered

Federal Status: Not Listed

Description



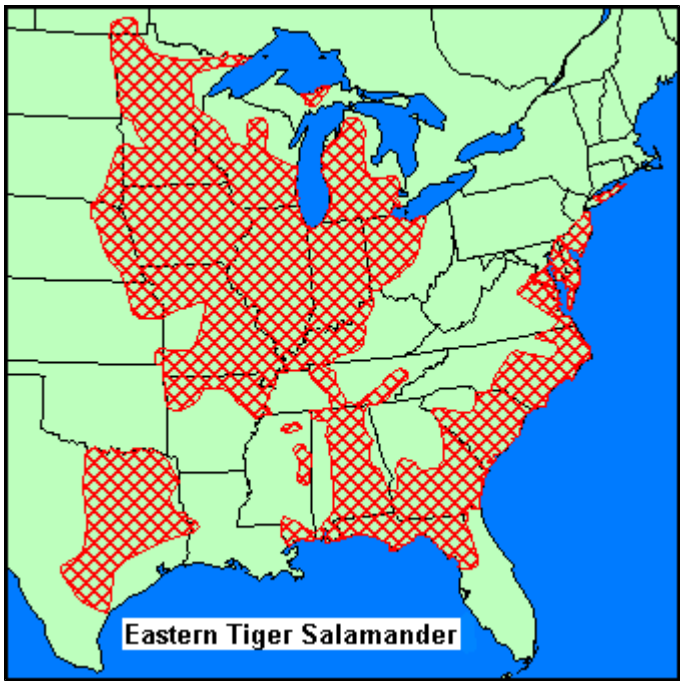
The tiger salamander is one of the largest terrestrial salamanders in the United States. The biggest specimen recorded was 13 inches long. The average size ranges between seven and eight inches. It is stocky with sturdy limbs and a long tail. The body color is dark brown, almost black, and irregularly marked with yellow to olive colored blotches. The only other salamander with which it might be confused is the smaller spotted salamander (*Ambystoma maculatum*). The spotted, however, has two rows of regular, yellow-to-orange spots running parallel down its back, as distinct from the irregularly distributed spots of the tiger salamander.

Life History

The tiger salamander spends most of its life underground, as do other members of the group referred to as "mole salamanders." On Long Island, it emerges from its burrow in February or March to migrate at night, usually during rain, to the breeding ponds. After a brief courtship which consists of the male pushing his nose against the female's body, eggs are laid in a mass and attached to twigs and weed stems under water. The female may deposit one or more egg masses containing 25-50 eggs per mass. Hatching occurs after approximately four weeks and the larvae remain in the ponds until late July or early August. After this time, the larvae transform into air breathing sub-adults measuring between four and five inches, and leave the ponds at night during wet weather to begin their underground existence. It takes four to five years for the salamanders to reach sexual maturity and they may live for 12-15 years. The tiger salamander eats invertebrates and small vertebrates.

Distribution and Habitat

The eastern tiger salamander ranges along the east coast from southern New York to northern Florida, west from Ohio to Minnesota and southward through eastern Texas to the Gulf. Historically, Albany is cited as being the northernmost point of this species' range along the east coast. The only two specimens recorded (1835, 1836) from this area may in fact have



been brought into the area accidentally via the Erie canal. The tiger salamander inhabits sandy pine barren areas with temporary or permanent pools for breeding. In New York,the tiger salamander is found only on Long Island with most of the known breeding colonies restricted to the central Pine Barrens. In the absence of natural pools or ponds, it may breed in man-made depressions filled with water.

Status

Loss of habitat has been responsible for the extirpation of this species from heavily developed western Long Island. Recent surveys have identified about 90 breeding ponds in New York, confined to eastern Nassau County and Suffolk County. Its status at these remaining sites is tenuous because of pesticides and other contaminants, threat of development, and other land use patterns.

Disturbance at ponds, introduction of predatory fish into permanent pools and expansion of bullfrog populations threaten annual reproduction. Recreational activities, especially off-road vehicles further impact breeding sites and year round habitat. Increased construction of roads has also bisected the habitat, jeopardizing migrating adults.

Management and Research Needs

Intensive surveys were conducted to determine the distribution of this species in New York. Breeding ponds have been designated as Class I wetlands. A five-year program to reintroduce tiger salamanders to an unoccupied historic site in Nassau County by transplanting egg masses was initiated in 1987 but has had limited success. A radio telemetry study, funded by Return A Gift to Wildlife was started in 1990 to study the biology and upland habitat requirements of this species is needed in order to develop appropriate management strategies.

The construction of salamander tunnels under roadways separating upland habitat from breeding ponds is being planned.

Additional References

Bishop, S. C. 1943. Handbook of Salamanders. Cornell University Press, Ithaca.

Conant, R. and J. T. Collins. 1998. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. Third Edition Expanded. Houghton Mifflin Co., Boston.

Harding, J. H. 1997. Amphibians and Reptiles of the Great Lakes Region. The University of Michigan Press, Ann Arbor. 378 pp.

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Petranka, J. W. 1998. Salamanders of the United States and Canada. Smithsonian Institute Press, Washington and London.

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Vogt, R. C. 1981. Natural History of Amphibians and Reptiles of Wisconsin. The Milwaukee Public Museum, Milwaukee, Wisconsin.

Map adapted from Conant and Collins (1998), Harding (1997) and Petranka (1998)

Progress Energy

Print Close Window

Cape Fear Plant

At A Glance

- Progress Energy's first coal-fired electric plant
- Two coal-fired units, 4 oil-fired units and 2 combined-cycle units can generate 400,000 kilowatts - enough to power 300,000+ homes
- First U.S. installation of Swedish ROFA/Rotamix emission-reduction technology
- Employs about 75 people from Chatham and surrounding counties
- Largest taxpayer in Chatham Co. - pays about $640,000 annually
- Part of the community for more than 75 years

Environmental Commitment

Protecting the environment is at the forefront of all we do at Progress Energy, from generating power to investing in stronger communities. Some of our environmental achievements include:

- Investment and commitment of more than $1 billion in nitrogen oxides and sulfur-dioxide emission-reduction technologies at our coal-fired power plants. Agreement in North Carolina to reduce NOx and SO2 by 70 percent from 1998 levels, in addition to reductions already achieved.
- Numerous wildlife protection initiatives, including the installation of specially designed osprey nesting platforms on transmission and distribution facilities in Florida as well as osprey platforms in the Carolinas.
- Removal of the Quaker Neck Dam (N.C.) in 1997 to allow natural fish spawning in Neuse River basin – first major voluntary dam removal in U.S. for conservation purposes.
- Transfer of ownership of Weedon Island property to Pinellas County to support county's effort to expand a park. Portions of the island also have been designated as a manatee refuge.
- Major partnerships with the Nature Conservancy in North Carolina, South Carolina and Florida.

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The Toxics Release Inventory

Companies in many industries, including the electric utility industry, are required to report to the U.S. Environmental Protection Agency the specific amounts of certain chemicals handled or released annually. This report is known as the Toxics Release Inventory, or TRI. Progress Energy announced data on substances produced at Progress Energy's coal- and oil-fueled power plants in generating electricity for the company's customers in the Carolinas and Florida. Utilities are required to file the report, including the inventory of pounds of emissions, with the EPA July 1.

TOP

Public Utilities

The City of Raleigh Public Utilities Department provides water and sanitary sewer service to over 167,000 metered customers and a service population of approximately 410,000 people in Raleigh, Garner, Wake Forest, Rolesville, Knightdale, Wendell and Zebulon areas. The Department is also developing its reuse water system to provide an alternative water resource for demands not requiring potable water quality. In addition to the retail customers, there are also wholesale customers that buy water in bulk from the City.

Falls Lake is the drinking water supply for the City with a capacity of 100 million gallons per day (mgd) allocated for drinking water. The City of Raleigh is the sole entity that is permitted to use Falls Lake water for drinking water.

Mission Statement:
To provide the best water and wastewater service for our customers while protecting the environment and maintaining public health at a fair and reasonable cost.

Department Goals/Information:
The Public Utilities Department has 9 divisions:

- Administration
- Construction
- Meters
- Reuse
- Sewer Maintenance
- Warehouse
- Wastewater Treatment Plants
- Water Distribution
- Water Plant

For More Information Contact:
Dale Crisp
Director
Public Utilities Department
One Exchange Plaza, Suite 620
Raleigh, NC 27602
919-857-4540

Related Information
Public Utilities Forms
Public Utilities News
Public Utilities Publications
Public Utilities Handbook
Monthly Water Quality Reports
Municipal Code
Site Specific Maps - FAQ

Contact List

Water Plant

Related Information
Public Utilities Forms
Public Utilities News
Public Utilities Publications

The Water Plant division operates and maintains the City's E.M. Johnson Water Treatment Plant, located near Falls Lake. This plant treats approximately 47 million gallons of water per day (MGD) while meeting State and federal drinking water quality standards, and is equipped with a sophisticated laboratory used to perform extensive water quality analysis. The Water Plant division also operates the G.G. Hill Water Plant acquired as part of the Town of Wake Forest water and sewer system merger.

In addition to water treatment operations, plant staff maintain and operate 18 water storage tanks, 12 remote booster stations, and other complex equipment utilized daily in the delivery of a safe water supply to the City's retail customers in Raleigh, Garner, Rolesville, Wake Forest, Knightdale, Wendell and Zebulon.

Download a virtual tour

Administrative Contact Hours: Monday through Friday 7:30 a.m. until 5:00 p.m. (excluding all scheduled holidays).

Location: 10301 Falls of the Neuse Road, Raleigh, NC 27614

Mailing Address: P.O. Box 590, Raleigh, NC 27602-0590

Telephone: 919-870-2870

For More Information Contact:
John Garland
Water Plant Superintendent
Public Utilities Department
10301 Falls of the Neuse Road
Raleigh, NC 27614
919-870-2870

Water Distribution Maintenance

Related Information
Public Utilities Forms
Public Utilities News
Public Utilities Publications

The Water Distribution division provides maintenance and repair services to more than 1,500 miles of water mains that exist within its service area. Division staff repair and maintain approximately 15,000 fire hydrants, more than 40,000 valves, and perform emergency repair and replacement of private water and sewer service taps. The water and sewer lines for the Garner, Wake Forest, Rolesville, Knightdale, Wendell and Zebulon service areas are also operated and maintained from this division as the result of the recent water and sewer system mergers with the respective Towns.

Administrative Contact Hours: Monday through Friday 7:30 a.m. until 4:00 p.m. (excluding all scheduled holidays).

Location: 3304 Lake Woodard Drive, Raleigh, NC 27604

Mailing Address: P.O. Box 590, Raleigh, NC 27602-0590

Telephone: 919-250-2737

For More Information Contact:
Andy Brogden
Water Distribution Superintendent
Public Utilities Department
3304 Lake Woodard Drive
Raleigh, NC 27604
919-250-2737

To: File
From: Dave Armstrong <armstrong3@llnl.gov>
Subject: Fwd: RE: Shearon Harris NRC - North Carolina
Cc:
Bcc:

Attachments:

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X-BrightmailFiltered: true
X-Brightmail-Tracker: AAAAAA==
X-IronPort-AV: i="4.14,589,1170662400";
d="scan'208,217"; a="21641490:sNHT197332880"
X-Possible-Spoof: True
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d="scan'208,217"; a="21417283:sNHT206840690"
Subject: RE: Shearon Harris NRC - North Carolina
Date: Tue, 29 May 2007 11:01:53 -0700
Thread-Topic: Shearon Harris NRC - North Carolina
Thread-Index: Acee50xMNd1TB1EVQQu6/5+xL8YS4gDM4dfw
From: "Ramsdell, James V Jr (Van)" <van.ramsdell@pnl.gov>
To: "Dave Armstrong" <armstrong3@llnl.gov>

Dave,

I estimate the tornado strike probability for Shearon Harris to be about 6.7E-4 per year. This includes both point and line strike components (See NUREG/CR-4461, Rev. 2)...

The wind power rating of the region near Shearon Harris is 1. However the wind power estimate along the northern coast of North Carolina is 3, and on exposed ridges and peaks of the Appalachian Mts to the east is 4 to 6.

Van

Station Details

Station: KRDU - Raleigh-Durham Airport **Date of first observation:** 1948-07-01
Station type: ASOS - Standard what is this?
City, State: Raleigh, NC **County:** Wake County
Latitude: 35.878° **Longitude:** -78.787°
Elevation: 435 feet above sea level
Climate division: NC04 - Central Piedmont
River basin: Neuse
Supported by: NOAA National Weather Service

show/hide list of nearby stations.

A climate summary is broken down into max, min, mean, and the average by month of each available parameter. These climate summaries are valid from July 1948 through January 2006 and are based on non-official data. Below are the summaries for the Raleigh-Durham Airport in Raleigh, NC. Click here to get recent data.

Air Temperature (Degrees Fahrenheit)

VARIABLE	STATISTIC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Ann
Maximum Temp.	Mean	50	53.2	61	71.1	78.1	84.7	88	86.4	80.5	71.1	61.9	52.3	69.9
	Highest Monthly Mean	61.5	62.7	68.2	76.3	84.7	91.3	92.9	90.7	87.5	75.6	70.3	61.5	73.5
	Year of Occurance	1950	1976	1976	1994	1953	2002	2005	2006	1954	1984	2001	1956	1990
	Lowest Monthly Mean	35.5	42.6	46.9	65	73.1	79.9	82.8	81.6	75.7	65.4	54.2	43.3	66.1
	Year of Occurance	1977	1978	1960	1961	1992	1979	1984	1969	1969	1957	1976	1989	1969
	Highest Daily	80.1	83	89	94	96	103	104	104	103	97	86	80.1	104
	Date of Occurance	2002-01-30	1989-02-03	1990-03-12	1980-04-23	1953-05-31	1954-06-27	1952-07-28	1988-08-18	1954-09-06	1954-10-06	2004-11-01	1998-12-06	1952-07-28
	Lowest Daily	16	18	19	40	49	58	66	63	52	46	33	18	16
	Date of Occurance	1985-01-21	1979-02-18	1980-03-02	1959-04-13	1992-05-07	1967-06-01	1984-07-29	1989-08-10	1984-09-28	1957-10-27	1970-11-24	1983-12-25	1985-01-21
Minimum Temp.	Mean	30.9	32.7	39.2	47.8	56.2	64.4	68.8	67.7	61.2	49.2	40	32.9	49.2
	Highest Monthly Mean	42.6	40.5	44.8	52	62.8	69.5	72.6	71.7	66	57.7	49.3	42.2	52.2
	Year of Occurance	1950	1990	1973	1954	1991	1981	1981	1995	1980	1971	1985	1971	1990
	Lowest Monthly Mean	17.1	23.5	28.8	42.8	50.8	58.7	66	64.1	56.8	42	31.9	25.5	47.1
	Year of Occurance	1977	1978	1960	1961	1997	1972	1963	1997	1963	1987	1976	1963	1963
	Highest Daily	64	62	68	67	73	78	78	79	75	72	68	69	79
	Date of Occurance	1998-01-07	1990-02-16	1990-03-16	1954-04-28	1991-05-28	1981-06-22	1981-07-13	1995-08-14	1950-09-01	2005-10-06	1971-11-02	1991-12-02	1995-08-14
	Lowest Daily	-7	-0	11	24	30	40	50	46	38	20	13	4	-7
	Date of Occurance	1985-01-21	1996-02-05	1980-03-02	1972-04-09	1963-05-02	1977-06-08	1963-07-11	1965-08-30	1950-09-26	1962-10-27	1970-11-25	1983-12-25	1985-01-21
Average Temp.	Mean	40.5	43	50.1	59.4	67.2	74.6	78.4	77.1	70.9	60.2	50.9	42.6	59.6

	Highest Monthly Mean	52.1	51.1	56.1	63.8	73.6	79.9	82.3	80.5	76	66.3	58.4	51.4	62.9
	Year of Occurance	1950	1990	1976	1994	1953	1952	1993	1995	2005	1984	1985	1956	1990
	Lowest Monthly Mean	26.3	33.1	37.8	53.9	63.1	69.9	74.9	73.4	67.4	54.5	43	34.8	56.8
	Year of Occurance	1977	1978	1960	1961	1954	1972	1984	1969	1969	1988	1976	1989	1969
	Highest Daily	69.5	71	76	78	84	89	89.5	90	85.5	81.5	75.5	73	90
	Date of Occurance	2005-01-13	1989-02-15	1990-03-16	1967-04-06	1953-05-23	1981-06-22	1952-07-28	1988-08-19	1954-09-06	1954-10-04	1993-11-15	1991-12-02	1988-08-19
	Lowest Daily	4.5	11.5	15	35.5	45.1	55	63.5	59	48	37	24.5	11	4.5
	Date of Occurance	1985-01-21	1996-02-05	1980-03-02	1972-04-08	2002-05-04	1997-06-07	1999-07-12	1986-08-29	1950-09-25	1962-10-27	1970-11-24	1983-12-25	1985-01-21

NORTH CAROLINA WILDLIFE RESOURCES COMMISSION

Division of Inland Fisheries

Piedmont Fisheries Investigations

Final Report

Harris Lake Creel Survey, 1997-1998

Project Type: Survey

Period Covered: 1 July 1997-31 June 1998

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2000

Abstract: A non-uniform probability, stratified access point creel survey was conducted on Harris Lake to estimate annual fishing effort, catch, and harvest. Creel clerks conducted 6,467 interviews from 1 July 1997 to 30 June 1998. The estimated total fishing effort was 188,948 hours or 118 hours/ha. Largemouth bass (*Micropterus salmoides*) fishing accounted for 67% of all fishing effort at Harris Lake. Crappie fishing (17%) was a distant second in popularity. Harvest rates by number and weight were highest for black crappie (*Pomoxis nigromaculatus*) (51,547 fish, 7,478 kg). Catch rates (fish/hour or CPUE) were 0.29 for largemouth bass, 2.46 for crappie, and 3.26 for bluegill (*Lepomis macrochirus*). Channel catfish (*Ictalurus punctatus*) contributed little to the fishery. Despite the intensive effort and catch statistics comparable to other piedmont reservoirs, 76.2% of anglers reported their fishing trip success as fair to poor. Most anglers (78%) felt boating access was adequate but a majority (75%) also thought the lake was at least occasionally too crowded. Only 10% of the anglers reported vegetation was a problem in the lake. We estimated anglers spent approximately $1,240,000 fishing Harris Lake during the creel period and expressed a willingness to spend an additional $1,010,000 for the same experience.

Harris Lake is a 1,600-ha impoundment of White Oak Creek, a tributary of the Cape Fear River, located 35-km southwest of Raleigh, North Carolina. It is owned by Carolina Power and Light Company (CP&L) and operated as a cooling water source for a nuclear powered electric generating facility. The shoreline is undeveloped and boating access is restricted to 2 North Carolina Wildlife Resources Commission (WRC) boat ramps.

Shoreline electrofishing and rotenone samples done for several years following impoundment described a fish population dominated by largemouth bass <350 mm and sunfish (*Lepomis* spp.) >150 mm (CP&L 1982, 1983, 1984, 1985, 1986). Black crappie, largemouth bass, and bluegill were the most sought after species in a creel survey conducted in 1984 (CP&L 1985). Bluegill was the most commonly harvested species. Few largemouth bass caught exceeded the 356-mm minimum size limit and anglers were unwilling to take advantage of the 2 fish creel exemption to the minimum size limit. The absence of largemouth bass >350 mm in the population persisted beyond the 3 or 4 years normally required to grow fish to that length in piedmont North Carolina (Van Horn et al. 1986) . Largemouth bass electrofishing catch rates and concurrent slow growth suggest crowding may have created unfavorable prey availability conditions.

Subsequent shoreline electrofishing samples indicated the relative abundance of largemouth bass >350 mm in the population increased through the early 1990s (WRC, unpubl. data). The reservoir currently enjoys a reputation as a trophy fish location among largemouth bass anglers. The reputation of the fishery may jeopardize the trophy fish resource if harvest becomes sufficient to alter largemouth bass age and size distributions in the lake. Current harvest information was needed to assess this risk.

Fall trap netting has been used to sample Harris Lake crappie since 1987 (WRC, unpubl. data). Trap net catch rates of crappie were <3 fish per net night. Crappie growth rates (age 2 fish are ~ 200-mm total length) suggest that available forage is high compared to crappie population density (Jones et al. 1994). Jones et al. suggested size and creel limits may be appropriate to increase yield by delaying crappie mortality and to redistribute the harvest among anglers.

However, the authors cautioned that if crappie trap net catches are low because of sampling difficulties and not low fish densities, size and creel limits may be unnecessary or inappropriate. Dense beds of hydrilla (*Hydrilla verticillata*) present in Harris Lake may interfere with trap net efficiency. An alternative crappie sampling technique was required to help make inferences about crappie population density.

Channel catfish were stocked in the reservoir in 1985. Rotenone samples (CP&L 1990) failed to detect any evidence of natural reproduction from the 1985 introduction. A second introduction was made in 1995. Fish sampling conducted since then has failed to demonstrate channel catfish reproduction; however, the sampling gears used (trap nets and shoreline electrofishing) may not effectively sample catfish. There has been no evaluation of the contribution of the catfish introductions to the sport fishery.

The initial creel survey on Harris Lake followed impoundment by only 2 years. Fish populations 2 years after impoundment change rapidly and are atypical of mature reservoir fish populations. Trap netting and shoreline electrofishing samples indicate current fish populations are quite different from those present during the 1984 creel survey. The objective of this study was to estimate current annual fishing effort, catch, and harvest at Harris Lake. The creel also gave investigators an opportunity to administer a questionnaire to identify socio-economic characteristics of Harris Lake anglers and estimate angler trip expenses.

METHODS

A non-uniform probability, stratified access point creel survey was conducted on Harris Lake beginning 1 July 1997 and extending through 30 June 1998. The survey was restricted to boat anglers only. Two weekdays and 2 weekend days were randomly chosen and sampled in each week (Monday through Sunday). Holidays falling on Friday or Monday were treated as weekend days. Sample days were divided into 2 segments, morning and afternoon. Each segment was assigned a sampling probability of 0.5. Morning samples started 2 hours after sunrise and were extended until midday. Afternoon samples began at midday and were terminated 0.5 hours after sunset. Midday was calculated as the midpoint between 2 hours after sunrise and 0.5 hours after sunset. Sampling was conducted at 1 or the other of the 2 boating access areas at Harris Lake, Holleman's Landing and Dam Site. We assigned a site sampling probability of 0.66 to Dam Site and 0.33 to Holleman's Landing.

Daily workday segments and interview sites were randomly selected using the predetermined sampling probabilities. The creel clerk began each work segment by filling out an access area sample sheet (Fig. 1). Boat anglers were interviewed at the completion of their trips. One interview sheet (Fig. 2) was completed for each angler party interviewed. Interviews consisted of recording the number of anglers in the fishing party, hours fished, species targeted, harvest/release data, plant safety information, angler opinion data, and economic information. A record was made of the number of boat parties leaving the site without being interviewed, differentiating between those that had fished and non-anglers. Trailer counts were made at the beginning of each workday segment, repeated at the top of each hour, and at the end of each

workday segment. The trailer counts adjusted for non-angling boaters were averaged to estimate an instantaneous count for the workday segment.

Creel statistics and associated proportional standard errors (PSEs) were estimated using a modified version of software designed for the WRC by the North Carolina State University Institute of Statistics. Categorical data (most of the opinion and preference information) were summarized and expressed as percentages of total responses. Total trip expenditures (including consumer surplus value) were calculated as mean trip value expanded by the estimated number of trips (Malvestuto 1983).

RESULTS

The numbers kept and released for species categories "redear sunfish" (*Lepomis microlophus*) (27,878 and 3,241) and "other" (6,656 and 3,241) were characterized by high proportional standard errors (PSEs > 0.20). The estimated total harvest weights for categories "redear sunfish" and "other" were 617 kg and 237 kg. The calculated weights per fish kept for the 2 categories (total weight/total kept) were 22 g and 36 g. Because it is nonsensical to accept that anglers caught and kept fish that small, we will only discuss largemouth bass, black crappie, channel catfish, and bluegill data for the remainder of the report.

Creel clerks conducted 6,467 interviews. The estimated total fishing effort for the 12-month creel survey period was 188,948 (PSE = 0.06) h or 118 h/ha. The average trip length was 5.1 hours. Anglers targeting largemouth bass accounted for 67% of all fishing effort at Harris Lake (Table 1) followed by directed fishing effort for crappie (17%) and bluegill (15%). Directed fishing for all lepomids combined, "bream" fishing, probably surpassed directed fishing for crappie to the extent that redear sunfish and lepomids in the "other" category contributed additional directed effort to that expended for bluegill. Directed effort for channel catfish was very low (<1% total effort). Consistent with the emphasis on largemouth bass fishing, 74.3% of anglers fished with artificial lures, 18.1% used live bait and 7.6% fished with both types of bait.

Total harvest by number and weight were highest for black crappie (Table 1). Bluegill were the second most harvested fish by number (27,588). Again, it seems possible that fishing for all lepomids combined might have produced the highest harvest by number of individuals. Largemouth bass were the second most harvested fish by weight (5,631 kg). Bluegill anglers had the highest catch rates (CPUE expressed as the number of fish caught per hour fishing). Directed fishing for largemouth bass and channel catfish produced the lowest catch rates.

Twenty six percent of the interviewed anglers reported making at least 1 fishing trip on Harris Lake at night. Anglers affirming they fished at night reported averaging 10 night trips per year on Harris Lake. Among anglers responding in the affirmative, 69.8% were fishing for largemouth bass and 16.7% were fishing for crappie when interviewed.

The large majority of anglers reported their fishing trip success as fair to poor (Table 2). This also was true of anglers targeting largemouth bass and crappie.

The majority of anglers (78.3%) agreed that there were sufficient access areas on the lake for fishing activity. However, approximately 60% of the anglers thought it occasionally took too

long to launch their boats (Fig. 3). Another 75% thought the lake was at least occasionally too crowded (Fig. 4).

Virtually all respondents (96.6%) were aware of the Carolina Power and Light Company's Emergency Response Notification Sign. Respondents indicated that on average it would take 7.1 minutes to trailer their boat and leave the area. The range of responses was from 1 to 55 minutes. Only 9.6% of the anglers reported vegetation was a problem in the lake.

Respondents estimated their mean trip cost at $33.47 and indicated they would continue to fish the lake until the average cost of the trip reached $60.79. Expanded by the estimated trip numbers, anglers spent an estimated $1.24 million fishing Harris Lake during the creel period. They were willing to spend an additional $1.01 million.

DISCUSSION

Harris Lake is heavily fished compared to other piedmont reservoirs. Creel surveys completed in North Carolina's piedmont region since 1993 indicate fishing effort at Harris is comparable to effort at Lake Wylie and nearly twice the effort estimated at lakes Norman and Gaston (Table 3). All of the lakes except Gaston are found near major population centers and Gaston is within an hour and a half travel time from metropolitan Raleigh/Durham, North Carolina, and Richmond, Virginia. Anglers fishing each of the lakes have easy access to nearby reservoirs.

Most of the fishing pressure at Harris Lake was directed at largemouth bass. It is the highest estimated directed effort for largemouth bass among the 4 lakes reported for comparisons (Table 3). The bass fishery gets national attention from several major fishing magazines.

Bass fishing success (CPUE) at Harris Lake was 0.29 fish/hour (PSE = 0.06). The more successful largemouth bass tournament catch rates from reservoirs reported by Van Horn and Finke (1995) had catch rates >0.20 fish/hour (total length > 35 cm). The Harris Lake catch rate includes both legal and sublegal fish, but electrofishing based largemouth bass size distributions collected a few years before the creel are characterized by large numbers of fish above the legal minimum size limit. In a shoreline electrofishing sample conducted at Harris Lake in 1995, 61% of the 436 largemouth bass >200 mm were >350 mm (T. Wayne Jones, WRC, unpubl.).

Catch and release is practiced extensively by Harris Lake largemouth bass anglers (90% release rate). The reported largemouth bass harvest (3.5 fish/ha/year) should not have a negative effect on the average size of a creeled largemouth bass in Harris Lake.

The directed effort for crappie at Harris Lake, expressed as a percentage of total effort, is similar to that observed at lakes Norman and Wylie (Table 3). There was very little directed effort for crappie at Gaston Lake. Crappie anglers caught 2.46 crappie/hour at Harris Lake. The comparable catch rate for Lake Norman was 1.77 crappie/hour. There are no catch rate data for crappie from Lake Wylie but the harvest rate in 1994 was 1.58 fish per hour. The effort and catch statistics suggest that the low trap net catches for crappie in Harris Lake reported by Jones (WRC, unpubl. data) were not indicative of poor crappie populations. A subsequent shift to larger mesh trap nets produced significantly higher crappie catches. The higher trap net catch rates and crappie angler success documented by the creel survey fail to support the hypothesis

that crappie abundance in Harris Lake is very low compared to other piedmont reservoirs (T. Wayne Jones, NCWRC, unpubl.).

The creel revealed only a small fishery for channel catfish (Table 1). The result is consistent with earlier trap net and electrofishing results suggesting the channel catfish population in the lake is small. Channel catfish stocking has not resulted in establishing a reproducing channel catfish population or a substantive put-grow-and-take fishery. Anecdotal evidence from discussions with creel clerks suggests no juvenile channel catfish were observed during the interview process and strengthens the hypothesis that channel catfish recruitment in Harris Lake is poor.

Catfishing is often associated with night fishing. The creel survey was not conducted at night. However, 25% of our interviewed parties indicated they did fish the lake at night and averaged 10 night trips per year per party. The majority of anglers indicating they do fish at night were fishing for largemouth bass (70%) or crappie (17%) when they were interviewed. We recognize anglers may fish for bass during the day and catfish at night, but suspect that most of the night fishing on Harris Lake is probably directed at largemouth bass and crappie.

The apparent high quality of the reservoir fishery, particularly for largemouth bass, was not reflected in the trip satisfaction ratings we collected (Table 2). Nearly half of all anglers interviewed described their trips as poor. Bass anglers were highly critical of a fishery with a national reputation for quality. Crappie fishermen showed only a slightly higher approval rating for a fishery that agency biologists originally believed might benefit from protective regulations because of good crappie growth, condition, and size distributions but low population density. The results suggest managers might need to use caution when using trip satisfaction as an indicator of fish population quality.

We can only speculate that expectations of success among bass anglers, inflated by a previous experience or media descriptions of the lake's fishery, may be so high as to be virtually unattainable for most anglers and most trips. Trip ratings among crappie anglers may be more reflective of the quality of the crappie population, but still seem unusually low. In a mail survey of licensed anglers, the majority of reservoir anglers rated their success as fair to excellent (Finke and Van Horn 1993). It is also possible that anglers felt providing a higher trip satisfaction rating might limit the chances that additional resources would be spent to make improvements in their fishery.

High fishing pressure did not appear to interfere consistently with angler access to Harris Lake. Most anglers thought access was adequate. However, most anglers also thought crowding was occasionally a problem affecting their use of the boating access areas and the lake.

Aquatic vegetation is viewed by many resource users from a variety of perspectives. Traditionally, property owners along the shoreline and facility managers on a lake (power production and water supply, for example) are likely to view aquatic vegetation as a potential nuisance while anglers may embrace aquatic vegetation as desirable fish habitat. Anglers in our survey were consistent with this pattern. The number of anglers perceiving aquatic plants as a nuisance may go up when plant infestations limit fishing opportunities on more of the lake. There is no evidence in this survey to suggest aquatic plant control is limiting fishing opportunities.

Virtually all anglers were aware of the Emergency Response Notification sign posted by CP&L. A rough estimate of the amount of time needed to clear the parking lot under emergency conditions if all boats were in the water at the 2 access areas could be calculated by dividing the number of trailers in the parking areas by the number of ramps and multiplying by the expressed average time to retrieve a boat from the water. The stated times seem optimistic to the authors. A time study observing actual boat retrievals should provide a better planning tool.

Finally, creel survey participants reported spending an average of $33.47 per fishing trip. The cost did not involve depreciating their boats or other equipment. Expanding the value per trip by the estimated number of trips produces a conservative estimate of the value of the fishery to the local economy of $1.24 million for the year. The number is comparable to similar estimates recently made for lakes Norman and Wylie (Table 3). However, Harris Lake is smaller by a factor of 8 than the largest of these reservoirs, indicating a higher value per unit area. The willingness expressed by anglers to pay an additional $1.01 million for the same fishing experience (surplus value) suggests that the potential economic value of the lake to the local economy is $2.25 million.

RECOMMENDATIONS

1. Do not change current largemouth bass creel and size regulations.
2. The need to regulate crappie harvest at Harris Lake should not be based on previously collected trap net catch rates.
3. Channel catfish stocking decisions should be addressed in a WRC Harris Lake fishery management plan. A decision to manage the reservoir for channel catfish will require identifying and correcting the causes of poor year class production or a much heavier commitment to channel catfish stocking.
4. Heavy fishing pressure and the perception among anglers that access is adequate would suggest access monies should not be spent on putting in additional access sites, but used to improve existing access facilities.
5. Aquatic vegetation removal should not be a fisheries management priority.
6. Evaluate creel survey based "poor, fair, good, and excellent" trip satisfaction questions as a reliable measure of actual angler satisfaction with the object fishery.

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Van Horn, S.L. and J.R.Finke. 1995. North Carolina black bass tournament catch survey. Fed. Aid Project F23. Final Rep. N. C. Wildl. Resour. Comm., Raleigh. 15pp.

Table 1. Estimates and proportional standard errors (PSE) of number and weight (kg) of fish kept, number released, and directed effort (hours), and catch/hr (CPUE), by species from the Harris Lake creel survey, 1997 – 1998.

	Total. Kept		Total Released		Total Kept		Directed Effort Only		
Species	Number	PSE	Number	PSE	Kg.	PSE	Hours	PSE	CPUE
Largemouth bass	5,876	0.09	55,010	0.08	5,631	0.10	127,570	0.06	0.29
Black crappie	51,547	0.13	42,147	0.16	7,478	0.13	32,727	0.14	2.46
Bluegill	27,588	0.19	30,509	0.12	2,854	0.26	11,458	0.20	3.26
Channel catfish	988	0.20	1,048	0.20	735	0.16	1,497	0.14	0.27

Table 2. Angler trip satisfaction expressed as a percentage (%) of respondents.

	All anglers	Largemouth bass anglers	Crappie anglers
Excellent	5	4	6
Good	19	18	22
Fair	25	24	25
Poor	51	54	47

Table 3. A comparison of estimated effort and economic valuations for fisheries from 4 reservoirs as determined by creel surveys.

Reservoir/ Year	Total effort (hours/ha)	Directed effort (% total)		Total trip expenditures ($)	Surplus value ($)
		Largemouth bass	Crappie		
Harris 1997	118	67	17	1,242,463	1,014,156
Gaston 1997[a]	53	60	1		
Norman 1993[b]	50	32	27	1,598,640	
Wylie 1994[c]	120	46	20	1,555,345	2,500,000
Wylie 1995[c]	91	45	19	1,273,743	887,763

[a] Fishery Information Management Systems, 1998
[b] Duke Power Company, 1997
[c] Christie and Stroud, 1996

Figure 1. Harris Lake creel survey access point sample sheet, 1997-1998.

Harris Lake Creel Survey
Access Point Sample Sheet

Period ___ ___

Access Point ___ ___
01 Holleman
02 Dam Site

Sample Number ___ ___

Kind of day (Weekday 01, Weekend or Holiday 02) ___ ___

Date (month, day, year) ___ ___ / ___ ___ / ___ ___

Day Segment (AM, PM) ___ ___

Instantaneous Counts

Count #	1	2	3	4	5	6	7	
Time								
Trailers								

Non Interviewed Trips

Number Boats Fishing_____

Non Fishing Boats_____

Total Number Fishing Boats Not Interviewed _____

Total Number Non Fishing Boats Not Interviewed _____

Figure 2. Harris Lake creel survey interview sheet, 1997-1998.

Harris Lake Creel Survey
Angler Interview Sheet

SAMPLE INFORMATION

Interview Date __ __/ __ __/ __ __Kind of Day, Weekday (01) __ __, Weekend (02) __ __

Period: __ __ Access Area: __ __ Sample #: __ __ __ Interview #: __ __ __ AM/PM: __ __

FISHING EFFORT

Number in Party __ __ Time Fished: __ __Hrs. __ __Mins.

Party Hours Fished: __ __Hrs. __ __Mins.

SPECIES TARGETED

Species Fished For: _____Largemouth Bass _____Crappie _____Channel Catfish
_____Bluegill _____Redear (shellcracker) _____Other

HARVEST & RELEASE INFORMATION

	Number Kept	Number Released	Total Weight (Kg)
Largemouth bass LMB	_____	_____	_____
Black crappie BCR.....	_____	_____	_____
Channel catfish CC.....	_____	_____	_____
Bluegill BG.....	_____	_____	_____
Redear RS.....	_____	_____	_____
Other.....	_____	_____	_____

Bait Used: _____Live _____Artificial _____Combination Zip Code __ __ __ __ __

Would you rate your fishing success today as: _____poor _____fair _____good _____excellent

Figure 2. Continued.

$$ spent on this trip: _____

How much more would you be willing to spend over the total? _____

Have you been interviewed here while fishing during the past month? ___Yes ___No

If YES do not fill out any of the following questions. If No then proceed.

1. Do you fish Harris at night? _____Yes ____ No If so at what frequency? _____

2. Did you see the emergency Response Notification Sign at the boat ramp? YES ___ NO____

3. Did you read and understand the information presented on the sign? YES ____ NO____

4. If you were directed to clear the lake by Wake Co. Sheriffs Dept., about how long would it take you to trailer your boat (assume boat at ramp) and exit the area (back onto paved road)? Minutes ____

5. Is this lake:
   1 = Usually too crowded
   2 = Occasionally too crowded
   3 = Never crowded
   4 = Don't know/no opinion

6. Is the time that you typically have to wait before launching or accessing a fishing site:
   1 = Usually too long
   2 = Occasionally too long
   3 = Usually not a problem
   4 = Don't know/no opinion

7. Are the public access sites on this lake adequate for your fishing activity? ____Yes ___No

8. Do you think vegetation is a problem in Harris Lake? ____Yes ____No

Figure 3. Responses of creel survey questionnaire respondents at Harris Lake when asked about wait times for boat launching or accessing a fishing site.

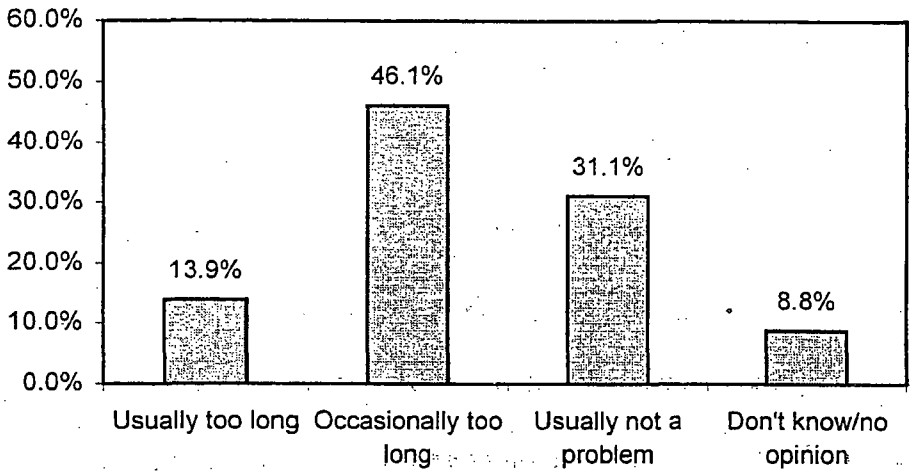
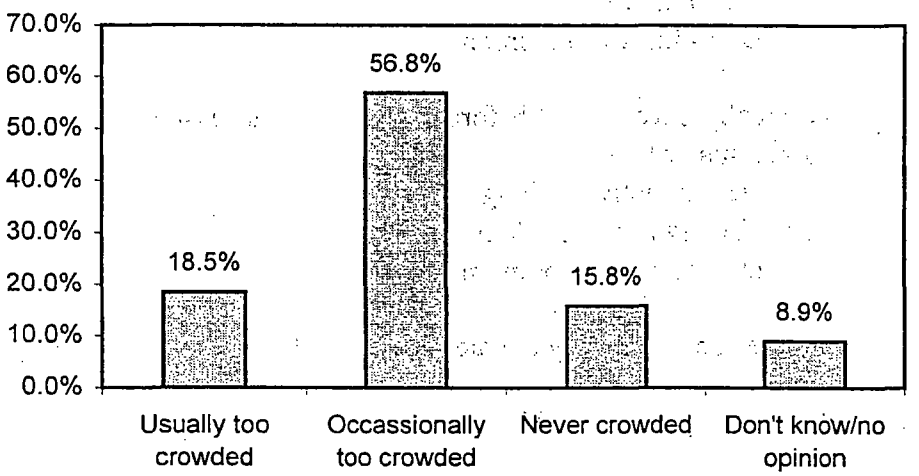


Figure 4. Responses of creel survey questionnaire respondents at Harris Lake when asked about crowding.



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Town of Apex Annual Wastewater Treatment and Collection System Report Fiscal Year July 2006— June 2007

The Town of Apex is pleased to provide this annual report on the operation of your municipal Water Reclamation Facility and the Wastewater Collection System.

Water Reclamation Facility

Treatment:

Your Water Reclamation Facility (WRF) is designed to treat up to 3.6 million gallons of wastewater a day. This past fiscal year over 871 million gallons were treated. This is an average of 2.38 million gallons a day. The facility provides nitrogen and phosphorus removal as well as removing other conventional pollutants. Critical equipment is monitored 24 hours a day with a computerized data acquisition system, and standby power. Upon receiving the wastewater from our collection system, the wastewater flows through a series of treatment processes which remove pollutants from the water. The facility provides screening and grit removal for preliminary treatment, biological nutrient removal for secondary treatment, traveling bridge sand filters for tertiary treatment, and ultraviolet high intensity lamps for disinfection. The reclaimed water is discharged into an unnamed tributary of Middle Creek under the National Pollutant Discharge Elimination System permit (NPDES) number NC0064050. This permit is issued to the Town of Apex by the State of North Carolina under the authority of the US Environmental Protection Agency. (EPA)

Apex Water Reclamation Facility

Biosolids:

Biosolids are the nutrient-rich organic materials resulting from the treatment of domestic sewage at a wastewater treatment facility. Through biosolids management, solid residue from wastewater treatment is processed to reduce or eliminate pathogens and minimize odors, forming a safe, beneficial agricultural product. Farmers and gardeners have been recycling biosolids for ages. Biosolids can be applied as fertilizer to improve and maintain productive soils and stimulate plant growth. Biosolids contain valuable nutrients such as nitrogen, phosphorus, calcium and micronutrients like zinc and copper, which are essential to plant growth. Recycling biosolids is consistently the most cost effective and environmentally safe method for the Town to manage its Biosolids program. The Town has approximately 1,267 acres of farm land available under this permit. Biosolids generated at the WRF are stabilized in aerobic digesters for additional breakdown of organic matter. The organic reduction meets the Class B requirements set forth by the State of North Carolina Water Quality Division. This fiscal year over 506 dry tons were added to farmland as soil amendments and fertilizer in accordance with the Town's Land Application permit.

Staffing:

Operation of the WRF and Collection System is provided by the Public Works and Utilities Department. There are 20 employees that provide day-to-day operation and 24 hour response to all WRF or Collection System emergencies. Employees are certified by the State of North Carolina for proficiency in plant operation, pump station maintenance, collection system repair, land application of biosolids, laboratory analysis, and pretreatment management.

Special points of interest:

- Water Reclamation Data
- Collection System Performance
- Grease Concerns
- What is a River Basin ?
- What is Stormwater ?
- Contact Information

Permit Numbers:

Water Reclamation Facility NPDES Permit: NC0064050

Collection System Permit: WQCS00064

Biosolids Land Application Permit: WQ0001060

Reuse Permit: WQ0021863

Water Reclamation Certified Laboratory Certificate: 276

Laboratory and Pretreatment Programs

Laboratory Analysis:

The Water Reclamation Facility maintains a certified analytical laboratory approved by the State of North Carolina and the EPA. The laboratory is certified to perform environmental analysis and report monitoring data to the Division of Water Quality for compliance with NPDES effluent, surface water, groundwater, and pretreatment regulations under the laboratory certificate number 267. This year, over 31,900 analyses were performed for process control, stream monitoring, and compliance requirements. All data reported was in compliance with the NPDES permit.

Pretreatment Program:

The purpose of this program is to protect the Town's WRF. Industrial discharges are monitored through the Town's pretreatment program. The Town issues specific permits to each industry specifying maximum amounts of pollutants that may be discharged to the facility. The staff conducts routine monitoring and quarterly inspections of these industries to ensure compliance. The Town also has an oil and grease inspection program for all restaurants and oil handling facilities. The staff currently monitors and inspects over 90 restaurants, 12 institutions such as schools and nursing homes, and 10 grocery and /or convenience stores.

Town of Apex Water Reclamation Facility
Effluent Data for July 2006 - June 2007

Month	Flow MGD		Biochemical Oxygen Demand MG/L		Ammonia MG/L		Total Suspended Solids MG/L		Fecal Coliform #/100ML		Dissolved Oxygen MG/L		Total Nitrogen MG/L		Total Phosphorus MG/L	
	Limit	Actual	Limit	Actual	Limit	Actual	Limit	Actual	Limit	Actual	Limit	Actual	Limit	Actual	Limit	Actual
July	3.6	2.181	5	2.47	1.0	<0.10	30	2.60	200	2	>5	7.3	**	3.08	2*	0.732
August	3.6	2.113	5	1.29	1.0	0.104	30	2.04	200	3	>5	7.1	**	2.94	2*	0.744
September	3.6	2.170	5	2.01	1.0	0.235	30	4.00	200	3	>5	7.5	**	4.65	2*	0.380
October	3.6	2.239	5	0.880	1.0	0.100	30	2.37	200	5	>5	8.0	**	4.15	2*	0.619
November	3.6	3.003	10	1.22	2.0	<0.10	30	3.23	200	4	>5	8.2	**	3.85	2*	0.786
December	3.6	2.557	10	2.33	2.0	0.143	30	3.64	200	2	>5	8.7	**	4.53	2*	1.19
January	3.6	2.681	10	2.71	2.0	0.404	30	3.54	200	4	>5	9.0	**	4.22	2*	0.731
February	3.6	2.421	10	3.07	2.0	0.211	30	3.27	200	9	>5	9.7	**	4.62	2*	1.24
March	3.6	2.603	10	2.20	2.0	<0.10	30	2.34	200	6	>5	9.3	**	4.00	2*	0.819
April	3.6	2.518	5	2.40	1.0	0.173	30	2.44	200	4	>5	8.7	**	3.92	2*	0.571
May	3.6	2.127	5	2.78	1.0	0.235	30	2.68	200	8	>5	7.7	**	4.17	2*	0.773
June	3.6	2.058	5	<2.00	1.0	<0.10	30	1.78	200	3	>5	7.6	**	3.77	2*	1.79

Million Gallons a Day (MGD) Milligrams per Liter (MG/L) Milliliter (ML) No monthly limit (**) Quarterly permit limit (*)

The Town's Water Reclamation Facility treats wastewater 24 hours a day, 7 days a week, 365 days a year. We are proud to report during the past fiscal year, the facility removed pollutants with an average efficiency of 98.8% . The Facility treated over 871 million gallons of wastewater and met all but two monitoring data and sampling frequencies in the National Pollutant Discharge Elimination System (NPDES) permit. On January 19, 2007 the dissolved oxygen concentration and temperature for the effluent was not sampled. The operators were involved in a maintenance project and overlooked the sampling protocol, thus the facility reported this violation of the NPDES permit requirements to the Division of Water Quality.

Apex's Water Reclamation Facility final treatment process; cascade aeration

Collection System Performance

The Town's wastewater collection system consists of approximately 166 miles of pipe. There are 137 miles of gravity sewer and 29 miles of force main pipe. The Town also owns and maintains 21 pumping stations. The pump stations are equipped with telemetry, standby power, audible/visible alarms, and automated telephone dialers. All stations are checked daily by the Wastewater Collection staff. These pump stations operate twenty-four hours a day, seven days a week, 365 days a year. The Town's collection system operates under the permit number WQCS00064 issued by the State of North Carolina.

Sanitary Sewer Overflow (SSO)

SSO's occur when problems in the system cause sewage to come out of manhole covers, service cleanouts or plumbing fixtures. Everyday an average of 2.38 million gallons of wastewater begins its journey from kitchen sinks, bathtubs, toilets, washing machines, and dishwashers in homes and businesses, and travels through the collection system to the Water Reclamation Facility. The Town strives to have zero spills from our collection system. However, because pump stations are mechanical devices and sewer lines are subject to unavoidable clogs from grease, roots, construction debris, etc., all systems are subject to spills. In a effort to minimize or to prevent spills, the Collection system staff uses television equipment for inspections and incorporates routine flushing for preventive maintenance. In addition, the Town has developed a rapid response program with vacuum equipment, and 24-hour on call personnel to help mitigate spills.

The staff inspects and cleans at least 10% of its sewer lines each year. During the past year, over 76,590 linear feet of sewer lines were cleaned by flushing, and16,800 feet were inspected by remote video. Approximately 9,000 feet of sewer lines were treated for root intrusion. This year we repaired 4,900 feet of sewer lines in the southwest section of Town. We used a process called slip-lining. This process enabled us to repair the sewer line without digging up the old pipe.

Kelly Road Pump Station

During the fiscal year from July 1, 2006 through June 30, 2007, the Town experienced only one SSO. On December 19,2006 at the intersection of Investment Blvd. and Schieffelin Rd. an odor control device installed in the manhole broke loose and entered into the collection line partially plugging the line and allowing wastewater to flow outside the system and enter a nearby ditch. Total volume of the overflow was approximately 20,000 gallons.

Grease, the ENEMY to Collection Systems

Each year there are more than 15,000 sewer overflows in North Carolina. Many of these overflows are directly related to the improper disposal of oil and grease in kitchen drains. Grease congeals on sewer pipes, which causes wastewater to flow back into homes and businesses or directly into waterways. Wastewater collection lines are designed to handle three things; used water, human waste, and toilet paper. It is very important to keep all foreign materials, such as grease and other household items and debris from entering the sewer system.

The Town's Oil and Grease program is designed to limit illegal discharges of fats, oil, and grease from homes and business into the wastewater collection system. Small amounts of grease entering the collection system can accumulate over time to cause blockages resulting in a SSO which can harm the environment and cost thousands to clean up.

We strive to maintain the Town's sewer infrastructure at the highest quality while protecting the environment and of course providing you with continuous service. You can help too. Please put used oil and cooking grease in collection containers for proper disposal. Remove oil and grease from kitchen utensils with scrapers or paper towels. Place food scraps in trash containers. All of us can work together to achieve our goal; providing you with reliable service and protecting the environment.

Grease Control… It's about the Environment

What is a River Basin?

A river basin is the land that water flows across or under on its way to a river. Ultimately, a river basin sends all of the water falling within it to a central river and out to the ocean. Basins can be divided into watersheds, or areas of land around a smaller river, stream, or lake. North Carolina is made up of many watersheds connected to each other. Within each water-shed, all water runs to the lowest point, like a stream, river, or ocean. On its way, water travels across farm fields, lawns, and city streets, or it seeps into the soil and travels as groundwater. Large river basins are made up of many smaller watersheds.

Everyone lives in a river basin. It is part of your ecological address. You can change what happens in your river basin for good or bad by how you treat the natural resources like the soil, water, air, plants, and animals. As water moves downstream, it carries and leaves behind gravel, sand, and silt. It also carries bacteria and chemicals. Whatever happens to the surface water and ground water upstream will eventually have an effect on the downstream. Even if you don't live near a river, you still have an effect on your river basin.

Did you know?

The Neuse river basin, the longest ***river*** contained in NC's boarders, and it is the widest in North America at 6 miles across. It contains an unusual feature for the costal plain, a 100 foot canyon carved by the river near Goldsboro. It is also the home to the Neuse River waterdog (a rare aquatic salamander), the rare Carolina madtom fish, and the Panhandle pebble snail.

The Cape Fear river basin is the largest ***river basin*** located entirely in North Carolina. It is home of the Cape Fear Shiner, an endangered species that lives nowhere else in the world. This river basin contains 1/4 of our State's population. Everyone in North Carolina lives in one of the State's seventeen river basins. As an Apex citizen you either live in the Neuse or Cape Fear river basin. The west side of Salem Street drains toward the Cape Fear river basin while the east side of Salem Street drains into the Neuse river basin.

What is Stormwater?

Stormwater is the flow of water that originates immediately following a rainfall. When a rainfall event occurs, some of the precipitation infiltrates into the soil surface, some is taken up by plants, and some is evaporated into the atmosphere. The remaining precipitation "runs off" from land, pavements, building rooftops, and other impervious (hardened) surfaces. Stormwater runoff accumulates pollutants such as chemicals, nutrients, oil and grease, metals, and bacteria as it travels across land. This runoff usually flows into the nearest creek, stream, river, lake, or ocean and is not treated in any way.

Why be concerned about stormwater?

As development (imperviousness) increases in an area, the infiltration of rainfall into the soil decreases and stormwater runoff increases. This can negatively impact the environment by causing erosion of land areas and stream banks, by causing or increasing flooding, and by carrying pollutants to surface waters. As Apex grows and develops, more houses, roads, and businesses will be constructed. This increased impervious area results in more stormwater runoff, which, if not restricted, can cause serious drainage, pollution, and sanitation problems.

What is Apex doing about stormwater?

The Town of Apex is required by the State to become compliant with the National Pollutant Discharge Elimination System Phase II permit. The six measures that the Town must comply with regarding stormwater include:

1. Public Education & Outreach
2. Public Involvement & Participation
3. Illicit Discharge Detection & Elimination
4. Construction Site Runoff Controls
5. Post-Construction Site Runoff Controls
6. Pollution Prevention & Good Housekeeping

In order to comply with the permit, The Town of Apex requires the following practices of developers:

- Plan and design new construction using Low Impact Development techniques to minimize impervious areas and runoff potential
- Maintain natural vegetation in buffer areas around streams to protect banks and provide for pollutant removal
- Ensure post-development peak runoff is limited to pre-development runoff for certain design storm events
- Control erosion on the construction site
- Remove 85% of sediment from stormwater before discharging to local waterways
- Provide scour protection at stormwater discharge points

Apex citizens can do their part in controlling stormwater pollution by:

- Minimizing use of lawn fertilizers and pesticides
- Collecting and bagging pet waste
- Remembering that *any* materials poured or placed on the ground, streets, driveways, etc. can be picked up and carried by stormwater runoff to our surface waters
- Reporting any pollution, illegal dumping, or soil erosion to appropriate authorities
- Volunteering

Town Mayor Keith Weatherly and Junior Girl Scout Troop 001 participate in a Storm Drain Marking Event on April 22, 2007

Volunteer Opportunities:

The Town of Apex Storm Drain Marking Program is a great opportunity for volunteers to help educate their community about the importance of stormwater pollution prevention. Many residents are not aware that stormwater runoff entering storm drains in the curb is not treated. This program allows volunteers to adhere watershed-specific markers to storm drains. The markers serve as a reminder to the community that stormwater runoff can wash pesticides, fertilizers, sediment, oil and other automotive fluids, household chemicals, pet waste, and litter into our valuable waterways.

Please contact Jessica Bolin at jessica.bolin@apexnc.org or (919) 249-3537 for more information on organizing a volunteer opportunity for your group.

Important Phone Numbers

Public Works and Utilities Department: ……..249-3427

Finance Department :……..362-8676

Police Department (non-emergencies) :……..362-8661

Fire Department (non-emergencies) :……..362-4001

Police or Fire Emergencies Dial: ……911

Power Outage (8:00am—5:00pm) ……..249-3427

Power Outage (nights and weekends) ……..362-8661

Contact Information

System Operator: Town of Apex Public Works and Utilities Department.

Contact: Tim Donnelly, PE, Public Works and Utilities Director.
105 Upchurch St. Apex, NC 27502
Phone : 919-249-3427

Data submitted for the Water Reclamation Facility was certified by John Cratch, Water Reclamation Facility Manager

Data submitted for the Collection System was certified by John Cannon, Public Works Operations Manager

We are on the web at: www.apexnc.org

WATER CONSERVATION & PEAK DEMAND MANAGEMENT PLAN

Adopted April, 2000

EXECUTIVE SUMMARY

Purpose and Scope of Plan

The purpose of the Water Conservation and Peak Demand Management Plan ("Conservation Plan") is to assist the Town of Cary ("Town") in identifying and developing cost effective water conservation and demand management alternatives, general and site specific conservation programs, and other water efficiency measures.

One focus of the Town's Conservation Plan is to address peak summer usage levels and, in particular, what can be done to reduce this use over the short-term until the Cary/Apex Water Treatment Plant ("C/AWTP") expansion is on-line. Currently, the Town experiences strong demand peaks during the summer due to demand for irrigation and other elective uses. This peak seasonal demand is driven by a large proportion of residential customers, an affluent customer base, and high community standards for the appearance of commercial properties. The primary objective of the short-term demand management measures is to address these summer peaks. In addition to the short-term focus on peak demand management, the Conservation Plan addresses long-term conservation measures designed to achieve a level of total water savings at least a ten-year planning horizon. Benefits from water savings during this longer-term planning horizon include savings associated from the deferral of capital projects that would otherwise have been necessary in the absence of conservation.

Service Area & Water Use Characteristics

The Town owns 77% of the C/AWTP and produces water for the Town's approximately 30,000 retail customers, the Town of Morrisville ("Morrisville"), the Raleigh Durham Airport Authority ("RDU"), the Wake County portion of Research Triangle Park ("RTP"). The C/AWTP also serves the retail and wholesale customers of the Town of Apex ("Apex"), which owns the remaining portion (23%) of the treatment plant.

Water use patterns for the Town were evaluated in terms of six general categories or customer groups. Table ES-1 below, presents a summary of these characteristics of each of these six retail customer groups for 1998, the most recent calendar year for which data was available at the time of the analysis of operating characteristics. The characteristics include the number of accounts in each group, the gallons per day per account ("gpda") for each group, the percentage of each customer group's consumption as it relates to total Cary retail consumption, and the percentage of each customer group's consumption attributable to indoor and outdoor uses.

Table ES-1

Summary of Customer Group Consumption Characteristics for 1998

Customer Group	Accounts	GPD/ Account	Percentage of Total Retail	Indoor Use as % of Class	Outdoor Use as a % of Class
Single-family (RSF)	27,409	197.1	63.1%	82.1%	17.9%
Multi-family (RMF)	548	1,843.6	11.8%	92.9%	7.1%
Institutional	74	1,272.7	1.1%	64.8%	35.2%
Commercial	1,462	1,200.6	20.5%	84.4%	15.6%
Industrial	14	8,562.0	1.4%	70.4%	29.6%
Irrigation	123	1,461.8	2.1%	38.7%	61.3%

As the table illustrates, the majority of retail water sales in the Town goes to Residential Single-family ("RSF"), Commercial, and Residential Multi-family ("RMF"). The combined sales of the three remaining customer groups amounts to less than 5% of the total retail water sales. Therefore, the Town's historical water use patterns suggest that the RSF, Commercial, and RMF customer groups provide the greatest potential for long-term water savings achieved through conservation measures and efforts.

Existing and Projected Water Demand and Supply

Since the C/AWTP was constructed in 1993, population growth in Cary and the surrounding area has increased peak seasonal water demand to levels that exceed the Town's existing capacity to produce and distribute water. In order to meet this level of demand, the Town is planning to expand the C/AWTP in order to provide a capacity of 40.0 MGD by fiscal year ("FY") 2002. The Town will continue to own 77% or approximately 30.8 MGD of the plant's expanded capacity. In the meantime, peak demand is met by purchasing finished water from the City of Raleigh ("Raleigh") and the City of Durham ("Durham").

Based on forecasted changes in the demographics of the Town, the average daily retail water demand is projected to increase from 8.6 MGD in 1998, the base year used for this study, to 26.7 MGD in 2028. This represents over a 300% increase in demand over the 30-year forecast period. In addition to the current plant expansion to 40.0 MGD, two subsequent expansions of 16.0 MGD are scheduled to occur during the planning horizon in order to meet the anticipated in growth in demand. These expansions are necessary in order to meet expected increases in peak day demand, which are projected to increase from 9.1 to 28.3 over the 30-year forecast period.

Current Water Conservation Programs

The Town began to address water conservation in late 1996 after hiring a water conservation specialist and subsequently adopted a formal Water Conservation and Demand Management Policy in March 1997. The Town's ongoing water conservation efforts are focused on both supply side conservation, to augment and preserve existing and future water supplies, and demand side conservation, to reduce demand and promote the efficient use of water.

To address the peak seasonal demand from a supply side perspective, the Town is committed to the construction of a Reclaimed Water System to provide non-potable reclaimed water for irrigation systems within its local retail service area. Initially, the reclaimed water distribution system will be limited to selected areas within reasonably close proximity to the Town's two

wastewater treatment plants. The first two projects are scheduled to be completed by the spring of 2001, and the use of reclaimed water is projected to reduce potable water demand for irrigation purposes by approximately 0.176 MGD beginning in the summer of 2002.

The Town already has in place a Water Conservation program focused on demand side conservation to encourage long-term conservation and wise water use. Demand side conservation activities already implemented by the Town to address the "long-term" conservation of water by its retail water customers include:

- A *Public Education Program* that incorporates a "Block Leader Program" and a summer "Beat the Peak Program" to convey to the public an understanding of why water conservation is important;
- A *Toilet Flapper Rebate Program* to provide customers with the incentive to replace existing flappers with early closure models;
- A *Water Waste Ordinance* that prohibits wasteful outdoor watering that falls directly onto impervious surfaces;
- A *Rain Sensor Ordinance* that requires all existing an new customers with irrigation systems to install a rain sensor that measures rainfall and overrides the irrigation cycle of the system; and
- A *Conservation Rate Structure* designed to encourage more efficient use of water resources by charging higher unit rates to residential customers as their level of consumption increases.

The Town has also been proactive in addressing its peak demand management issues by implementing various water use restrictions that may be imposed during those periods that constitute a water emergency. These peak demand management restrictions include:

- Odd-Even Day Outdoor Watering;
- Total Ban on Turf Watering; and
- Odd-Even Day Turf Watering.

Assessment of Water Conservation Potential

The vast majority of retail water sales (97.5%) in the Town is attributable to four of the six customer groups: RSF (63.1%); Commercial (20.5%); RMF (11.8%); and Irrigation (2.1%). Therefore, these four customer groups provide the greatest potential to achieve long-term average day water savings through conservation measures and efforts. However, achieving long-term average water savings will be more difficult in a newly developed community, such as Cary, where a large proportion of homes are relatively new. A large proportion of structures in Cary were built after the adoption of revised plumbing codes in 1992, thereby eliminating many opportunities to achieve conservation that might be available in other communities. In fact, the analysis of water usage patterns indicates that residential indoor usage measured on a per account basis already demonstrated acceptable water use efficiency.

From the perspective of deferring proposed water capital improvement projects (additional

expansions to the C/AWTP), the objective is to reduce summer peak day water use because water treatment plants are sized, and expansions are timed, based upon peak day demand. Outdoor water use by the four groups identified above represents over 95% of the total retail outdoor water use. As a result, there appears to be potential for significant conservation in each of these customer groups related to outdoor or landscape water use.

Conservation Plan and Implementation Recommendations

In March 1999, the Town distributed a Request for Proposals ("RFP") to conduct a Water Conservation and Peak Demand Management Plan. The project team, which includes Raftelis Financial Consulting, ("RFC") in association with Maddaus Water Management ("MWM") and the Weber Group ("WG"), was selected based on its response to the RFP. The following is a summary of the findings of the study and recommendations for a comprehensive cost-effective water conservation plan.

Benefit Cost Analysis and Recommendations

Over 130 potential conservation measures were considered. After a screening process, water savings were estimated and costs were developed for 15 conservation measures or programs. Benefits and costs were compared in a formal present worth analysis and conclusions were drawn about which programs produce cost-effective water savings for the Town. Cost categories include labor (by Town staff or outside contractors to administer and perform any required fieldwork), expenses, incentives, and one-time setup costs. Benefits from conservation include:

- Current savings in operations and maintenance ("O&M"); and
- Savings from the deferral and/or elimination of capital projects that would have been necessary in the absence of conservation.

Capital savings were estimated by comparing existing treatment capacity with the capacity that would be required through the year 2028. Water demand projections were adjusted for expected demand reductions from long-term implementation of existing plumbing code requirements for water conserving toilets, urinals, faucets, and showerheads. The need for additional plant capacity was estimated, excluding the initial 40.0 MGD expansion already underway, assuming that treatment capacity would be added in 16.0 MGD increments over the 30-year forecast period. Of the 16.0 MGD increments of expansion Cary would receive 12.3 MGD, representing its 77% ownership stake in the plant.

The Recommended Plan

Based on the results of the benefit-cost analysis, a recommended plan was developed using the following criteria:

- Benefit-cost ratio greater than 1.0 (i.e., the program must save more than it costs);
- Reasonable cost (i.e., affordable);
- Significant water savings; and
- Acceptable non-quantifiable impacts.

The recommended plan includes seven programs targeted mainly at residential (RSF and RMF), commercial, and irrigation accounts. A list of the programs, water savings, and total costs (over the first five years) of each program included in the recommended plan are shown in Table ES-2.

Table ES-2
Recommended Plan

Program Element	Water Savings in 2009 MGD	Unit Cost of Water Saved, $/MGD	First Five Years of Costs	Utility Benefit-Cost Ratio
Residential Water Audits	.053	$546.85	$71,300	1.1
New Home Points Program	.491	36.46	100,000	16.2
Public Education	.300	400.59	314,300	1.5
Flapper Rebate	.005	828.04	11,800	1.0
Water Reclamation Facility (Water Reuse)	.270	0.00	1 [(1)]	N/A
Landscape Water Budgets	.013	754.33	64,200	.9
Landscape/Irrigation Codes	.019	276.07	128,400	2.6
Increasing Block Rate Structure	.143	49.40	54,000	14.3
Combined Results [(2)]	1.169	137.5	$655,500	4.4

[(1)] The decision to construct a Water Reclamation Facility was made independent of this study. Although the water savings and benefits of the facility are included in the Conservation Plan, the capital costs associated with this project have not been factored into the benefit-cost analysis, as the costs will be incurred regardless of this analysis. In order to include the Facility as a measure in the DSS Model, a $1 cost had to be included. For more information regarding this issue, please see the discussion included on page 5 of Chapter 7.

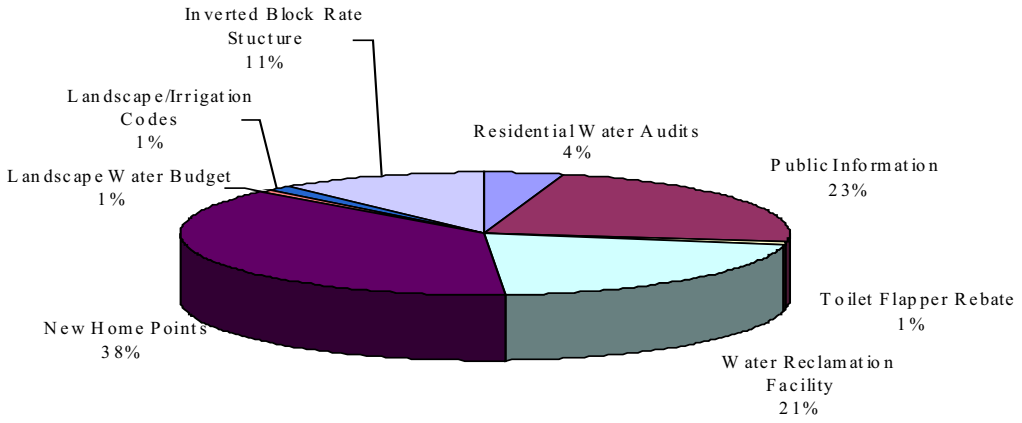
[(2)] For more information on the relationship between the water savings estimated for each stand-alone measure and the combined results of incorporating the water savings associated with the stand-alone measures into an alternative program, see the discussion on page 6 of Chapter 7.

The plan assumes the programs will be implemented in FY 2001. Water savings in retail water production expected from the recommended plan by the end of the forecast period in 2028 total 4.6 MGD. This represents a reduction in retail water production of approximately 16.3%. It should be noted that the water savings estimated for the Recommended Plan does not equal the total water savings associated with the sum of each plan elements due to the "shared water savings" produced by those conservation measures that focus on similar end uses.

For information purposes, Figure ES-1 provides a distribution of the water savings associated with each individual plan element, as a percentage of the sum of the savings for all of the individual plan elements over the entire planning horizon.

Figure ES-1

Distribution of Water Savings by Programmatic Element



Benefits of the Recommended Plan

Benefits of the plan include the deferral of considerable capital expenditures and the operating costs associated with them (Phase I and II of expanding the C/AWTP) and save money by reducing the annual system operating costs. Even with projected water savings from enforcement of plumbing code provisions, the Town's share of the total C/AWTP capacity projected to be needed by 2028 in the absence of the Conservation Plan is approximately 55.4 MGD. This represents an increase of 4.5 times the current Town share (11.6 MGD) of the existing 15.0 MGD capacity. Although both expansions of the C/AWTP to provide the Town with additional capacity will still be required by 2028, the Recommended Plan is projected to provide water savings that will allow these expansions to be delayed. By extending the timing of the capital cost associated with these expansions, the present worth of these expansions are reduced. The projected delay for the first phase represents approximately a 4.5-year delay from 2009 to 2013. The projected delay for the second expansion phase represents approximately a 5.8-year delay from 2018 to 2024.

Implementation Considerations

The recommended water conservation plan represents a significant commitment and effort by the Town over the next ten years to implement proposed water efficiency programs. In addition to the programs included in the recommended plan, the Town will continuously monitor and evaluate its overall water conservation effort in relation to its water supply and water and wastewater facility capacity needs. As the need for major capital investments draw near, the

Town may consider expanding current programs and/or implementing additional water conservation measures. More aggressive water conservation measures may be implemented throughout the service area or targeted to specific sub-areas in order to delay planned capital improvements. Proper timing of future investments by the Town for water conservation is essential to maximizing the benefits of such programs to the utility and its ratepayers.

It is important that the Town proceed in a planned and careful manner, ramping up the program as new staff is hired and becomes capable of conducting programs and administering contracts. Staffing is discussed in the next section. Not all new programs need start in the first year; and expansion of the programs should be paced with the growing capabilities of the new staff and increases in budgets. The programs can be ramped up over a 3-year period so that at the end of the third year all programs are up and running. (This also coincides with the need to focus most of the effort and attention over the next two summers on short-term measures and water use restrictions that may be discontinued once the plant expansion is completed.)

The conservation programs that will be implemented should be monitored to ensure that they are generating the level of savings that is required to meet long-range demand and strategic supply objectives. In addition, the findings of this monitoring will provide the cost effectiveness information required for Town management to make future adjustments and modifications to the Conservation Plan to provide the most efficient long-term allocation of conservation resources.

Proudly Presented By:

TOWN of CARY

ANNUAL WATER QUALITY REPORT

Water testing performed in 2006

PWS ID#: 03-92-020

Continuing Our Commitment

Once again we are pleased to present our annual drinking water quality report. This edition covers all testing completed from January 1, 2006 through December 31, 2006. As in the past, we are committed to delivering the highest quality drinking water to our customers. To that end, we remain vigilant in meeting the challenges of source water protection, water conservation, and community education while continuing to serve the needs of all of our water users.

For any questions or concerns relating to your drinking water or water service, please contact Customer Service for the Department of Public Works and Utilities at (919) 469-4090. For more information about this report, please contact Penny Rosser, Chemist at the Cary/Apex Water Treatment Facility, at (919) 362-5502.

Important Health Information

Some people may be more vulnerable to contaminants in drinking water than the general population. Immunocompromised persons such as persons with cancer undergoing chemotherapy, persons who have undergone organ transplants, people with HIV/AIDS or other immune system disorders, some elderly, and infants may be particularly at risk from infections. These people should seek advice about drinking water from their health care providers. The U.S. EPA/CDC (Centers for Disease Control and Prevention) guidelines on appropriate means to lessen the risk of infection by *Cryptosporidium* and other microbial contaminants are available from the Safe Drinking Water Hotline at (800) 426-4791.

Where Does Our Water Come From?

The Town of Cary's drinking water source is the B. Everett Jordan Reservoir, more commonly known as Jordan Lake, which lies approximately ten miles west of Cary in eastern Chatham County. The lake is a surface water supply that is part of the Cape Fear River basin. The water is treated at the Cary/Apex Water Treatment Facility, a plant co-owned by the towns of Cary and Apex and located in western Wake County.

For the fourth consecutive year in 2006, the Cary/Apex Water Treatment Facility received the Partnership for Safe Water Director's Award. The facility proudly joins less than 5% of water utilities nationwide in this honor. For more information about the Partnership for Safe Water and this award, please visit the American Water Works Association Web site at www.awwa.org/science/partnership/.

Source Water Assessment Program (SWAP) Results

The North Carolina Department of Environment and Natural Resources (DENR), Public Water Supply (PWS) Section, Source Water Assessment Program (SWAP) conducted assessments for all drinking water sources across North Carolina. The purpose of the assessments was to determine the susceptibility of each drinking water source (well or surface water intake) to potential contaminant sources (PCSs). The results of the assessments are available in SWAP Assessment Reports that include maps, background information, and higher, moderate, or lower relative susceptibility ratings.

The relative susceptibility rating of Jordan Lake, the water source for the Town of Cary, was determined by combining the contaminant rating (number and location of PCSs within the assessment area) and the inherent vulnerability rating, i.e., characteristics or existing conditions of the well or watershed and its delineated assessment area. The assessment reported a higher rating for Jordan Lake. This assessment was most recently updated on March 15, 2005.

The complete SWAP Assessment Report for the Town of Cary may be viewed on the Web at www.deh.enr.state.nc.us/pws/swap. Please note that because SWAP results and reports are periodically updated by the PWS Section, the results available on this Web site may differ from the results that were available at the time this water quality report was prepared. To obtain a printed copy of this report, please mail a written request to Source Water Assessment Program - Report Request, 1634 Mail Service Center, Raleigh, North Carolina 27699-1634, or e-mail a request to swap@ncmail.net. Please indicate your system's name, your PWSID, and your name, mailing address and phone number. If you have any questions about the SWAP Report please contact the Source Water Assessment staff by phone at (919) 715-2633.

Please understand that a higher susceptibility rating does not imply poor water quality, but rather the system's potential to become contaminated by PCSs in the assessment area.

Testing Results

Once again, we're pleased to report that your drinking water continues to be safe. During the past year we have tested thousands of water samples in order to determine the presence of any radioactive, biological, inorganic, volatile organic, or synthetic organic contaminants. The table below shows only those contaminants that were detected in the water. We feel it is important that you know exactly what was detected and how much of the substance was present in your water. Unless otherwise noted, the data presented in this table is from testing performed from January 1, 2006 through December 31, 2006. The U.S. EPA and/or the state require us to monitor for certain substances less than once per year because the concentrations of these substances are not expected to vary significantly from year to year. Some of this data, though representative of the water quality, is more than one year old.

REGULATED SUBSTANCES

SUBSTANCE (UNIT OF MEASURE)	YEAR SAMPLED	MCL [MRDL]	MCLG [MRDLG]	YOUR WATER	RANGE LOW-HIGH	VIOLATION	TYPICAL SOURCE
Beta/Photon Emitters[1] (pCi/L)	2006	50	0	4.4	NA	No	Decay of natural and man-made deposits
Chloramines (ppm)	2006	[4]	[4]	2.82	0.85–3.39	No	Water additive used to control microbes
Chlorine (ppm)	2006	[4]	[4]	0.40	0.14–1.71	No	Water additive used to control microbes
Fecal coliform and E. coli (# positive samples)	2006	0	0	1	NA	Yes	Human and animal fecal waste
Fluoride (ppm)	2006	4	4	1.2	0.108–1.2	No	Erosion of natural deposits; Water additive which promotes strong teeth; Discharge from fertilizer and aluminum factories
Haloacetic Acids [HAA] (ppb)	2006	60	NA	26	19–40	No	By-product of drinking water disinfection
Nitrite (ppm)	2006	1	1	0.02	ND–0.02	No	Runoff from fertilizer use; Leaching from septic tanks, sewage; Erosion of natural deposits
TTHMs [Total Trihalomethanes][2] (ppb)	2006	80	NA	73	47–136	No	By-product of drinking water chlorination
Total Coliform Bacteria (% positive samples)	2006	5% of monthly samples are positive	0	5%	NA	Yes	Naturally present in the environment
Total Organic Carbon [TOC]–TREATED[3] (removal ratio)	2006	TT	NA	1.16	0.97–1.33	No	Naturally present in the environment
Turbidity[4] (NTU)	2006	TT = 1 NTU	NA	0.14	0.05–0.14	No	Soil runoff
Turbidity (Lowest monthly percent of samples meeting limit)	2006	TT > 95	NA	100	NA	No	Soil runoff

Tap water samples were collected from 50 sample sites throughout the community

SUBSTANCE (UNIT OF MEASURE)	YEAR SAMPLED	ACTION LEVEL	MCLG	YOUR WATER (90TH%TILE)	SITES ABOVE ACTION LEVEL	VIOLATION	TYPICAL SOURCE
Copper (ppm)	2006	1.3	1.3	0.138	0	No	Corrosion of household plumbing systems; Erosion of natural deposits; Leaching from wood preservatives
Lead (ppb)	2006	15	0	< 3.0	1	No	Corrosion of household plumbing systems; Erosion of natural deposits

SECONDARY SUBSTANCES [5]

SUBSTANCE (UNIT OF MEASURE)	YEAR SAMPLED	SMCL	MCLG	YOUR WATER	RANGE LOW-HIGH	VIOLATION	TYPICAL SOURCE
Iron (ppb)	2006	300	NA	70	ND–70	No	Leaching from natural deposits; Industrial wastes
Manganese (ppb)	2006	50	NA	20	ND–20	No	Leaching from natural deposits
pH (Units)	2006	6.5-8.5	NA	7.85	7.20–8.92	No	Naturally occurring

UNREGULATED SUBSTANCES			
SUBSTANCE (UNIT OF MEASURE)	YEAR SAMPLED	YOUR WATER	RANGE LOW-HIGH
Bromodichloromethane (ppb)	2006	50	17–50
Bromoform (ppb)	2006	5	1–5
Chlorodibromomethane (ppb)	2006	30	11–30
Chloroform (ppb)	2006	51	14–51
Sodium (ppm)	2006	40.7	20.6–40.7
Sulfate (ppm)	2006	36	NA

[1] The MCL for beta particles is 4mrem/year. The U.S. EPA considers 50 pCi/L to be the level of concern for beta particles.

[2] The MCL for TTHMs is based on the overall Running Annual Average (RAA) of four individual samples tested on a quarterly basis, which is shown in the Your Water column. Compliance is not based on the levels found in the individual samples reported in the Range column. An individual sample result above the MCL does not constitute a regulatory violation.

[3] For compliance purposes, we are required to maintain an annual TOC removal ratio of 1.0 or greater calculated as a Running Annual Average (RAA) of monthly averages computed quarterly. The value in the Your Water column is the RAA for 2006. The state classifies this compliance method as Step 1. If we fail to meet Step 1 requirements, there are alternative compliance criteria that may be used. If we fail to meet the alternative compliance criteria, we are in violation of a Treatment Technique (TT) and deemed out of compliance. We have consistently met Step 1 compliance criteria for TOC removal.

[4] Turbidity is a measure of the cloudiness of the water. We monitor it because it is a good indicator of the effectiveness of our filtration system. The turbidity rule requires that 95% or more of the monthly samples must be less than or equal to 0.3 NTU.

[5] Secondary contaminants, required by the North Carolina Public Water Supply Section, are substances that affect the taste, odor, and/or color of drinking water. These aesthetic contaminants do not normally have any health effects and normally do not affect the safety of your drinking water.

Substances That Might Be in Drinking Water

To ensure that tap water is safe to drink, the U.S. EPA prescribes regulations limiting the amount of certain contaminants in water provided by public water systems. U.S. Food and Drug Administration regulations establish limits for contaminants in bottled water, which must provide the same protection for public health. Drinking water, including bottled water, may reasonably be expected to contain at least small amounts of some contaminants. The presence of these contaminants does not necessarily indicate that the water poses a health risk.

The sources of drinking water (both tap water and bottled water) include rivers, lakes, streams, ponds, reservoirs, springs, and wells. As water travels over the surface of the land or through the ground, it dissolves naturally occurring minerals, in some cases, radioactive material, and substances resulting from the presence of animals or from human activity. Substances that may be present in source water include:

Microbial Contaminants, such as viruses and bacteria, which may come from sewage treatment plants, septic systems, agricultural livestock operations, or wildlife;

Inorganic Contaminants, such as salts and metals, which can be naturally occurring or may result from urban stormwater runoff, industrial or domestic wastewater discharges, oil and gas production, mining, or farming;

Pesticides and Herbicides, which may come from a variety of sources such as agriculture, urban stormwater runoff, and residential uses;

Organic Chemical Contaminants, including synthetic and volatile organic chemicals, which are by-products of industrial processes and petroleum production, and may also come from gas stations, urban stormwater runoff, and septic systems;

Radioactive Contaminants, which can be naturally occurring or may be the result of oil and gas production and mining activities.

For more information about contaminants and potential health effects, call the U.S. EPA's Safe Drinking Water Hotline at (800) 426-4791.

Community Participation

The Town of Cary encourages public input regarding decisions that affect our community's drinking water. Regular meetings of the Cary Town Council are held the second and fourth Thursday of each month at 6:30 p.m. in the Council Chambers at Town Hall located at 316 North Academy Street in Cary. The public is welcome.

About Our Violations

In August 2006, the Town of Cary experienced localized contamination in our water system from an outside source that affected two homes on Coronado Way in Cary. Multiple positive total coliform samples from these two homes caused the Town to be out of compliance for total coliform bacteria for the month of August 2006. During that same period on the same street, one positive *E. coli* sample from one of these two homes also caused the Town to be out of compliance for *E. coli.*

The Town acted quickly to protect public health by issuing a "boil water notice". Then, Coronado Way was isolated from the Town's water system and the contamination was flushed from the system. Multiple subsequent samples were analyzed from this area to confirm that the contamination had been removed and had not reached other parts of our water supply.

Fortunately, there were no confirmed reports of illness from these incidents.

Coliforms are bacteria that are naturally present in the environment and are used as an indicator that other, potentially harmful, bacteria may be present. Coliforms were found in more samples than allowed and this was a warning of potential problems. Fecal coliforms and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes can cause short-term effects, such as diarrhea, cramps, nausea, headaches, or other symptoms. They may pose a special health risk for infants, young children, and people with severely compromised immune systems.

Table Definitions

AL (Action Level): The concentration of a contaminant which, if exceeded, triggers treatment or other requirements which a water system must follow.

MCL (Maximum Contaminant Level): The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to the MCLGs as feasible using the best available treatment technology.

MCLG (Maximum Contaminant Level Goal): The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety.

MRDL (Maximum Residual Disinfectant Level): The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.

MRDLG (Maximum Residual Disinfectant Level Goal): The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.

NA: Not applicable.

ND (Not detected): Indicates that the substance was not found by laboratory analysis.

NTU (Nephelometric Turbidity Units): Measurement of the clarity, or turbidity, of water. Turbidity in excess of 5 NTU is just noticeable to the average person.

pCi/L (picocuries per liter): A measure of radioactivity.

ppb (parts per billion): One part substance per billion parts water (or micrograms per liter).

ppm (parts per million): One part substance per million parts water (or milligrams per liter).

removal ratio: A ratio between the percentage of a substance actually removed to the percentage of the substance required to be removed.

TT (Treatment Technique): A required process intended to reduce the level of a contaminant in drinking water.

Water Quality Department

The Department of Water Quality is responsible for all maintenance of water and wastewater (sewer) facilities.

Contact the Water Quality Department to report changes or problems with discoloration, taste or odor of drinking water.

Contact the Finance Department to begin or end utility service or if you have questions about your utility bill.

Drinking Water

To ensure adequate supply now and in the future, the Town of Holly Springs buys treated drinking water from two sources.

- **Harnett County** - Allocates 2 million gallons daily to Holly Springs, which is in the process of obtaining an additional 1 million gallons for a total of 3 million gallons per day. Harnett County draws water from the Cape Fear River for treatment in Lillington. Water reaches Holly Springs through a 36-inch diameter pipe that could carry up to 10 million gallons a day.

- **City of Raleigh** - Allocates up to 1.2 million gallons daily. Raleigh draws from Falls Lake and pumps treated water to Holly Springs' system through a 16-inch diameter line along Holly Springs Road.

The Town's water system includes three water towers with a total storage capacity of 2.3 million gallons.

The Consumer Confidence Report is an annual report that details the quality of drinking water that Holly Springs distributes to its customers.

Wastewater Treatment

Holly Springs has treatment capacity of 1.75 million gallons a day at its wastewater plant, which discharges into Utley Creek in the Cape Fear River basin. Design of expansion is under way.

Treatment Plant Expansion

- Construction Begins - 2007
- Plant Capacity after Expansion - 6 million gallons daily
- Anticipated Life of Expansion - 20 years (2025)

Discharging Treated Wastewater

The Town has a permit to discharge up to 2.4 million gallons of treated wastewater into Utley Creek daily and is in the process of increasing the amount the Town is allowed to discharge.

Longer range, Holly Springs plans to continue treating wastewater while using a regional pipeline to discharge into the Cape Fear River. The regional system is scheduled to begin operating by 2011.

The Wastewater Performance Report summarizes treatment and collection system performance throughout town annually.

Reuse for Irrigation

To preserve drinking water, construction is under way on a system to pipe treated wastewater for irrigation in what will be the largest project of its kind in the state. The piping system will serve the Twelve Oaks development, a golf course community under construction off New Hill Road at the western edge of Holly Springs.

By early 2008, the system is expected to be operating in Twelve Oaks.

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Red-cockaded Woodpecker
(Picoides borealis)

Status:

Population size:

Photo by Cornell Laborato Ornithology.

The pinelands of the southeastern U.S. are the year-round home to this unique and social woodpecker. Unfortunately, habitat loss and degradation have greatly reduced its range and negatively affected this species, which has been considered Federally Endangered since 1968. Because of this designation and its presence on many federal and private lands, a great deal of research has been conducted. This species is probably the most well-studied woodpecker in the world. Management has improved over the years however but many challenges lie ahead.

Identification

While the name seems as if it should describe a salient feature, the red "cockade" on the sides of the male's nape is actually almost invisible in the field, making it extremely difficult to reliably separate the sexes without capture. This woodpecker, like most in its genus, is predominantly black and white. It has a ladder pattern on the back and large white cheeks, which are unique among woodpeckers in its range. The size varies slightly throughout the range with a gradient from smaller individuals in southern and coastal populations to larger birds inland and north. This species is quite rare outside of suitable habitat and does not frequent feeders. The larger and somewhat similar Hairy Woodpecker (Picoides villosus) and, less commonly, the smaller Downy Woodpecker (P. pubescens) may occur alongside Red-cockaded Woodpeckers. Both of these species lack the white "cheeks", have a large white patch on their back and the males have an obvious red spot on the back of the head.

Distribution and Population Trends

This species is a year-round resident in mature pine forests of the southeastern U.S. This bird was once considered common throughout the southern part of its range, which formerly stretched north to New Jersey Oklahoma. With the cutting of the large tracts of pine throughout much of the south, this species has been completely from several states and continues to decline in most others. Its range is currently includes the very eastern edge of Te coast states to central Florida and reaches north to North Carolina and Tennessee. Populations are fragmented and rar on the edges but also in many areas throughout its range. There are now approximately 30 distinct populations with tl birds occurring in only six populations. In North Carolina, the Sandhills East IBA, which includes Fort Bragg and Weym State Park, hosts one of the largest populations of Red-cockaded Woodpeckers in the world (280 pairs). In Florida a nu IBAs support populations of the species including Eglin Air Force Base which may host as many as 300 pairs. Overall, t continues to decline as a result of human activity and while the logging threat has diminished, new stresses such as de and fragmentation take their toll.

Ecology

Much of this bird's life is centered around stands of large, open pine (esp. Longleaf Pine) stands that are maintained n lightning-started fires that occur about every 1-5 years. This woodpecker requires mature pine trees (75-100 years old ample foraging surface area and to hold nest and roost cavities, which are typically located close together in area calle The nest clusters, which contain family groups of 3-4 individuals, are indicative of the fascinating social and cooperativ behaviors of this species. The first-year males usually help the cluster's one breeding female with incubation and feedi females often disperse to new cavities or clusters to breed. Usually 3-4 eggs are laid in their cavity nest (the breeding cavity), constructed in a live tree, 10-13m above the ground. Cavities can take several years to construct and are freq reused. Below the cavities, resin wells are drilled and the resulting sticky layer of pine pitch coating the trunk protects nests from predation by rat snakes. Red-cockaded Woodpeckers forage in a wide variety of pine species and especially that contain large trees due to the large surface area and loose bark. They feed on adults, larvae and eggs of arthropo ants and termites that they find by flaking bark from the tree.

Threats

Loss of habitat is by far the greatest threat to the survival of the Red-cockaded Woodpecker. The impact of large-scale the southern pinelands in the early part of this century unfortunately demonstrated this fact all too well. Even-aged, sl forest management techniques eliminate the large nesting and foraging trees that this species requires. Development

fragmentation cause habitat destruction and degradation but also may isolate populations and potentially cause localiz extirpation if dispersal is no longer possible. Humans also limit fire, which plays an essential role in the ecosystem, an noises, which may disturb nesting birds. Other woodpecker species also disrupt Red-cockadeds by enlarging holes and nest cavities. In doing so, Red-bellied and Red-headed Woodpeckers may remove and eat the eggs. Other nest threats Snakes, Corn Snakes and Southern Flying Squirrels. Screech Owls, American Kestrels and Accipiters are predators of a and fledglings.

Conservation

Two recovery plans have been written for the Red-cockaded Woodpecker; the first was never implemented, and the se been heavily criticized. The devastation of the Francis Marion National Forest population by Hurricane Hugo stimulated artificial cavities and the translocation of birds as part of common management practice. The hurricane also made mar of the species' vulnerability. Federal action was initiated when a Texas judge declared that the species was declining b management practices on Forest Service lands. To improve habitat on federal lands, managers have started extensive hardwood understory. To make enlarged cavities suitable and to prevent other cavities from being enlarged, metal pla cavity restrictors have been installed. Artificial cavities have been constructed to augment existing cavity tree clusters establish new groups. Young females have also been relocated to isolated family groups that previously lacked a fema some cases also improves genetic diversity of the group.

What Can You Do?

Audubon's Important Bird Area program is a tool for the conservation of Red-cockaded Woodpckers as well as other sp learn more about the Important Bird Areas program in Florida, North Carolina and others states where the species is f http://www.audubon.org/bird/iba/

Audubon and our partners in conservation coordinated the submission of over two million comments to the U.S. Forest support of the Roadless Area Conservation Rule, which would protect habitat for Red-cockaded Woodpeckers and man species. Unfortunately, implementation of the Rule has been stalled and attempts are being made to weaken it. To hel protecting these vital habitats visit: http://www.audubon.org/campaign/latestnews.html#roadless

The Endangered Species Act has helped protect the Red-cockaded Woodpecker and made it possible to learn critical in about its biology. Audubon continues to work to ensure that this vital legislation is being used to protect our publicly-o resources. Check out http://www.audubon.org/campaign/ to learn of the latest news about the Endangered Species A you can help. To learn more about other species protected under this legislation, visit: http://endangered.fws.gov/

U.S. National Wildlife Refuges provide essential habitat for the Red-cockaded Woodpecker, and a great number of othe throughout the U.S. and its territories. Unfortunately, the refuge system is often under-funded during the U.S. govern budgeting process. To learn more about how you can help gain much needed funding for U.S. National Wildlife Refuge http://www.audubon.org/campaign/refuge_report/

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Table 7. **Hired Farm Labor - Workers and Payroll: 2002**

[Data are based on a sample of farms. For meaning of abbreviations and symbols, see introductory text]

Item	North Carolina	Alamance	Alexander	Alleghany	Anson	Ashe	Avery
Hired farm labor ..... farms	16,091	141	124	209	170	273	243
workers	97,138	443	404	880	715	2,415	1,227
$1,000 payroll	552,486	2,969	2,330	1,940	6,134	7,639	3,283
Farms with-							
1 worker ..... farms	4,742	33	12	119	54	45	33
workers	4,742	33	12	119	54	45	33
2 workers ..... farms	2,869	70	69	18	50	63	17
workers	5,738	140	138	36	100	126	34
3 or 4 workers ..... farms	3,087	15	22	34	18	68	95
workers	10,556	58	77	109	59	241	313
5 to 9 workers ..... farms	2,752	17	17	22	38	39	72
workers	17,913	108	125	155	298	233	474
10 workers or more ..... farms	2,641	6	4	16	10	58	26
workers	58,189	104	52	461	204	1,770	373
Workers by days worked:							
150 days or more ..... farms	6,080	26	45	49	76	89	55
workers	27,916	105	128	116	259	519	182
Farms with-							
1 worker ..... farms	2,289	8	2	19	48	23	15
workers	2,289	8	(D)	19	48	(D)	(D)
2 workers ..... farms	1,441	2	29	24	8	34	15
workers	2,882	(D)	58	48	16	68	30
3 or 4 workers ..... farms	1,079	13	11	2	5	2	15
workers	3,690	40	35	(D)	18	(D)	51
5 to 9 workers ..... farms	733	2	1	2	6	8	9
workers	4,683	(D)	(D)	(D)	40	54	56
10 workers or more ..... farms	538	1	2	2	9	22	1
workers	14,372	(D)	(D)	(D)	137	366	(D)
Less than 150 days ..... farms	13,417	132	85	181	125	262	234
workers	69,222	338	276	764	456	1,896	1,045
Farms with-							
1 worker ..... farms	4,502	27	13	117	51	61	36
workers	4,502	27	(D)	117	(D)	61	36
2 workers ..... farms	2,340	71	43	1	39	62	39
workers	4,680	142	86	(D)	78	124	78
3 or 4 workers ..... farms	2,490	28	13	29	1	69	72
workers	8,533	100	50	(D)	(D)	259	234
5 to 9 workers ..... farms	2,171	3	14	20	33	23	66
workers	13,934	26	105	136	262	152	422
10 workers or more ..... farms	1,914	3	2	14	1	47	21
workers	37,573	43	(D)	420	(D)	1,300	275
Reported only workers working 150 days or more ..... farms	2,674	9	39	28	45	11	9
workers	12,970	59	100	65	200	22	45
$1,000 payroll	200,327	1,359	1,428	802	4,869	260	371
Reported only workers working less than 150 days ..... farms	10,011	115	79	160	94	184	188
workers	42,548	274	252	651	408	1,087	788
$1,000 payroll	55,620	462	351	184	248	441	982
Reported both - workers working 150 days or more and workers working less than 150 days ..... farms	3,406	17	6	21	31	78	46
150 days or more, workers	14,946	46	28	51	59	497	137
less than 150 days, workers	26,674	64	24	113	48	809	257
$1,000 payroll	296,538	1,148	550	954	1,016	6,937	1,929
Migrant farm labor on farms with hired labor (see text) ..... farms	3,097	11	1	27	1	74	109
Migrant farm labor on farms reporting only contract labor (see text) ..... farms	364	-	-	6	-	11	23

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Table 7. **Hired Farm Labor - Workers and Payroll: 2002** - Con.

[Data are based on a sample of farms. For meaning of abbreviations and symbols, see introductory text]

Item		Beaufort	Bertie	Bladen	Brunswick	Buncombe	Burke	Cabarrus
Hired farm labor	farms	171	135	187	109	344	71	58
	workers	1,582	870	2,040	815	1,686	751	226
	$1,000 payroll	9,338	6,577	17,369	4,489	(D)	6,323	3,071
Farms with-								
1 worker	farms	27	21	49	44	110	24	17
	workers	27	21	49	44	110	24	(D)
2 workers	farms	24	22	54	16	53	10	24
	workers	48	44	108	32	106	(D)	48
3 or 4 workers	farms	36	39	16	19	44	1	10
	workers	123	124	53	64	133	(D)	37
5 to 9 workers	farms	43	25	22	11	109	11	2
	workers	264	167	132	74	637	60	(D)
10 workers or more	farms	41	28	46	19	28	25	5
	workers	1,120	514	1,698	601	700	644	112
Workers by days worked:								
150 days or more	farms	86	99	130	37	45	33	25
	workers	330	364	791	212	229	346	100
Farms with-								
1 worker	farms	35	38	73	12	9	8	5
	workers	35	38	73	12	(D)	(D)	(D)
2 workers	farms	15	20	21	8	2	9	14
	workers	30	40	42	16	(D)	18	28
3 or 4 workers	farms	24	21	12	7	27	1	2
	workers	79	70	39	26	106	(D)	(D)
5 to 9 workers	farms	4	13	8	3	4	9	-
	workers	21	76	51	21	30	47	-
10 workers or more	farms	8	7	16	7	3	6	4
	workers	165	140	586	137	80	270	59
Less than 150 days	farms	136	95	124	97	335	57	48
	workers	1,252	506	1,249	603	1,457	405	126
Farms with-								
1 worker	farms	29	17	47	42	142	16	15
	workers	29	(D)	47	42	142	16	15
2 workers	farms	18	38	18	20	43	10	26
	workers	36	76	36	40	86	20	52
3 or 4 workers	farms	14	1	8	11	43	9	2
	workers	47	(D)	28	41	131	27	(D)
5 to 9 workers	farms	49	28	21	9	80	11	3
	workers	305	192	128	66	478	75	19
10 workers or more	farms	26	11	30	15	27	11	2
	workers	835	218	1,010	414	620	267	(D)
Reported only workers working 150 days or more	farms	35	40	63	12	9	14	10
	workers	147	160	380	30	63	263	17
	$1,000 payroll	3,274	2,832	7,056	252	513	3,955	532
Reported only workers working less than 150 days	farms	85	36	57	72	299	38	33
	workers	746	152	512	227	1,300	311	58
	$1,000 payroll	1,197	187	2,125	294	370	561	127
Reported both - workers working 150 days or more and workers working less than 150 days	farms	51	59	67	25	36	19	15
	150 days or more, workers	183	204	411	182	166	83	83
	less than 150 days, workers	506	354	737	376	157	94	68
	$1,000 payroll	4,867	3,558	8,188	3,943	(D)	1,807	2,412
Migrant farm labor on farms with hired labor (see text)	farms	44	28	38	16	3	22	3
Migrant farm labor on farms reporting only contract labor (see text)	farms	10	17	1	4	10	-	-

--continued

Table 7. **Hired Farm Labor - Workers and Payroll: 2002** - Con.

[Data are based on a sample of farms. For meaning of abbreviations and symbols, see introductory text]

Item	Caldwell	Camden	Carteret	Caswell	Catawba	Chatham	Cherokee
Hired farm labor ..... farms	69	34	40	244	88	306	66
workers	301	169	311	1,473	522	907	210
$1,000 payroll	1,781	2,899	1,959	3,236	2,663	5,364	1,347
Farms with-							
1 worker ..... farms	13	3	11	26	28	142	24
workers	13	(D)	(D)	26	28	142	(D)
2 workers ..... farms	6	13	2	50	8	75	32
workers	12	(D)	(D)	100	16	150	64
3 or 4 workers ..... farms	24	9	7	44	22	52	8
workers	78	34	28	147	70	193	31
5 to 9 workers ..... farms	22	7	9	82	7	21	1
workers	143	39	64	573	55	122	(D)
10 workers or more ..... farms	4	2	11	42	23	16	1
workers	55	(D)	204	627	353	300	(D)
Workers by days worked:							
150 days or more ..... farms	38	23	15	30	22	57	29
workers	120	79	80	148	100	176	108
Farms with-							
1 worker ..... farms	2	5	6	5	3	42	1
workers	(D)	(D)	(D)	5	3	42	(D)
2 workers ..... farms	22	9	4	3	7	8	19
workers	44	18	8	6	14	16	38
3 or 4 workers ..... farms	9	5	2	5	9	2	7
workers	28	18	(D)	15	34	(D)	(D)
5 to 9 workers ..... farms	3	3	-	17	2	2	1
workers	20	19	-	122	(D)	(D)	(D)
10 workers or more ..... farms	2	1	3	-	1	3	1
workers	(D)	(D)	60	-	(D)	98	(D)
Less than 150 days ..... farms	58	25	36	231	85	263	39
workers	181	90	231	1,325	422	731	102
Farms with-							
1 worker ..... farms	28	12	8	28	37	113	24
workers	28	(D)	(D)	28	37	113	(D)
2 workers ..... farms	2	6	2	49	7	63	14
workers	(D)	12	(D)	98	14	126	28
3 or 4 workers ..... farms	14	1	7	40	18	55	-
workers	49	(D)	25	134	61	203	-
5 to 9 workers ..... farms	13	5	12	78	-	20	-
workers	90	28	80	530	-	121	-
10 workers or more ..... farms	1	1	7	36	23	12	1
workers	(D)	(D)	114	535	310	168	(D)
Reported only workers working 150 days or more ..... farms	11	9	4	13	3	43	27
workers	49	27	18	62	9	65	71
$1,000 payroll	748	605	(D)	458	(D)	724	(D)
Reported only workers working less than 150 days ..... farms	31	11	25	214	66	249	37
workers	119	36	148	1,229	349	659	(D)
$1,000 payroll	143	91	196	1,145	(D)	824	71
Reported both - workers working 150 days or more and workers working less than 150 days ..... farms	27	14	11	17	19	14	2
150 days or more, workers	71	52	62	86	91	111	(D)
less than 150 days, workers	62	54	83	96	73	72	(D)
$1,000 payroll	891	2,203	(D)	1,634	2,013	3,816	(D)
Migrant farm labor on farms with hired labor (see text) ..... farms	15	2	12	100	5	4	-
Migrant farm labor on farms reporting only contract labor (see text) ..... farms	-	-	-	10	5	-	-

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Table 7. **Hired Farm Labor - Workers and Payroll: 2002** - Con.

[Data are based on a sample of farms. For meaning of abbreviations and symbols, see introductory text]

Item		Chowan	Clay	Cleveland	Columbus	Craven	Cumberland	Currituck	Dare
Hired farm labor	farms	74	30	233	307	105	162	33	5
	workers	622	46	691	1,714	584	944	138	19
	$1,000 payroll	3,562	35	3,601	6,707	4,027	4,358	821	163
Farms with-									
1 worker	farms	16	24	132	42	43	58	5	-
	workers	16	24	132	42	43	58	(D)	-
2 workers	farms	20	-	43	17	10	40	4	1
	workers	40	-	86	34	20	80	8	(D)
3 or 4 workers	farms	12	6	33	137	6	14	11	3
	workers	37	22	100	499	22	45	35	(D)
5 to 9 workers	farms	15	-	4	42	31	20	12	1
	workers	90	-	27	255	199	134	78	(D)
10 workers or more	farms	11	-	21	69	15	30	1	-
	workers	439	-	346	884	300	627	(D)	-
Workers by days worked:									
150 days or more	farms	55	1	52	131	53	51	19	3
	workers	196	(D)	181	394	257	214	57	6
Farms with-									
1 worker	farms	21	1	35	39	21	24	6	1
	workers	(D)	(D)	35	39	21	24	(D)	(D)
2 workers	farms	14	-	1	64	9	9	2	1
	workers	28	-	(D)	128	18	18	(D)	(D)
3 or 4 workers	farms	14	-	3	8	12	7	8	1
	workers	53	-	(D)	26	40	23	25	(D)
5 to 9 workers	farms	5	-	9	11	5	6	3	-
	workers	32	-	69	64	31	42	22	-
10 workers or more	farms	1	-	4	9	6	5	-	-
	workers	(D)	-	65	137	147	107	-	-
Less than 150 days	farms	51	29	194	286	89	132	25	4
	workers	426	(D)	510	1,320	327	730	81	13
Farms with-									
1 worker	farms	15	23	98	40	43	50	7	1
	workers	15	(D)	98	40	43	50	7	(D)
2 workers	farms	14	-	43	79	5	26	4	2
	workers	28	-	86	158	10	52	8	(D)
3 or 4 workers	farms	9	6	34	77	3	10	7	-
	workers	27	22	103	272	11	31	25	-
5 to 9 workers	farms	3	-	4	35	30	22	7	1
	workers	19	-	25	218	174	143	41	(D)
10 workers or more	farms	10	-	15	55	8	24	-	-
	workers	337	-	198	632	89	454	-	-
Reported only workers working 150 days or more	farms	23	1	39	21	16	30	8	1
	workers	44	(D)	89	101	101	82	33	(D)
	$1,000 payroll	721	(D)	914	1,532	924	1,178	246	(D)
Reported only workers working less than 150 days	farms	19	29	181	176	52	111	14	2
	workers	70	(D)	412	913	143	492	42	(D)
	$1,000 payroll	60	(D)	175	1,679	313	1,189	46	(D)
Reported both - workers working 150 days or more and workers working less than 150 days	farms	32	-	13	110	37	21	11	2
	150 days or more, workers	152	-	92	293	156	132	24	(D)
	less than 150 days, workers	356	-	98	407	184	238	39	(D)
	$1,000 payroll	2,781	-	2,512	3,496	2,789	1,991	528	(D)
Migrant farm labor on farms with hired labor (see text)	farms	17	-	1	43	22	41	3	-
Migrant farm labor on farms reporting only contract labor (see text)	farms	-	-	-	2	1	6	-	-

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Table 7. **Hired Farm Labor - Workers and Payroll: 2002** - Con.

[Data are based on a sample of farms. For meaning of abbreviations and symbols, see introductory text]

Item		Davidson	Davie	Duplin	Durham	Edgecombe	Forsyth	Franklin	Gaston
Hired farm labor	farms	206	156	636	56	152	133	192	89
	workers	1,252	706	3,365	298	1,630	537	1,477	210
	$1,000 payroll	2,031	1,059	27,107	978	16,713	3,647	9,180	1,519
Farms with-									
1 worker	farms	71	44	219	13	37	38	41	55
	workers	71	44	219	13	37	38	41	55
2 workers	farms	15	45	90	10	28	5	48	8
	workers	30	90	180	20	56	10	96	16
3 or 4 workers	farms	24	20	177	9	14	64	30	10
	workers	73	65	597	27	50	214	95	31
5 to 9 workers	farms	36	30	58	13	39	16	29	12
	workers	230	252	381	81	237	97	163	68
10 workers or more	farms	60	17	92	11	34	10	44	4
	workers	848	255	1,988	157	1,250	178	1,082	40
Workers by days worked:									
150 days or more	farms	63	45	323	22	84	25	100	47
	workers	181	136	1,427	62	558	94	413	95
Farms with-									
1 worker	farms	28	14	165	6	29	13	24	23
	workers	(D)	14	165	(D)	29	13	24	(D)
2 workers	farms	17	10	50	9	12	4	59	12
	workers	34	20	100	18	24	8	118	24
3 or 4 workers	farms	2	3	53	5	19	-	4	10
	workers	(D)	12	190	15	64	-	13	35
5 to 9 workers	farms	16	18	24	-	14	4	5	2
	workers	111	90	154	-	97	33	32	(D)
10 workers or more	farms	-	-	31	2	10	4	8	-
	workers	-	-	818	(D)	344	40	226	-
Less than 150 days	farms	181	134	441	44	135	113	127	66
	workers	1,071	570	1,938	236	1,072	443	1,064	115
Farms with-									
1 worker	farms	67	35	144	11	39	27	33	43
	workers	67	35	144	11	39	27	(D)	43
2 workers	farms	11	35	65	6	30	-	1	11
	workers	22	70	130	12	60	-	(D)	22
3 or 4 workers	farms	10	22	142	8	16	64	36	7
	workers	32	72	473	24	58	214	120	21
5 to 9 workers	farms	34	25	33	10	33	12	19	5
	workers	215	223	210	68	200	64	101	29
10 workers or more	farms	59	17	57	9	17	10	38	-
	workers	735	170	981	121	715	138	808	-
Reported only workers working 150 days or more	farms	25	22	195	12	17	20	65	23
	workers	30	41	1,029	37	56	53	239	41
	$1,000 payroll	302	462	17,722	244	974	849	5,346	422
Reported only workers working less than 150 days	farms	143	111	313	34	68	108	92	42
	workers	822	377	1,026	172	220	382	721	42
	$1,000 payroll	469	272	2,236	344	383	1,272	658	14
Reported both - workers working 150 days or more and workers working less than 150 days	farms	38	23	128	10	67	5	35	24
	150 days or more, workers	151	95	398	25	502	41	174	54
	less than 150 days, workers	249	193	912	64	852	61	343	73
	$1,000 payroll	1,261	325	7,150	391	15,356	1,525	3,176	1,083
Migrant farm labor on farms with hired labor (see text)	farms	24	9	128	10	51	41	36	-
Migrant farm labor on farms reporting only contract labor (see text)	farms	1	-	3	3	6	31	14	-

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Table 7. **Hired Farm Labor - Workers and Payroll: 2002** - Con.

[Data are based on a sample of farms. For meaning of abbreviations and symbols, see introductory text]

Item		Gates	Graham	Granville	Greene	Guilford	Halifax	Harnett	Haywood
Hired farm labor	farms	48	33	230	161	245	192	253	172
	workers	179	79	1,084	1,350	1,617	1,095	1,592	643
	$1,000 payroll	2,148	171	3,399	8,036	6,161	5,141	6,132	1,933
Farms with-									
1 worker	farms	15	15	79	17	53	79	37	59
	workers	15	15	79	17	53	79	37	59
2 workers	farms	13	3	37	35	12	17	49	26
	workers	26	(D)	74	70	24	34	98	52
3 or 4 workers	farms	8	13	32	27	92	25	44	32
	workers	27	46	119	95	338	87	165	111
5 to 9 workers	farms	9	2	59	38	23	46	63	40
	workers	59	(D)	389	277	151	339	420	214
10 workers or more	farms	3	-	23	44	65	25	60	15
	workers	52	-	423	891	1,051	556	872	207
Workers by days worked:									
150 days or more	farms	27	2	78	97	70	76	94	50
	workers	114	(D)	185	468	346	389	404	175
Farms with-									
1 worker	farms	10	1	45	36	13	23	26	18
	workers	(D)	(D)	45	36	13	23	26	(D)
2 workers	farms	4	1	14	20	3	17	20	1
	workers	8	(D)	28	40	6	34	40	(D)
3 or 4 workers	farms	4	-	7	21	34	14	9	15
	workers	14	-	(D)	71	110	43	29	45
5 to 9 workers	farms	7	-	11	13	13	15	29	16
	workers	44	-	71	84	88	100	163	110
10 workers or more	farms	2	-	1	7	7	7	10	-
	workers	(D)	-	(D)	237	129	189	146	-
Less than 150 days	farms	37	32	216	132	226	169	208	155
	workers	65	(D)	899	882	1,271	706	1,188	468
Farms with-									
1 worker	farms	22	15	91	21	52	85	31	46
	workers	22	15	91	21	52	85	31	(D)
2 workers	farms	7	3	30	28	17	21	29	39
	workers	(D)	(D)	60	56	34	42	58	78
3 or 4 workers	farms	7	12	24	17	82	11	62	32
	workers	24	43	87	62	297	39	228	110
5 to 9 workers	farms	1	2	54	35	33	37	40	37
	workers	(D)	(D)	325	234	218	278	238	224
10 workers or more	farms	-	-	17	31	42	15	46	1
	workers	-	-	336	509	670	262	633	(D)
Reported only workers working 150 days or more	farms	11	1	14	29	19	23	45	17
	workers	46	(D)	50	147	86	71	206	27
	$1,000 payroll	1,100	(D)	520	2,377	1,354	1,038	2,166	298
Reported only workers working less than 150 days	farms	21	31	152	64	175	116	159	122
	workers	39	75	636	335	820	415	903	323
	$1,000 payroll	81	(D)	884	768	490	278	1,021	144
Reported both - workers working 150 days or more and workers working less than 150 days	farms	16	1	64	68	51	53	49	33
	150 days or more, workers	68	(D)	135	321	260	318	198	148
	less than 150 days, workers	26	(D)	263	547	451	291	285	145
	$1,000 payroll	966	(D)	1,995	4,891	4,317	3,825	2,945	1,491
Migrant farm labor on farms with hired labor (see text)	farms	2	1	58	73	58	31	61	27
Migrant farm labor on farms reporting only contract labor (see text)	farms	-	-	8	-	-	-	8	1

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Table 7. **Hired Farm Labor - Workers and Payroll: 2002** - Con.

[Data are based on a sample of farms. For meaning of abbreviations and symbols, see introductory text]

Item	Henderson	Hertford	Hoke	Hyde	Iredell	Jackson	Johnston	Jones
Hired farm labor . . . . . farms	187	63	68	57	299	81	379	90
workers	2,748	424	593	674	1,358	592	2,644	908
$1,000 payroll	15,370	5,760	6,647	3,967	6,403	2,384	13,312	5,991
Farms with-								
1 worker . . . . . farms	32	17	28	11	107	5	51	18
workers	(D)	17	28	11	107	5	51	18
2 workers . . . . . farms	1	10	5	6	74	23	84	16
workers	(D)	20	10	12	148	46	168	32
3 or 4 workers . . . . . farms	19	9	15	12	28	27	38	13
workers	67	33	56	41	93	95	133	44
5 to 9 workers . . . . . farms	34	18	12	19	43	8	115	19
workers	180	114	75	117	290	45	751	136
10 workers or more . . . . . farms	101	9	8	9	47	18	91	24
workers	2,467	240	424	493	720	401	1,541	678
Workers by days worked:								
150 days or more . . . . . farms	67	47	31	50	72	19	181	58
workers	847	275	312	165	333	134	696	420
Farms with-								
1 worker . . . . . farms	6	12	9	16	25	12	64	18
workers	6	12	(D)	16	25	(D)	64	18
2 workers . . . . . farms	26	8	9	9	18	2	52	18
workers	52	16	18	18	36	(D)	104	36
3 or 4 workers . . . . . farms	16	12	6	14	14	2	24	9
workers	48	42	20	50	53	(D)	86	34
5 to 9 workers . . . . . farms	13	12	4	8	8	-	24	6
workers	93	75	23	44	48	-	156	38
10 workers or more . . . . . farms	6	3	3	3	7	3	17	7
workers	648	130	(D)	37	171	110	286	294
Less than 150 days . . . . . farms	178	38	56	33	260	78	303	64
workers	1,901	149	281	509	1,025	458	1,948	488
Farms with-								
1 worker . . . . . farms	36	16	26	4	105	3	56	12
workers	36	16	26	4	105	3	56	12
2 workers . . . . . farms	3	6	7	7	69	29	35	9
workers	6	12	14	14	138	58	70	18
3 or 4 workers . . . . . farms	27	8	14	9	20	26	43	11
workers	96	30	53	30	69	92	151	37
5 to 9 workers . . . . . farms	22	4	4	5	27	5	96	17
workers	129	31	25	29	189	36	609	112
10 workers or more . . . . . farms	90	4	5	8	39	15	73	15
workers	1,634	60	163	432	524	269	1,062	309
Reported only workers working 150 days or more . . . . . farms	9	25	12	24	39	3	76	26
workers	54	136	251	69	257	(D)	300	200
$1,000 payroll	701	2,988	5,072	1,548	3,902	(D)	4,019	3,242
Reported only workers working less than 150 days . . . . . farms	120	16	37	7	227	62	198	32
workers	1,056	31	80	34	901	305	1,133	136
$1,000 payroll	1,664	47	135	167	756	(D)	2,059	202
Reported both - workers working 150 days or more and workers working less than 150 days . . . . . farms	58	22	19	26	33	16	105	32
150 days or more, workers	793	139	61	96	76	(D)	396	220
less than 150 days, workers	845	118	201	475	124	153	815	352
$1,000 payroll	13,004	2,725	1,440	2,251	1,745	1,399	7,234	2,547
Migrant farm labor on farms with hired labor (see text) . . . . . farms	69	9	5	10	8	9	153	31
Migrant farm labor on farms reporting only contract labor (see text) . . . . . farms	9	-	-	3	-	4	10	-

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Table 7. **Hired Farm Labor - Workers and Payroll: 2002** - Con.

[Data are based on a sample of farms. For meaning of abbreviations and symbols, see introductory text]

Item		Lee	Lenoir	Lincoln	McDowell	Macon	Madison	Martin	Mecklenburg
Hired farm labor	farms	82	266	63	47	42	238	178	51
	workers	415	1,752	169	415	113	697	1,002	841
	$1,000 payroll	1,719	7,356	2,015	3,194	345	760	4,112	(D)
Farms with-									
1 worker	farms	34	57	33	21	13	80	65	18
	workers	(D)	57	33	21	(D)	80	65	18
2 workers	farms	1	44	9	5	14	57	9	6
	workers	(D)	88	18	(D)	28	114	18	12
3 or 4 workers	farms	27	40	16	10	13	51	42	14
	workers	92	147	64	30	51	153	135	46
5 to 9 workers	farms	7	83	3	1	1	40	36	4
	workers	46	540	(D)	(D)	(D)	204	230	24
10 workers or more	farms	13	42	2	10	1	10	26	9
	workers	241	920	(D)	348	(D)	146	554	741
Workers by days worked:									
150 days or more	farms	26	130	30	16	15	34	76	13
	workers	115	470	90	125	28	43	209	512
Farms with-									
1 worker	farms	12	54	9	4	6	32	27	-
	workers	12	54	9	4	(D)	(D)	(D)	-
2 workers	farms	6	25	-	-	7	-	17	5
	workers	12	50	-	-	14	-	34	(D)
3 or 4 workers	farms	-	27	18	11	1	1	22	-
	workers	-	92	56	(D)	(D)	(D)	75	-
5 to 9 workers	farms	4	15	2	-	1	1	9	4
	workers	25	95	(D)	-	(D)	(D)	54	27
10 workers or more	farms	4	9	1	1	-	-	1	4
	workers	66	179	(D)	(D)	-	-	(D)	(D)
Less than 150 days	farms	74	225	52	42	40	205	165	49
	workers	300	1,282	79	290	85	654	793	329
Farms with-									
1 worker	farms	29	50	40	19	19	48	69	22
	workers	29	50	40	19	(D)	48	69	22
2 workers	farms	3	39	10	5	15	57	22	6
	workers	6	78	(D)	(D)	30	114	44	(D)
3 or 4 workers	farms	26	48	1	7	5	52	32	13
	workers	89	171	(D)	21	20	156	111	43
5 to 9 workers	farms	5	59	-	1	-	38	26	1
	workers	32	384	-	(D)	-	190	165	(D)
10 workers or more	farms	11	29	1	10	1	10	16	7
	workers	144	599	(D)	235	(D)	146	404	246
Reported only workers working 150 days or more	farms	8	41	11	5	2	33	13	2
	workers	42	185	19	11	(D)	(D)	27	(D)
	$1,000 payroll	483	2,256	341	86	(D)	(D)	280	(D)
Reported only workers working less than 150 days	farms	56	136	33	31	27	204	102	38
	workers	141	545	42	50	65	651	499	(D)
	$1,000 payroll	240	701	57	12	(D)	554	687	(D)
Reported both - workers working 150 days or more and workers working less than 150 days	farms	18	89	19	11	13	1	63	11
	150 days or more, workers	73	285	71	114	20	(D)	182	355
	less than 150 days, workers	159	737	37	240	(D)	(D)	294	232
	$1,000 payroll	995	4,399	1,617	3,096	174	(D)	3,145	(D)
Migrant farm labor on farms with hired labor (see text)	farms	21	80	4	11	7	84	56	10
Migrant farm labor on farms reporting only contract labor (see text)	farms	5	-	-	2	-	26	-	-

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Table 7. **Hired Farm Labor - Workers and Payroll: 2002** - Con.

[Data are based on a sample of farms. For meaning of abbreviations and symbols, see introductory text]

Item	Mitchell	Montgomery	Moore	Nash	New Hanover	Northampton	Onslow	Orange
Hired farm labor ..... farms	67	59	280	230	29	117	122	232
workers	291	244	1,130	3,331	349	550	720	774
$1,000 payroll	530	2,085	6,822	12,793	1,561	5,637	5,268	3,383
Farms with-								
1 worker ..... farms	20	16	153	64	8	35	27	88
workers	20	16	153	64	(D)	35	27	88
2 workers ..... farms	10	17	15	15	5	26	20	40
workers	20	34	30	30	10	52	40	80
3 or 4 workers ..... farms	17	14	59	37	8	17	15	60
workers	58	48	197	118	28	57	57	217
5 to 9 workers ..... farms	10	9	28	50	2	26	38	39
workers	70	53	179	302	(D)	171	251	281
10 workers or more ..... farms	10	3	25	64	6	13	22	5
workers	123	93	571	2,817	289	235	345	108
Workers by days worked:								
150 days or more ..... farms	9	33	95	127	16	80	61	86
workers	42	109	341	626	112	266	298	261
Farms with-								
1 worker ..... farms	5	11	20	43	3	39	21	37
workers	(D)	11	(D)	43	(D)	39	21	37
2 workers ..... farms	-	12	47	23	4	15	8	14
workers	-	24	94	46	8	30	16	(D)
3 or 4 workers ..... farms	-	6	21	35	3	17	7	21
workers	-	20	82	127	9	59	26	79
5 to 9 workers ..... farms	1	2	2	17	1	5	15	12
workers	(D)	(D)	(D)	99	(D)	28	98	62
10 workers or more ..... farms	3	2	5	9	5	4	10	2
workers	30	(D)	131	311	84	110	137	(D)
Less than 150 days ..... farms	67	37	235	180	19	82	88	175
workers	249	135	789	2,705	237	284	422	513
Farms with-								
1 worker ..... farms	20	12	163	40	6	38	21	70
workers	20	(D)	163	40	(D)	38	21	70
2 workers ..... farms	13	9	8	17	2	9	16	29
workers	26	18	16	34	(D)	18	32	(D)
3 or 4 workers ..... farms	17	6	16	47	6	12	18	46
workers	58	19	51	153	22	39	70	162
5 to 9 workers ..... farms	10	8	27	24	-	14	22	28
workers	65	49	168	140	-	79	145	199
10 workers or more ..... farms	7	2	21	52	5	9	11	2
workers	80	(D)	391	2,338	205	110	154	(D)
Reported only workers working 150 days or more ..... farms	-	22	45	50	10	35	34	57
workers	-	46	173	111	44	157	184	123
$1,000 payroll	-	428	2,151	1,976	491	3,674	2,676	981
Reported only workers working less than 150 days ..... farms	58	26	185	103	13	37	61	146
workers	188	77	422	801	94	136	260	422
$1,000 payroll	55	233	1,924	1,169	27	158	297	256
Reported both - workers working 150 days or more and workers working less than 150 days ..... farms	9	11	50	77	6	45	27	29
150 days or more, workers	42	63	168	515	68	109	114	138
less than 150 days, workers	61	58	367	1,904	143	148	162	91
$1,000 payroll	475	1,424	2,747	9,648	1,043	1,805	2,295	2,147
Migrant farm labor on farms with hired labor (see text) ..... farms	25	4	13	78	6	7	34	21
Migrant farm labor on farms reporting only contract labor (see text) ..... farms	10	-	1	-	-	-	-	-

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Table 7. **Hired Farm Labor - Workers and Payroll: 2002** - Con.

[Data are based on a sample of farms. For meaning of abbreviations and symbols, see introductory text]

Item	Pamlico	Pasquotank	Pender	Perquimans	Person	Pitt	Polk	Randolph
Hired farm labor ..... farms	33	59	124	87	189	250	55	234
workers	158	634	1,172	330	904	1,645	187	1,030
$1,000 payroll	1,713	3,416	9,628	1,833	3,105	12,027	1,387	4,890
Farms with-								
1 worker ..... farms	6	24	27	37	90	53	40	66
workers	6	24	27	37	90	53	40	66
2 workers ..... farms	14	7	26	14	9	57	2	34
workers	28	14	52	28	18	114	(D)	68
3 or 4 workers ..... farms	4	11	17	18	7	35	1	58
workers	12	38	56	66	22	117	(D)	189
5 to 9 workers ..... farms	4	8	22	13	48	52	2	66
workers	24	50	144	67	322	359	(D)	485
10 workers or more ..... farms	5	9	32	5	35	53	10	10
workers	88	508	893	132	452	1,002	128	222
Workers by days worked:								
150 days or more ..... farms	21	44	53	50	57	140	9	63
workers	67	168	544	93	206	621	44	242
Farms with-								
1 worker ..... farms	6	21	14	26	12	44	-	27
workers	(D)	21	14	(D)	12	44	-	27
2 workers ..... farms	6	6	8	15	20	24	-	8
workers	12	12	16	30	40	48	-	16
3 or 4 workers ..... farms	7	9	9	8	13	31	5	19
workers	25	33	30	29	47	103	15	61
5 to 9 workers ..... farms	1	4	7	1	5	27	3	5
workers	(D)	23	42	(D)	31	182	(D)	38
10 workers or more ..... farms	1	4	15	-	7	14	1	4
workers	(D)	79	442	-	76	244	(D)	100
Less than 150 days ..... farms	21	40	94	62	171	221	54	194
workers	91	466	628	237	698	1,024	143	788
Farms with-								
1 worker ..... farms	3	20	24	31	93	64	40	55
workers	3	20	24	31	93	64	(D)	55
2 workers ..... farms	10	4	27	9	3	75	2	31
workers	20	(D)	54	18	6	150	(D)	62
3 or 4 workers ..... farms	4	7	12	15	9	17	-	46
workers	14	24	38	58	33	59	-	143
5 to 9 workers ..... farms	-	1	14	3	43	32	7	56
workers	-	(D)	93	15	268	215	49	410
10 workers or more ..... farms	4	8	17	4	23	33	5	6
workers	54	409	419	115	298	536	50	118
Reported only workers working 150 days or more ..... farms	12	19	30	25	18	29	1	40
workers	27	(D)	435	43	85	202	(D)	172
$1,000 payroll	710	558	7,453	628	1,041	3,069	(D)	2,403
Reported only workers working less than 150 days ..... farms	12	15	71	37	132	110	46	171
workers	23	(D)	349	83	474	258	76	718
$1,000 payroll	60	68	858	162	356	806	(D)	669
Reported both - workers working 150 days or more and workers working less than 150 days ..... farms	9	25	23	25	39	111	8	23
150 days or more, workers	40	127	109	50	121	419	(D)	70
less than 150 days, workers	68	251	279	154	224	766	67	70
$1,000 payroll	943	2,790	1,318	1,043	1,709	8,152	1,204	1,818
Migrant farm labor on farms with hired labor (see text) ..... farms	12	5	33	3	72	107	7	14
Migrant farm labor on farms reporting only contract labor (see text) ..... farms	-	2	-	-	-	1	-	-

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Table 7. **Hired Farm Labor - Workers and Payroll: 2002** - Con.

[Data are based on a sample of farms. For meaning of abbreviations and symbols, see introductory text]

Item	Richmond	Robeson	Rockingham	Rowan	Rutherford	Sampson	Scotland	Stanly
Hired farm labor ..... farms	85	292	321	104	141	626	68	148
workers	592	1,976	1,719	634	303	4,908	383	442
$1,000 payroll	2,618	14,532	3,253	5,642	466	38,674	4,237	2,158
Farms with-								
1 worker ..... farms	26	48	73	57	57	183	23	49
workers	26	48	73	57	57	183	23	49
2 workers ..... farms	16	85	38	20	38	129	13	60
workers	32	170	76	40	76	258	26	120
3 or 4 workers ..... farms	11	27	89	7	46	117	13	28
workers	37	91	316	25	170	371	44	101
5 to 9 workers ..... farms	10	49	68	12	-	81	11	5
workers	67	310	451	70	-	549	59	32
10 workers or more ..... farms	22	83	53	8	-	116	8	6
workers	430	1,357	803	442	-	3,547	231	140
Workers by days worked:								
150 days or more ..... farms	43	144	44	23	21	350	35	78
workers	143	645	156	255	36	1,998	199	180
Farms with-								
1 worker ..... farms	17	65	21	4	6	140	10	64
workers	17	65	21	(D)	6	140	(D)	64
2 workers ..... farms	9	25	2	6	15	88	10	3
workers	18	50	(D)	12	30	176	20	6
3 or 4 workers ..... farms	8	32	3	4	-	69	3	4
workers	26	107	10	14	-	228	9	14
5 to 9 workers ..... farms	6	12	16	1	-	17	10	4
workers	40	74	101	(D)	-	109	51	26
10 workers or more ..... farms	3	10	2	8	-	36	2	3
workers	42	349	(D)	217	-	1,345	(D)	70
Less than 150 days ..... farms	60	241	305	93	122	448	50	132
workers	449	1,331	1,563	379	267	2,910	184	262
Farms with-								
1 worker ..... farms	18	65	85	59	54	166	24	70
workers	18	65	85	59	54	166	24	70
2 workers ..... farms	12	52	27	21	23	88	11	36
workers	24	104	54	(D)	46	176	(D)	72
3 or 4 workers ..... farms	6	13	88	2	45	66	8	21
workers	20	45	310	(D)	167	228	25	63
5 to 9 workers ..... farms	6	50	55	9	-	47	1	3
workers	35	298	364	46	-	331	(D)	(D)
10 workers or more ..... farms	18	61	50	2	-	81	6	2
workers	352	819	750	(D)	-	2,009	108	(D)
Reported only workers working 150 days or more ..... farms	25	51	16	11	19	178	18	16
workers	90	397	87	110	34	1,049	147	78
$1,000 payroll	1,370	8,362	783	566	(D)	17,700	3,263	526
Reported only workers working less than 150 days ..... farms	42	148	277	81	120	276	33	70
workers	193	915	1,458	126	264	1,185	109	107
$1,000 payroll	118	1,210	1,174	333	221	2,102	85	509
Reported both - workers working 150 days or more and workers working less than 150 days ..... farms	18	93	28	12	2	172	17	62
150 days or more, workers	53	248	69	145	(D)	949	52	102
less than 150 days, workers	256	416	105	253	(D)	1,725	75	155
$1,000 payroll	1,131	4,960	1,296	4,743	(D)	18,872	889	1,123
Migrant farm labor on farms with hired labor (see text) ..... farms	9	37	98	8	-	142	2	2
Migrant farm labor on farms reporting only contract labor (see text) ..... farms	-	12	-	-	-	2	-	25

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Table 7. **Hired Farm Labor - Workers and Payroll: 2002** - Con.

[Data are based on a sample of farms. For meaning of abbreviations and symbols, see introductory text]

Item	Stokes	Surry	Swain	Transylvania	Tyrrell	Union	Vance	Wake
Hired farm labor ..... farms	283	377	15	72	43	285	72	370
workers	1,618	2,003	29	365	267	1,007	497	2,408
$1,000 payroll	2,254	4,931	51	2,889	4,677	8,888	2,458	13,337
Farms with-								
1 worker ..... farms	67	110	8	16	10	125	20	136
workers	67	110	(D)	16	10	125	20	136
2 workers ..... farms	42	63	1	19	7	58	9	25
workers	84	126	(D)	38	14	116	18	50
3 or 4 workers ..... farms	24	87	6	18	10	74	10	52
workers	72	312	19	64	34	253	30	166
5 to 9 workers ..... farms	86	51	-	10	12	13	15	66
workers	537	317	-	80	80	70	115	515
10 workers or more ..... farms	64	66	-	9	4	15	18	91
workers	858	1,138	-	167	129	443	314	1,541
Workers by days worked:								
150 days or more ..... farms	33	56	2	36	26	111	31	106
workers	195	224	(D)	157	144	329	138	882
Farms with-								
1 worker ..... farms	8	31	2	17	9	52	7	23
workers	(D)	31	(D)	17	9	52	7	23
2 workers ..... farms	1	6	-	9	2	39	9	22
workers	(D)	12	-	18	(D)	78	18	44
3 or 4 workers ..... farms	9	5	-	2	11	10	3	6
workers	35	19	-	(D)	36	31	9	19
5 to 9 workers ..... farms	5	7	-	2	2	4	9	33
workers	40	40	-	(D)	(D)	28	56	277
10 workers or more ..... farms	10	7	-	6	2	6	3	22
workers	110	122	-	103	(D)	140	48	519
Less than 150 days ..... farms	262	353	14	62	30	229	62	304
workers	1,423	1,779	(D)	208	123	678	359	1,526
Farms with-								
1 worker ..... farms	60	102	8	18	6	124	16	142
workers	60	102	(D)	18	(D)	124	16	142
2 workers ..... farms	42	65	-	22	8	42	9	-
workers	84	130	-	44	(D)	84	18	-
3 or 4 workers ..... farms	25	90	6	8	8	45	11	58
workers	75	327	19	31	30	151	33	177
5 to 9 workers ..... farms	88	36	-	11	6	9	14	35
workers	548	232	-	66	36	48	94	251
10 workers or more ..... farms	47	60	-	3	2	9	12	69
workers	656	988	-	49	(D)	271	198	956
Reported only workers working 150 days or more ..... farms	21	24	1	10	13	56	10	66
workers	137	131	(D)	79	98	145	51	733
$1,000 payroll	850	1,939	(D)	1,684	2,974	2,140	450	6,950
Reported only workers working less than 150 days ..... farms	250	321	13	36	17	174	41	264
workers	1,327	1,599	26	104	49	528	124	1,208
$1,000 payroll	975	1,111	(D)	131	88	1,753	377	3,446
Reported both - workers working 150 days or more and workers working less than 150 days ..... farms	12	32	1	26	13	55	21	40
150 days or more, workers	58	93	(D)	78	46	184	87	149
less than 150 days, workers	96	180	(D)	104	74	150	235	318
$1,000 payroll	429	1,880	(D)	1,074	1,615	4,994	1,631	2,941
Migrant farm labor on farms with hired labor (see text) ..... farms	85	54	1	3	-	13	36	101
Migrant farm labor on farms reporting only contract labor (see text) ..... farms	-	18	-	-	-	1	3	-

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Table 7. **Hired Farm Labor - Workers and Payroll: 2002** - Con.

[Data are based on a sample of farms. For meaning of abbreviations and symbols, see introductory text]

Item	Warren	Washington	Watauga	Wayne	Wilkes	Wilson	Yadkin	Yancey
Hired farm labor ..... farms	116	85	200	304	237	128	270	106
workers	640	366	1,196	2,019	1,180	2,115	1,543	315
$1,000 payroll	5,429	3,514	956	22,190	7,100	11,138	4,083	245
Farms with-								
1 worker ..... farms	20	28	11	99	64	17	56	68
workers	20	28	11	99	64	17	56	68
2 workers ..... farms	46	17	95	54	35	24	42	6
workers	92	34	190	108	70	48	84	12
3 or 4 workers ..... farms	14	16	49	45	49	10	101	6
workers	52	56	170	154	157	35	356	24
5 to 9 workers ..... farms	9	17	19	39	35	24	26	19
workers	59	111	113	258	208	145	161	141
10 workers or more ..... farms	27	7	26	67	54	53	45	7
workers	417	137	712	1,400	681	1,870	886	70
Workers by days worked:								
150 days or more ..... farms	70	45	13	160	110	68	77	12
workers	223	153	87	986	341	484	273	24
Farms with-								
1 worker ..... farms	16	14	1	68	54	18	26	-
workers	16	14	(D)	68	54	18	26	-
2 workers ..... farms	42	11	9	33	12	22	16	12
workers	84	22	(D)	66	24	44	32	24
3 or 4 workers ..... farms	3	12	2	34	5	13	19	-
workers	11	38	(D)	115	(D)	43	58	-
5 to 9 workers ..... farms	3	3	-	10	37	4	6	-
workers	18	17	-	62	195	30	38	-
10 workers or more ..... farms	6	5	1	15	2	11	10	-
workers	94	62	(D)	675	(D)	349	119	-
Less than 150 days ..... farms	69	68	188	237	173	111	228	100
workers	417	213	1,109	1,033	839	1,631	1,270	291
Farms with-								
1 worker ..... farms	21	33	12	94	24	17	60	68
workers	21	33	12	94	24	17	60	68
2 workers ..... farms	8	13	85	33	25	19	30	6
workers	16	26	170	66	50	38	60	12
3 or 4 workers ..... farms	15	10	47	32	43	7	83	-
workers	51	35	162	108	137	25	302	-
5 to 9 workers ..... farms	6	9	19	39	62	24	24	19
workers	46	55	113	249	331	145	155	141
10 workers or more ..... farms	19	3	25	39	19	44	31	7
workers	283	64	652	516	297	1,406	693	70
Reported only workers working 150 days or more ..... farms	47	17	12	67	64	17	42	6
workers	155	56	(D)	702	120	151	211	12
$1,000 payroll	3,868	1,142	789	13,838	1,630	1,799	1,388	150
Reported only workers working less than 150 days ..... farms	46	40	187	144	127	60	193	94
workers	186	93	1,108	514	640	595	657	279
$1,000 payroll	305	142	(D)	888	728	903	611	68
Reported both - workers working 150 days or more and workers working less than 150 days ..... farms	23	28	1	93	46	51	35	6
150 days or more, workers	68	97	(D)	284	221	333	62	12
less than 150 days, workers	231	120	(D)	519	199	1,036	613	12
$1,000 payroll	1,256	2,230	(D)	7,464	4,742	8,436	2,083	27
Migrant farm labor on farms with hired labor (see text) ..... farms	65	8	3	67	2	53	43	5
Migrant farm labor on farms reporting only contract labor (see text) ..... farms	-	1	-	-	-	-	48	-

Radioactive Elements in Coal and Fly Ash: Abundance, Forms, and Environmental Significance

U.S. Geological Survey Fact Sheet FS-163-97 October, 1997

Introduction

Coal is largely composed of organic matter, but it is the inorganic matter in coal—minerals and trace elements—that have been cited as possible causes of health, environmental, and technological problems associated with the use of coal. Some trace elements in coal are naturally radioactive. These radioactive elements include uranium (U), thorium (Th), and their numerous decay products, including radium (Ra) and radon (Rn). Although these elements are less chemically toxic than other coal constituents such as arsenic, selenium, or mercury, questions have been raised concerning possible risk from radiation. In order to accurately address these questions and to predict the mobility of radioactive elements during the coal fuel-cycle, it is important to determine the concentration, distribution, and form of radioactive elements in coal and fly ash.

Abundance of Radioactive Elements in Coal and Fly Ash

Assessment of the radiation exposure from coal burning is critically dependent on the concentration of radioactive elements in coal and in the fly ash that remains after combustion. Data for uranium and thorium content in coal is available from the U.S. Geological Survey (USGS), which maintains the largest database of information on the chemical composition of U.S. coal. This database is searchable on the World Wide Web at: **http://energy.er.usgs.gov/products/databases/CoalQual/intro.htm**. Figure 1 displays the frequency distribution of uranium concentration for approximately 2,000 coal samples from the Western United States and approximately 300 coals from the Illinois Basin. In the majority of samples, concentrations of uranium fall in the range from slightly below 1 to 4 parts per million (ppm). Similar uranium concentrations are found in a variety of common rocks and soils, as indicated in figure 2. Coals with more than 20 ppm uranium are rare in the United States. Thorium concentrations in coal fall within a similar 1–4 ppm range, compared to an average crustal abundance of approximately 10 ppm. Coals with more than 20 ppm thorium are extremely rare.

During coal combustion most of the uranium, thorium, and their decay products are released from the original coal matrix and are distributed between the gas

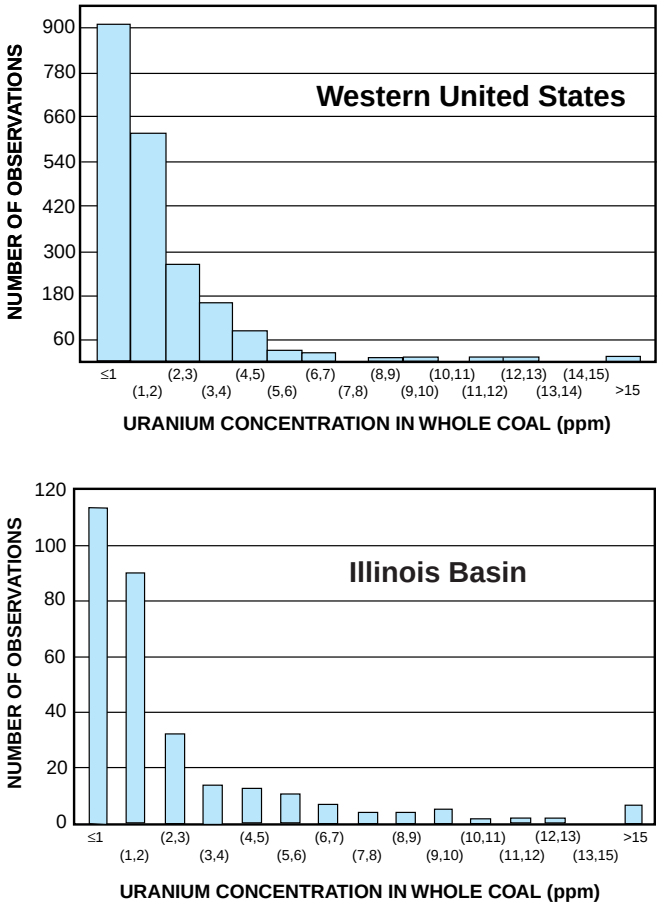

Figure 1. Distribution of uranium concentration in coal from two areas of the United States.

phase and solid combustion products. The partitioning between gas and solid is controlled by the volatility and chemistry of the individual elements. Virtually 100 percent of the radon gas present in feed coal is transferred to the gas phase and is lost in stack emissions. In contrast, less volatile elements such as thorium, uranium, and the majority of their decay products are almost entirely retained in the solid combustion wastes. Modern power plants can recover greater than 99.5 percent of the solid combustion wastes. The average ash yield of coal burned in the United States is approximately 10 weight percent. Therefore, the concentration of most radioactive elements in solid combustion wastes will be approximately 10 times the concentration in the original coal. Figure 2 illustrates that the uranium concentration of most fly ash (10 to 30 ppm) is still in the range found in some granitic rocks, phosphate rocks, and shales. For example,

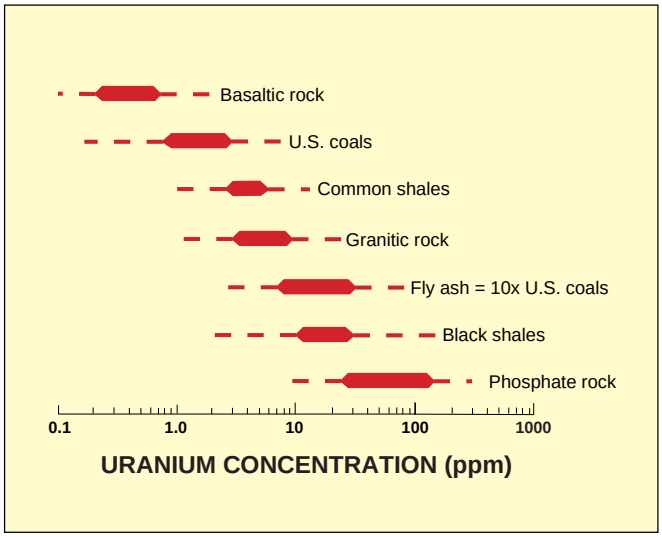

Figure 2. Typical range of uranium concentration in coal, fly ash, and a variety of common rocks.

the Chattanooga Shale that occurs in a large portion of the Southeastern United States contains between 10 and 85 ppm U.

Forms of Occurrence of Radioactive Elements in Coal and Fly Ash

The USGS has a current research project to investigate the distribution and modes of occurrence (chemical form) of trace elements in coal and coal combustion products. The approach typically involves (1) ultra sensitive chemical or radiometric analyses of particles separated on the basis of size, density, mineral or magnetic properties, (2) analysis of chemical extracts that selectively attack certain components of coal or fly ash, (3) direct observation and microbeam analysis of very small areas or grains, and (4) radiographic techniques that identify the location and abundance of radioactive elements.

Most thorium in coal is contained in common phosphate minerals such as monazite or apatite. In contrast, uranium is found in both the mineral and organic fractions of coal. Some uranium may be added slowly over geologic time because organic matter can extract dissolved uranium from ground water. In fly ash, the uranium is more concentrated in the finer sized particles. If during coal combustion some uranium is concentrated on ash surfaces as a condensate, then this surface-bound uranium is potentially more susceptible to leaching. However, no obvious evidence of surface enrichment of uranium has been found in the hundreds of fly ash particles examined by USGS researchers.

The above observation is based on the use of fission-track radiography, a sophisticated technique for observing the distribution of uranium in particles as small as 0.001 centimeter in diameter. Figure 3 includes a photograph of a hollow glassy sphere of fly ash and its corresponding fission track image. The diameter of this relatively large glassy sphere is approximately 0.01 cm. The distribution and concentration of uranium are indicated by fission tracks, which appear as dark linear features in the radiograph. Additional images produced by USGS researchers from a variety of fly ash particles confirm the preferential location of uranium within the glassy component of fly ash particles.

Health and Environmental Impact of Radioactive Elements Associated With Coal Utilization

Radioactive elements from coal and fly ash may come in contact with the general public when they are dispersed in air and water or are included in commercial products that contain fly ash.

The radiation hazard from airborne emissions of coal-fired power plants was evaluated in a series of studies conducted from 1975–1985. These studies concluded that the maximum radiation dose to an individual living within 1 km of a modern power plant is equivalent to a minor, perhaps 1 to 5 percent, increase above the radiation from the natural environment. For the average citizen, the radiation dose from coal burning is considerably less. Components of the radiation environment that impact the U.S. population are illustrated in figure 4. Natural sources account for the majority (82 percent) of radiation. Man-made sources of radiation are dominated by medical X-rays (11 percent). On this plot, the average population dose attributed to coal burning is included under the consumer products category and is much less than 1 percent of the total dose.

Fly ash is commonly used as an additive to concrete building products, but the radioactivity of typical fly ash is not significantly different from that of more conventional concrete additives or other building materials such as granite or red brick. One extreme calculation that assumed high proportions of fly-ash-rich concrete in a residence suggested a dose enhancement, compared to normal concrete, of 3 percent of the natural environmental radiation.

Another consideration is that low-density, fly-ash-rich concrete products may be a source of radon gas. Direct measurement of this contribution to indoor radon is complicated by the much larger contribution from underlying soil and rock (see fig. 4). The emanation of radon gas from fly ash is less than from natural soil of

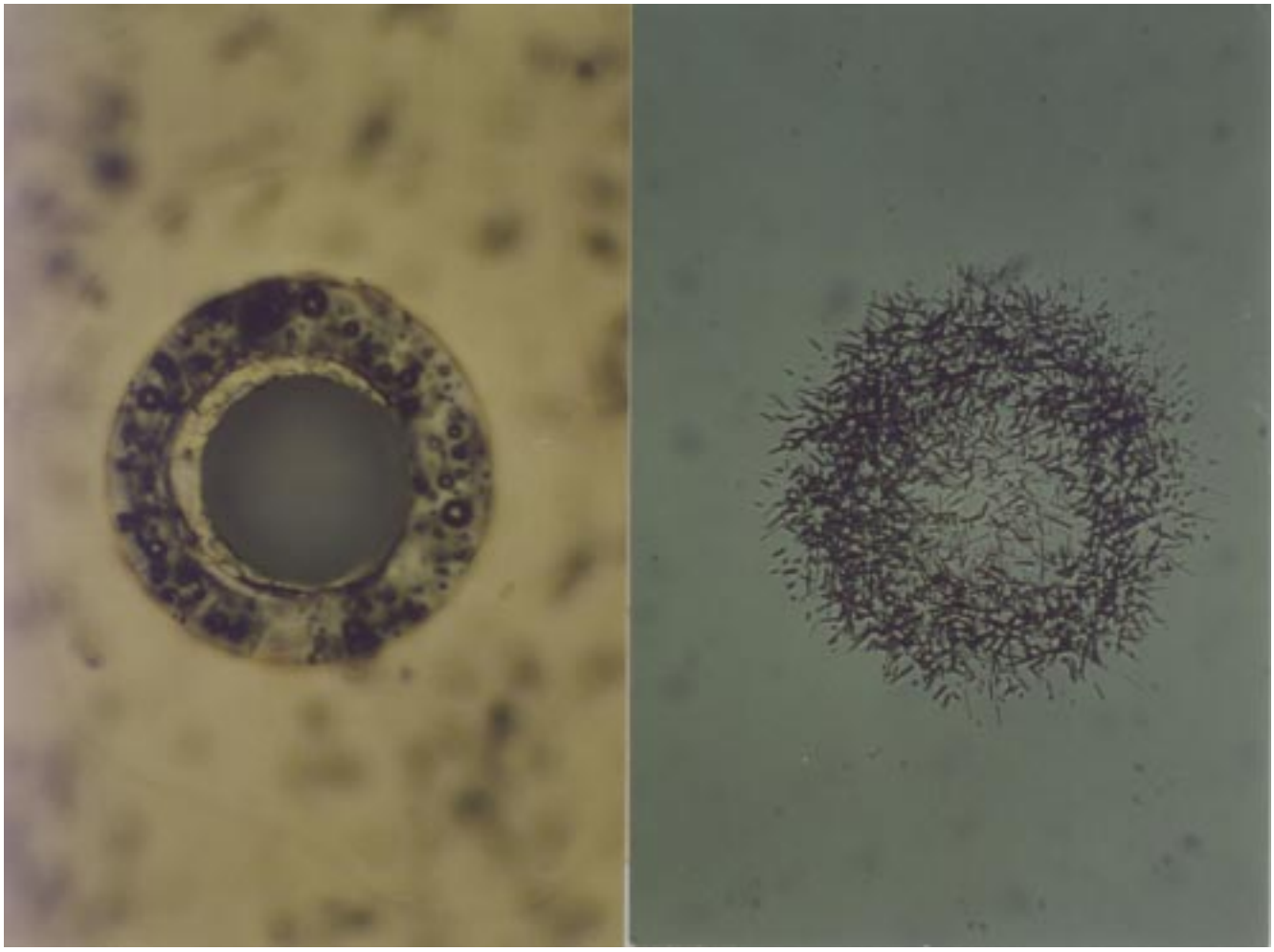

Figure 3. Photograph (left) of a hollow glassy fly ash particle (0.01 cm diameter) and its fission track radiograph (right). Uranium distribution and concentration are indicated by the location and density of dark linear fission tracks in the radiograph.

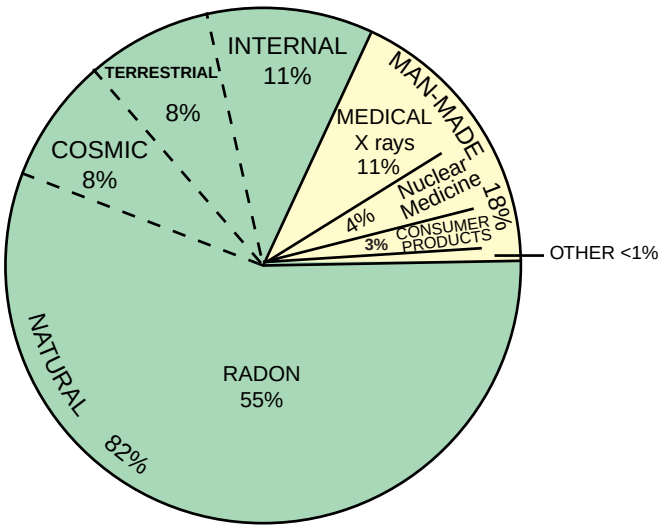

Figure 4. Percentage contribution of various radiation sources to the total average radiation dose to the U.S. population.

similar uranium content. Present calculations indicate that concrete building products of all types contribute less than 10 percent of the total indoor radon.

Approximately three-fourths of the annual production of fly ash is destined for disposal in engineered surface impoundments and landfills, or in abandoned mines and quarries. The primary environmental concern associated with these disposal sites is the potential for groundwater contamination. Standardized tests of the leachability of toxic trace elements such as arsenic, selenium, lead, and mercury from fly ash show that the amounts dissolved are sufficiently low to justify regulatory classification of fly ash as nonhazardous solid waste. Maximum allowable concentrations under these standardized tests are 100 times drinking water standards, but these concentration limits are rarely approached in leachates of fly ash.

The leachability of radioactive elements from fly ash has relevance in view of the U.S. Environmental Protection Agency (USEPA) drinking water standard for dissolved radium (5 picocuries per liter) and the proposed addition of drinking water standards for uranium and radon by

the year 2000. Previous studies of radioelement mobility in the enviroment, and in particular, in the vicinity of uranium mines and mills, provide a basis for predicting which chemical conditions are likely to influence leachability of uranium, barium (a chemical analog for radium), and thorium from fly ash. For example, leachability of radioactive elements is critically influenced by the pH that results from reaction of water with fly ash. Extremes of either acidity (pH<4) or alkalinity (pH>8) can enhance solubility of radioactive elements. Acidic solutions attack a variety of mineral phases that are found in fly ash. However, neutralization of acid solutions by subsequent reaction with natural rock or soil promotes precipitation or sorption of many dissolved elements including uranium, thorium, and many of their decay products. Highly alkaline solutions promote dissolution of the glassy components of fly ash that are an identified host of uranium; this can, in particular, increase uranium solubility as uranium-carbonate species. Fortunately, most leachates of fly ash are rich in dissolved sulfate, and this minimizes the solubility of barium (and radium), which form highly insoluble sulfates.

Direct measurements of dissolved uranium and radium in water that has contacted fly ash are limited to a small number of laboratory leaching studies, including some by USGS researchers, and sparse data for natural water near some ash disposal sites. These preliminary results indicate that concentrations are typically below the current drinking water standard for radium (5 picocuries per liter) or the initially proposed drinking water standard for uranium of 20 parts per billion (ppb).

Summary

Radioactive elements in coal and fly ash should not be sources of alarm. The vast majority of coal and the majority of fly ash are not significantly enriched in radioactive elements, or in associated radioactivity, compared to common soils or rocks. This observation provides a useful geologic perspective for addressing societal concerns regarding possible radiation and radon hazard.

The location and form of radioactive elements in fly ash determine the availability of elements for leaching during ash utilization or disposal. Existing measurements of uranium distribution in fly ash particles indicate a uniform distribution of uranium throughout the glassy particles. The apparent absence of abundant, surface-bound, relatively available uranium suggests that the rate of release of uranium is dominantly controlled by the relatively slow dissolution of host ash particles.

Previous studies of dissolved radioelements in the environment, and existing knowledge of the chemical properties of uranium and radium can be used to predict the most important chemical controls, such as pH, on solubility of uranium and radium when fly ash interacts with water. Limited measurements of dissolved uranium and radium in water leachates of fly ash and in natural water from some ash disposal sites indicate that dissolved concentrations of these radioactive elements are below levels of human health concern.

Suggested Reading:

Tadmore, J., 1986, Radioactivity from coal-fired power plants: A review: Journal of Environmental Radioactivity, v. 4, p. 177–204.

Cothern, C.R., and Smith, J.E., Jr., 1987, Environmental Radon: New York, Plenum Press, 363 p.

Ionizing radiation exposure of the population of the United States, 1987: Bethesda, Md., National Council on Radiation Protection and Measurements, Report 93, 87 p.

Swaine, D.J., 1990, Trace Elements in Coal: London, Butterworths, 278 p.

Swaine, D.J., and Goodarzi, F., 1997, Environmental Aspects of Trace Elements in Coal: Dordrecht, Kluwer Academic Publishers, 312 p.

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Strategy Report

Growth Management Strategy Report - February 2003

Wake County, North Carolina, has a strategic location in the Research Triangle, an excellent quality of life that consistently ranks high in national surveys, and an exciting mix of urban, small town, and rural lifestyles. Research Triangle Park and the Raleigh-Durham International Airport act as major growth engines not only for Wake County, but also for the entire surrounding region. Thanks to all these factors and more, the county has experienced rapid, exponential growth in recent years. It has grown by over 37 percent since 1990, adding an average of 57 persons per day and bringing the July 2002 population to 678,751. The county is projected to grow by another one-third over the next twenty years, bringing the total population close to one million.

At first, as this rapid regional growth occurred, the county and its 12 municipalities continued a traditional approach of working independently to deliver services, to plan for their own futures, and to address growth-related impacts within their own borders. For example, the county and municipalities each adopted their own land use plans, zoning and subdivision ordinances, and capital improvement programs. There were some efforts at joint planning and intergovernmental coordination. For example, an intergovernmental study explored the idea of merging existing water and sewer utility systems. Some joint planning was done in cases where issues arose that crossed local boundaries; for example, Wendell and Zebulon initiated a joint planning effort for the Little River Watershed, which extends into both communities.

By early 2000, the county, municipalities, and the Wake County Public School System were facing significant challenges resulting from rapid growth, including traffic jams, overcrowded schools, and loss of
open space and natural areas. Communities grew closer and closer to their neighbors, as sprawling development extended across the county. Increasingly, county and municipal officials began to see the need for a more comprehensive effort to address growth concerns in Wake County. Building on their existing collaborative approaches, they sought to develop a new, comprehensive growth management strategy that recognized both the interdependence and also the uniqueness of each of the communities. Local officials realized that effective regional solutions would only come about through the cooperation of all the governments, working together, in an open and participatory process.

For the Growth Management Strategy Report:

- Click here for the executive summary.
- Click here for the Task Force Recommended High Priority Strategies
- Full Growth Management Strategy Report
  - Click here for part 1 (pages 1 - 150)
  - Click here for part 2 (pages 151-299)
- Click here to find out more about updates (meetings and reports following up on the original Growth Management Strategies that have occured since February 2003).

To download these reports, **right** click the link above for the desired report, choose "Save Target As", and browse to where you would like to save the report on your computer.

Where Your Money Goes

Wake County	
Wake County Schools - Operating	56.631%
Wake County Schools - Capital	19.710%
County Capital Program	6.315%
Human Services	6.154%
General Government	4.272%
Sheriff	3.442%
Community Services	1.157%
Public Safety	.958%
Wake Tech Community College	.952%
Environmental Services	.407%
Total	100%

Town of Angier	
Public Works	31%
Public Safety	20%
General Government	14%
Transportation	13%
Other	13%
Debt Service	9%
Total	100%

Town of Apex	
Public Safety	33.988%
Recreation	13.523%
Public Works	12.500%
Solid Waste	11.425%
Administration	8.089%
Construction Management	6.946%
Information Systems	6.048%
Community Development	4.586%
Public Buildings	2.895%
Total	100%

Town of Cary	
Police	18.63%
Fire	18.42%
Debt	16.22%
General Administration	15.42%
Public Works	15.10%
Development Services	7.24%
Parks, Rec & Cultural Resources	6.62%
Solid Waste/Recycling	2.35%
Total	100%

Town of Fuquay-Varina	
Public Safety	42%
General Government	17%
Streets	9%
Parks & Recreation	8%
Sanitation	7%
IT	6%
Planning	3%
Debt	4%
Other	4%
Total	100%

Town of Garner	
General Government	21%
Community Services	9%
Parks & Recreation	8%
Public Works	25%
Public Safety	37%
Total	100%

Town of Holly Springs	
Public Safety	25%
Public Works	17%
Debt Service	17%
Parks & Recreation	17%
General Government	15%
Physical Development	9%
Total	100%

Town of Knightdale	
Public Safety	32.28%
General Administration	17.18%
Fire Protection	15.77%
Parks & Recreation	12.77%
Debt Service	10.41%
Public Works	7.19%
Community Development	4.17%
Other	.23%
Total	100%

Town of Morrisville	
Public Safety	39.675%
Public Works	17.382%
General Government	14.268%
Culture & Recreation	11.687%
Debt Service	10.797%
Economic & Physical Dev.	3.603%
Engineering	2.588%
Total	100%

City of Raleigh	
Public Safety	39.70%
Public Works & Transit	11.80%
Leisure Services	10.90%
General Government	9.20%
Appropriation to Capital Debt	8.50%
Solid Waste Services	6.10%
Community Development Services	5.80%
Information Technology	3.50%
Financial Management	3.00%
External Agencies	0.90%
Appropriation to Capital Program	0.60%

Total	100%

Town of Rolesville

Public Safety	38%
Administrative	23%
Public Works	21%
Recreation	10%
Planning & Development	6%
Legislative Body	2%
Total	100%

Town of Wake Forest

General Government	30.0%
Public Safety	26.7%
Fire Services	11.3%
Capital Outlay	10.2%
Transportation	7.5%
Debt Service	6.5%
Cultural & Recreational	5.5%
Environmental Protection	2.3%
Total	100%

Town of Wendell

General Government	27.14%
Police	25.09%
Public Works	24.71%
Parks & Recreation	13.49%
Community Dev & Planning	6.82%
Debt Service	2.75%
Total	100%

Town of Zebulon

Police	29.6%
General Government	18.2%
Fire	13.3%
Culture & Recreation	12.3%
Transportation	11.4%
Sanitation	10.3%
Building Maintenance	4.9%
Total	100%

Need help? Email us your questions and we'll respond as quickly as we possibly can.

WAKE

Major Employers Directory

Company Name	Number of Employees
State of North Carolina	37,671
Wake County Public School System	15,000
International Business Machines (IBM)	13,000
North Carolina State University	7,787
WakeMed Health & Hosptials	6,500
GlaxoSmithkKline, Inc.	4,800
Pinkerton & Burns	4,500
SAS Institute, Inc.	4,300
Wake Med Faculty Physicians Internal Medicine	4,000
Rex Healthcare	3,800
Progress Energy	3,400
Wake County	3,300
Nortel	3,150
City of Raleigh	3,000
Research Triangle Institute	2,600
Cisco Systems	2,500
RTI International	2,260
US Environmental Protection Agency	2,000
Waste Industries, Inc.	2,000
Verizon Wireless	1,600
First Citizens Bank & Trust Company	1,574
Eaton Division/Headquarters	1,500
Food Lion Stores	1,500
Longistics International	1,500
Misys Healthcare Systems	1,500

For a complete directory contact Wendy Pedraza at 919.664.7047.

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Biomass Feedstock Availability in the United States: 1999 State Level Analysis

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April 30, 1999, Updated January, 2000

I. Introduction

Interest in using biomass feedstocks to produce power, liquid fuels, and chemicals in the U.S. is increasing. Central to determining the potential for these industries to develop is an understanding of the location, quantities, and prices of biomass resources. This paper describes the methodology used to estimate biomass quantities and prices for each state in the continental U.S. An Excel™ spreadsheet contains estimates of biomass quantities potentially available in five categories: mill wastes, urban wastes, forest residues, agricultural residues and energy crops. Availabilities are sorted by anticipated delivered price. A presentation that explains how this information was used to support the goal of increasing biobased products and bioenergy 3 times by 2010 expressed in Executive Order 13134 of August 12, 1999 is also available.

II. Biomass Feedstock Availability

For the purpose of this analysis, biomass feedstocks are classified into five general categories: forest residues, mill residues, agricultural residues, urban wood wastes, and dedicated energy crops. Forestry is a major industry in the United States encompassing nearly 559 million acres in publicly and privately held forest lands in the continental U.S. (USDA, 1997). Nearly 16 million cubic feet of roundwood are harvested and processed annually to produce sawlogs, paper, veneers, composites and other fiber products (USDA, 1998a). The extensive forest acreage and roundwood harvest generate logging residues and provide the potential to harvest non-merchantable wood for energy. Processing of the wood into fiber products creates substantial quantities of mill residues that could potentially be used for energy. Agriculture is another major industry in the United States. Approximately 337 million acres of cropland are currently in agricultural production (USDA, 1997). Following the harvest of many of the traditional agricultural crops, residues (crop stalks) are left in the field. A portion of these residues could

potentially be collected and used for energy. Alternatively, crop acres could be used to grow dedicated energy crops. A final category of biomass feedstocks includes urban wood wastes. These wastes include yard trimmings and other wood materials that are generally disposed of in municipal solid waste (MSW) and construction/demolition (C/D) landfills. Following is a description of the potential availability of these biomass feedstocks in the United States.

A. Forest Residues

Forest wood residues can be grouped into the following categories--logging residues; rough, rotten, and salvable dead wood; excess saplings; and small pole trees[(1)]. The forest wood residue supplies that could potentially be available for energy use in the U.S. are estimated using an updated version of a model originally developed by McQuillan et al. (1984). The McQuillan model estimates the total quantities of forest wood residues that can be recovered by first classifying the total forest inventory by the above wood categories (for both softwood and hardwood), and by volume, haul distances, and equipment operability constraints. This total inventory is then revised downward to reflect the quantities that can be recovered in each class due to constraints on equipment retrieval efficiencies, road access to a site, and impact of site slope on harvest equipment choice[(2)].

The costs of obtaining the recoverable forest wood residues are estimated for each category. Prices include collection, harvesting, chipping, loading, hauling, and unloading costs, a stumpage fee, and a return for profit and risk. Prices are in 1995 dollars. For the purposes of this analysis, we have included only logging residues and rough, rotten, and salvable dead wood quantities. The potential annual forest waste residues available by state for three price scenarios are presented in Table 1. Quantities are cumulative quantities at each price (i.e., quantities at $50/dt include all quantities available at $40/dt plus quantities available between $40 and $50/dt).

Polewood, which represent the growing stock of merchantable trees, has not been included in the analysis due to the fact that it could potentially be left to grow and used for higher value fiber products. It is doubtful that these trees will be harvested for energy use. However, if harvested, they could add another 17 million dry tons at less than $30/dt delivered; 37.7 million dry tons at less than $40 delivered; and 65 million dry tons at less than $50/dt delivered. For a more detailed explanation of the methodology used to estimate the forest wood residue quantities and prices, see Walsh et al, 1998.

Table 1: Estimated Annual Cumulative Forest Residues Quantities (dry tons), by Delivered Price and State

	< $30/dry ton delivered	< $40/dry ton delivered	< $50/dry ton delivered
Alabama	1009000	1475000	1899000
Arizona	134000	200000	261400

Arkansas	928000	1352000	1737800
California	1231000	1819000	2364400
Colorado	373000	554000	720300
Connecticut	109000	159000	204100
Delaware	26000	37000	48400
Florida	515000	755000	9757000
Georgia	1041000	1525000	1967800
Idaho	605000	902000	1179500
Illinois	228000	330000	423300
Indiana	253000	367000	470100
Iowa	72000	105000	135000
Kansas	47000	68000	88100
Kentucky	475000	690000	883500
Louisiana	872000	1275000	1641800
Maine	806000	1182000	1529100
Maryland	189000	273000	351200
Massachusetts	196000	284000	366200
Michigan	710000	1034000	1327900
Minnesota	468000	682000	874900
Mississippi	946000	1380000	1774600
Missouri	505000	733000	938700
Montana	676000	1007000	1316700
Nebraska	19000	27000	34400
Nevada	8000	11000	14400
New Hampshire	299000	438000	564400
New Jersey	70000	102000	130700

New Mexico	125000	185000	241900
New York	933000	1360000	1746400
North Carolina	1068000	1557000	2004900
North Dakota	11000	17000	21700
Ohio	232000	335000	430100
Oklahoma	156000	228000	292200
Oregon	1299000	1928000	2515900
Pennsylvania	948000	1377000	1763000
Rhode Island	20000	27000	35900
South Carolina	613000	898000	1158400
South Dakota	33000	49000	64300
Tennessee	930000	1351000	1732600
Texas	557000	814000	1050700
Utah	90000	133000	173000
Vermont	265000	386000	497200
Virginia	959000	1397000	1793600
Washington	1230000	1825000	2379600
West Virginia	727000	1056000	1352500
Wisconsin	609000	886000	1138400
Wyoming	132000	196000	256100
U.S. Total	23747000	34771000	44871800

B. Primary Mill Residues

The quantities of mill residues generated at primary wood mills (i.e., mills producing lumber, pulp, veneers, other composite wood fiber materials) in the U.S. are obtained from the data compiled by the USDA Forest Service for the 1997 Resource Policy Act (RPA) Assessment (USDA, 1998a). Mill

residues are classified by type and include bark; coarse residues (chunks and slabs); and fine residues (shavings and sawdust). Data is available for quantities of residues generated by residue type and on uses of residues by residue type and use category (i.e., not used, fuel, pulp, composite wood materials, etc.). Data is available at the county, state, subregion, and regional level. In cases where a county has fewer than three mills, data from multiple counties are combined to maintain the confidentiality of the data provided by individual mills. Data represent short run average quantities.

Because primary mill residues are clean, concentrated at one source, and relatively homogeneous, nearly 98 percent of all residues generated in the United States are currently used as fuel or to produce other fiber products. Of the 24.2 million dry tons of bark produced in the U.S., 2.2 percent is not used while 79.4 percent is used for fuel and 18 percent is used for such things as mulch, bedding, and charcoal. Only about 1.4 percent of the 38.7 million dry tons of coarse residues are not used. The remainder are used to produce pulp or composite wood products such as particle board, wafer board, and oriented strand board (78 percent) and about 13 percent are used for fuel. Of the 27.5 million dry tons of fine wood residues, approximately 55.6 percent are used for fuel, 23 percent are used to produce pulp or composite wood products, 18.7 percent are used for bedding, mulch and other such uses, and about 2.6 percent are unused.

The residues, while currently used, could potentially be available for energy use if utilities could pay a higher price for the residues than their value in their current uses. Data regarding the value of these residues in their current uses are difficult to obtain. Much of the residues used for fuel are used on site by the residue generator in low efficiency boiler systems to produce heat and steam. Conversations with those in the industry and other anecdotal evidence suggests that these residues could be purchased for $15-25/dry ton for use in higher efficiency fuel systems. Similar anecdotal evidence suggests that residues used to produce fiber products (pulp, composite wood materials) sell for about $30-40/dry ton. For the purposes of this analysis, we assume that the residues not currently used could potentially be available for energy uses at delivered prices of less than $20/dry ton (assuming transportation distances of less than 50 miles). For similar transportation distances, we assume that residues currently used for fuel could be available at less than $30/dry ton delivered and residues currently used for pulp, composite wood materials, mulch, bedding, and other such uses could potentially be available at delivered prices of less than $50/dry ton. Table 2 presents the cumulative annual quantities of mill residues by delivered price for each state.

Table 2: Estimated Annual Cumulative Mill Residue Quantities (dry tons), by Delivered Price and State

	< $20/dry ton delivered	< $30/dry ton delivered	< $50/dry ton delivered
Alabama	17000	4581000	7802000
Arizona	0	75000	251000

Arkansas	2000	2497000	4705000
California	8000	2294000	4823000
Colorado	86000	121000	180000
Connecticut	0	40000	91000
Delaware	0	4000	16000
Florida	4000	1412000	2678000
Georgia	72000	3913000	7969000
Idaho	69000	1629000	4400000
Illinois	19000	117000	282000
Indiana	31000	213000	699000
Iowa	2000	46000	158000
Kansas	1000	9000	20000
Kentucky	109000	421000	1940000
Louisiana	64000	1943000	3245000
Maine	43000	209000	504000
Maryland	0	13000	166000
Massachusetts	0	44000	135000
Michigan	10000	932000	1564000
Minnesota	71000	916000	1121000
Mississippi	128000	3178000	6029000
Missouri	162000	315000	1196000
Montana	17000	659000	2173000
Nebraska	12000	21000	69000
Nevada	0	0	0
New Hampshire	23000	439000	1109000
New Jersey	0	8000	21000

New Mexico	25000	61000	125000
New York	28000	495000	1274000
North Carolina	33000	2060000	5028000
North Dakota	0	3000	4000
Ohio	0	0	0
Oklahoma	0	318000	698000
Oregon	10000	1738000	6834000
Pennsylvania	172000	591000	1628000
Rhode Island	0	11000	25000
South Carolina	4000	1706000	3382000
South Dakota	8000	46000	124000
Tennessee	202000	1325000	2018000
Texas	18000	1649000	4043000
Utah	20000	67000	102000
Vermont	0	59000	124000
Virginia	80000	1234000	2860000
Washington	5000	2262000	5689000
West Virginia	136000	459000	967000
Wisconsin	42000	1202000	192000
Wyoming	47000	124000	255000
U.S. Total	1780000	41459000	90418000

C. Agricultural Residues

Agriculture is a major activity in the United States. Among the most important crops in terms of average total acres planted from 1995 to 1997 are corn (77 million acres), wheat (72 million acres), soybeans (65 million acres), hay (60.5 million acres), cotton (15 million acres), grain sorghum (10 million acres),

barley (7 million acres), oats (5 million acres), rice (3 million acres), and rye (1.5 million acres) (USDA, 1998b). After harvest, a portion of the stalks could potentially be collected for energy use. The analysis in this paper is limited to corn stover and wheat straw. Large acreage is dedicated to soybean production, but in general, residue production is relatively small and tends to deteriorate rapidly in the field, limiting the usefulness of soybean as an energy feedstock. However, additional residue quantities could be available from this source that have not been included in this analysis. Similarly, additional residue quantities could be available if barley, oats, rice, and rye production were included. Production of some of these crops (rice in particular) tends to be concentrated in a relatively small geographic area, and thus these crops could be an important local source of resources. Another potential source in the southern U. S. is cotton. A recent study (NEOS, 1998) suggests that approximately 500,000 dry tons of cotton gin trash is currently produced in the United States and this material is generally given away to farmers for use as a soil amendment. Another 171,000 dry tons of textile mill residues are produced, but much of this material is used to make other textiles and sells for prices in excess of $100/dry ton. These quantities are not included in this analysis.

The quantities of corn stover and wheat straw residues that can be available in each state are estimated by first calculating the total quantities of residues produced and then calculating the total quantities that can be collected after taking into consideration quantities that must be left to maintain soil quality (i.e., maintain organic matter and prevent erosion). Residue quantities generated are estimated using grain yields, total grain production, and a ratio of residue quantity to grain yield,[(3)]

The net quantities of residue per acre that are available for collection are estimated by subtracting from the total residue quantity generated, the quantities of residues that must remain to maintain quality (Lightle, 1997). Quantities that must remain differ by crop type, soil type, typical weather conditions, and the tillage system used. A state average was used for this analysis. In general, about 30 to 40 percent of the residues can be collected.

The estimated prices of corn stover and wheat straw include the cost of collecting the residues, the premium paid to farmers to encourage participation, and transportation costs.

The cost of collecting the agricultural residues are estimated using an engineering approach. For each harvest operation, an equipment complement is defined. Using typical engineering specifications, the time per acre required to complete each operation and the cost per hour of using each piece of equipment is calculated (ASAE, 1995; NADA, 1995; USDA, 1996; Doanes, 1995). For corn stover, the analysis assumes 1x mow, 1x rake, 1x bale with a large round baler, and pickup, transport, and unloading of the bales at the side of the field where they are stored until transport to the user facility. The same operations are assumed for wheat straw minus the mowing. The operations assumed are conservative--mowing is often eliminated and the raking operation is also eliminated in some circumstances. The method used to estimate collection costs is consistent with that used by USDA to estimate the costs of producing agricultural crops (USDA, 1996).

An additional cost of $20/dry ton is added to account for the premium paid to farmers and the

transportation cost from the site of production to the user facility. Currently, several companies purchase corn stover and/or wheat straw to produce bedding, insulating materials, particle board, paper, and chemicals (Gogerty, 1996). These firms typically pay $10 to $15/dry ton to farmers to compensate for any lost nutrient or environmental benefits that result from harvesting residues. The premium paid to farmers depends, in part, on transportation distance with farmers whose fields are at greater distances from the user facility receiving lower premiums. Studies have estimated that the cost of transporting giant round bales of switchgrass are $5 to $10 per dry ton for haul distances of less than 50 miles (Bhat et al, 1992; Graham et al, 1996; Noon et al, 1996). Agricultural residue bales are of similar size, weight, and density as switchgrass bales, and a similar transportation cost is assumed. This cost is similar to the reported transportation costs of facilities that utilize agricultural residues (Schechinger, 1997). Prices are in 1995$. For a more detailed explanation of the methodology used to estimate agricultural residue quantities and prices, see Walsh et al, 1998. The estimated annual cumulated agricultural residues quantities, by delivered price and state are contained in Table 3. Table 3 also contains by state, the percent of the total available residues that are corn stover.

Table 3: Estimated Annual Cumulative Agricultural Residue Quantities (dry tons), by Delivered Price and State

	< $30/dry ton delivered		< $40/dry ton delivered		< $50/dry ton delivered	
	Quantity	% Corn	Quantity	% Corn	Quantity	% Corn
Alabama	0	0	0	0	19267	0
Arizona	0	0	221864	24	221864	24
Arkansas	0	0	859361	0	984495	13
California	0	0	1478283	40	1478283	40
Colorado	0	0	2523820	90	2523820	90
Connecticut	0	0	0	0	0	0
Delaware	0	0	88077	0	300736	0
Florida	0	0	14824	0	14824	0
Georgia	0	0	344423	0	779871	56
Idaho	0	0	1248120	10	1248120	10
Illinois	0	0	24270757	94	24270757	94
Indiana	0	0	11883845	94	11883845	94

Iowa	0	0	23911214	99	23911214	99
Kansas	0	0	8570003	48	8570003	48
Kentucky	0	0	471819	0	2280603	49
Louisiana	0	0	80930	0	380557	79
Maine	0	0	0	0	0	0
Maryland	0	0	272468	0	802298	66
Massachusetts	0	0	0	0	0	6
Michigan	0	0	680783	0	4265671	84
Minnesota	0	0	11935896	88	11935896	88
Mississippi	0	0	0	0	37877	0
Missouri	0	0	1204353	0	4081358	70
Montana	0	0	406592	9	406592	9
Nebraska	0	0	16326915	98	16326915	98
Nevada	0	0	15350	0	15350	0
New Hampshire	0	0	0	0	0	0
New Jersey	0	0	32723	0	32723	0
New Mexico	0	0	476529	55	476529	55
New York	0	0	129515	0	129515	0
North Carolina	0	0	473229	0	1130744	58
North Dakota	0	0	14015	0	3715404	0
Ohio	0	0	7634476	82	7634476	82
Oklahoma	3214403	0	3440745	7	3440745	7
Oregon	0	0	155855	40	155855	40
Pennsylvania	0	0	197689	0	1031195	0
Rhode Island	0	0	0	0	0	0
South Carolina	0	0	239680	0	239680	0

South Dakota	0	0	3686246	71	2852740	71
Tennessee	0	0	300849	0	1004781	70
Texas	0	0	4497784	66	4497784	66
Utah	0	0	216546	29	216546	29
Vermont	0	0	0	0	0	0
Virginia	0	0	297986	0	585717	21
Washington	0	0	1364254	30	1364254	30
West Virginia	0	0	12008	0	51295	77
Wisconsin	0	0	5179618	97	5179618	97
Wyoming	0	0	171585	51	171585	51
U.S. Total	3214403	0	135331029	81	150651402	80

D. Dedicated Energy Crops

Dedicated energy crops include short rotation woody crops (SRWC) such as hybrid poplar and hybrid willow, and herbaceous crops such as switchgrass (SG). Currently, dedicated energy crops are not produced in the United States, but could be if they could be sold at a price that ensures the producer a profit at least as high as could be earned using the land for alternative uses such as producing traditional agricultural crops. The POLYSYS model is used to estimate the quantities of energy crops that could potentially be produced at various energy crop prices. POLYSYS is an agricultural sector model that includes all major agricultural crops (wheat, corn, soybeans, cotton, rice, grain sorghum, barley, oats, alfalfa, other hay crops); a livestock sector; and food, feed, industrial, and export demand functions. POLYSYS was developed and is maintained by the Agricultural Policy Analysis Center at the University of Tennessee and is used by the USDA Economic Research Service to conduct economic and policy analysis. Under a joint project between USDA and DOE, POLYSYS is being modified to include dedicated energy crops. A workshop consisting of USDA and DOE experts was held in November, 1997 to review the energy crop data being incorporated into the POLYSYS model.

The analysis includes cropland acres that are presently planted to traditional crops, idled, in pasture, or are in the Conservation Reserve Program. Energy crop production is limited to areas climatically suited for their production--states in the Rocky Mountain region and the Western Plains region are excluded. Because the CRP is an environmental program, two management scenarios have been evaluated--one to optimize for biomass yield and one to provide for high wildlife divesity. Energy crop yields vary within and between states, and are based on field trial data and expert opinion. Energy crop production costs are

estimated using the same approach that is used by USDA to estimate the cost of producing conventional crops (USDA, 1996). Recommended management practices (planting density, fertilizer and chemical applications, rotation lengths) are assumed. Additionally, switchgrass stands are assumed to remain in production for 10 years before replanting, are harvested annually, and are delivered as large round bales. Hybrid poplars are planted at a 8 x 10 foot spacing (545 trees/acre) and are harvested in the 10th year of production in the northern U.S., after 8 years of production in the southern U.S., and after 6 years of production in the Pacific Northwest. Poplar harvest is by custom operation and the product is delivered as whole tree wood chips. Hybrid willow varieties are suitable for production in the northern U.S. The analysis assumes 6200 trees/acre, with first harvest in year 4 and subsequent harvests every three years for a total of 7 harvests before replanting is necessary. Willow is delivered as whole tree chips.

The estimated quantities of energy crops are those that could potentially be produced at a profit at least as great as could be earned producing traditional crops on the same acres, given the assumed energy crop yield and production costs, and the 1999 USDA baseline production costs, yields, and traditional crop prices (USDA, 1999b). In the U.S., switchgrass production dominates hybrid poplar and willow production at the equivalent (on an MBTU basis) market prices. The POLYSYS model estimates the farmgate price; an average transportation cost of $8/dt is added to determine the delivered price. Prices are in $1997. Table 4 presents the estimated annual cumulative quantities of energy crops by state by delivered price. For a more detailed explanation of the methodology used to estimate dedicated energy crop prices and quantities, see Walsh et al, 1998 and de la Torre Ugarte et al, 1999.

Table 4: Estimated Annual Cumulative Energy Crop Quantities (dry tons), by Delivered Price and State

	< $30/dry ton delivered	< $40/dry ton delivered	< $50/dry ton delivered
Alabama	0	3283747	6588812
Arizona	0	0	0
Arkansas	0	1709915	5509780
California	0	0	0
Colorado	0	0	0
Connecticut	0	0	199646
Delaware	0	0	31454
Florida	0	0	1268290
Georgia	0	1321438	3958181
Idaho	0	0	0

Illinois	0	1427349	7689694
Indiana	0	418042	5026234
Iowa	0	234292	8295486
Kansas	0	2859261	11438271
Kentucky	0	3598827	5128780
Louisiana	0	3923954	5813200
Maine	0	0	0
Maryland	0	0	298653
Massachusetts	0	0	235908
Michigan	0	1154228	4179308
Minnesota	0	427467	5783002
Mississippi	0	5330671	9304782
Missouri	0	5251442	12780923
Montana	0	0	2778386
Nebraska	0	1922058	5172860
Nevada	0	0	0
New Hampshire	0	0	158757
New Jersey	0	0	142902
New Mexico	0	0	0
New York	0	0	3388035
North Carolina	0	639228	1632077
North Dakota	0	1928463	16757889
Ohio	0	3808089	9657080
Oklahoma	0	3644173	8083722
Oregon	0	0	0
Pennsylvania	0	0	2338243

Rhode Island	0	0	4943
South Carolina	0	1338745	2438152
South Dakota	0	5613863	12757734
Tennessee	0	6616717	9350856
Texas	0	4549899	9139885
Utah	0	0	0
Vermont	0	0	333465
Virginia	0	1260668	2609867
Washington	0	0	0
West Virginia	0	269250	1190299
Wisconsin	0	3595636	6114270
Wyoming	0	0	487361
U.S. Total	0	66127422	188067187

E. Urban Wood Wastes

Urban wood wastes include yard trimmings, site clearing wastes, pallets, wood packaging, and other miscellaneous commercial and household wood wastes that are generally disposed of at municipal solid waste (MSW) landfills and demolition and construction wastes that are generally disposed of in construction/demolition (C/D) landfills. Data regarding quantities of these wood wastes is difficult to find and price information is even rarer. Additionally, definitions differ by states. Some states collect data on total wastes deposited at each MSW and C/D landfill in their states, and in some states, the quantities are further categorized by type (i.e., wood, paper and cardboard, plastics, etc.). However, not all states collect this data. Therefore, the quantities presented are crude estimates based on survey data (Glenn, 1998; Bush et al, 1997; Araman et al, 1997).

For municipal solid wastes (MSW) a survey by Glenn, 1998 is used to estimate total MSW generated by state. These quantities are adjusted slightly to correspond to regional MSW quantities that are land-filled as estimated by a survey conducted by Araman et al, 1997. Using the Araman survey, the total amount of wood contained in land-filled MSW is estimated. According to this survey, about 6 percent of municipal solid waste in the Midwest is wood, with 8 percent of the MSW being wood in the South, 6.6 percent being wood in the Northeast and 7.3 percent being wood in the West. Estimated quantities were

in wet tons; they were corrected to dry tons by assuming a 15 percent moisture content by weight.

To estimate construction and demolition wastes (C/D), the Glenn study and the Bush et al, 1997 survey were used. The Glenn study provided the number of C/D landfills by state, and the Bush et al survey provided the average quantity of waste received per C/D landfill by region as well as the regional percent of the waste that was wood. According to the Bush et al survey, C/D landfills in the Midwest receive an average 25,700 tons of waste per year with 46 percent of that quantity being wood. In the South, C/D landfills receive an average 36,500 tons of waste/yr with 39 percent being wood. Northeastern C/D landfills receive an average 13,700 tons of waste/yr with 21 percent being wood and Western C/D landfills receive an average 28,800 tons of waste/yr with 18 percent being wood. Estimated quantities were in wet tons; they were corrected to dry tons by assuming a 15 percent moisture content by weight.

Yard trimmings taken directly to a compost facility rather than land-filled, were estimated from the Glenn study. This estimate was made by multiplying the number of compost facilities in each state by the national average tons of material received by site (2750 tons). The total compost material was then corrected for the percent that is yard trimmings (assumed to be 80 percent) and for the quantity that is wood (assumed to be 90 percent). Quantities were corrected to dry tons by assuming a 40 percent moisture by weight.

In an effort to reduce the quantities of waste materials that are land-filled, most states actively encourage the recycling of wastes. Quantities and prices of recycled wood wastes are not readily available. However, the Araman and Bush surveys report limited data on the recycling of wood wastes at MSW and C/D sites. They report that in the South, approximately 36 percent of C/D landfills and 50 percent of MSW landfills operate a wood/yard waste recycling facility and that about 34 percent of the wood at C/D landfills and 39 percent of the wood at MSW landfills is recycled. In the Midwest, about 31 percent of the MSW and 25 percent of the C/D landfills operate wood recycling facilities with 16 percent of the MSW wood and 1 percent of the C/D wood is recycled. In the West, 27 percent of the MSW and C/D landfills operate wood recycling facilities and recycle 25 percent each of their wood. In the Northeast, 39 percent of the MSW and 28 percent of the C/D landfills operate wood recycling facilities and recycle 39 percent of the MSW wood and 28 percent of the C/D wastes.

The surveys do not report the use of total recycled wood, but do report the uses of recycled pallets which represent about 7 percent of the total wood and 4 percent of the recycled wood at C/D landfills and about 24 percent of the total wood and about 13 percent of the recycled wood at MSW landfills. At C/D landfills, about 14 percent of the recycled pallets are re-used as pallets, about 39 percent are used as fuel, and the remainder is used for other purposes such as mulch and composting. About 69 percent of the recyclers reported that they gave away the pallet material. Of those selling the material, the mean sale price was $11.01/ton and the median sale price was $10.50/ton. At MSW landfills, about 3 percent of the recycled pallets are re-used as pallets, about 41 percent are used as fuel, and the remainder is used for other purposes such as mulch and composting. About 58 percent of the C/D recyclers reported that they gave away the pallet material. Of those selling the material, the mean sale price was $13.17/ton and the median sale price was $10.67/ton. Transportation costs must still be added to the sale price. Given the

lack of information regarding prices, we assumed that of the total quantity available, 60 percent could be available at less than $20/dry ton and that the remaining quantities could be available at less than $30/dry ton. Table 5 presents the estimated annual cumulative quantities of urban wood wastes by state and price.

Table 5: Estimated Annual Cumulative Urban Wood Waste Quantities (dry tons), by Delivered Price and State

	< $20/dry ton	< $30/dry ton	< $40/dry ton	< $50/dry ton
Alabama	823566	1372610	1372610	1372610
Arizona	219736	366227	366227	366227
Arkansas	400364	667273	667273	667273
California	1579813	2633022	2633022	2633022
Colorado	94661	157769	157769	157769
Connecticut	246938	411563	411563	411563
Delaware	38959	64931	64931	64931
Florida	2757950	4596584	4596584	4596584
Georgia	862094	1436823	1436823	1436823
Idaho	135265	338162	338162	338162
Illinois	416047	693411	693411	693411
Indiana	316610	527684	527684	527684
Iowa	171802	286337	286337	286337
Kansas	736289	1227148	1227148	1227148
Kentucky	345699	576165	576165	576165
Louisiana	452322	753870	753870	753870
Maine	108358	180597	180597	180597
Maryland	204643	341071	341071	341071
Massachusetts	419272	698787	698787	698787
Michigan	495734	826224	826224	826224
Minnesota	919517	1532529	1532529	1532529
Mississippi	470831	784719	784719	784719
Missouri	315547	525911	525911	525911
Montana	52060	86766	86766	86766
Nebraska	102073	170121	170121	170121

Nevada	184112	306853	306853	306853
New Hampshire	110579	184298	184298	184298
New Jersey	389089	648481	648481	648481
New Mexico	142896	238160	238160	238160
New York	1140080	1900133	1900133	1900133
North Carolina	636035	1060056	1060056	1060056
North Dakota	326510	544184	544184	544184
Ohio	744518	1240864	1240864	1240864
Oklahoma	111173	185289	185289	185289
Oregon	182532	304220	304220	304220
Pennsylvania	399963	666605	666605	666605
Rhode Island	29803	49671	49671	49671
South Carolina	1289900	2149833	2149833	2149833
South Dakota	123982	206637	206637	206637
Tennessee	676029	1126715	1126715	1126715
Texas	1209449	2015749	2015749	2015749
Utah	138765	231275	231275	231275
Vermont	40802	68004	68004	68004
Virginia	519454	865757	865757	865757
Washington	292432	487387	487387	487387
West Virginia	105236	175393	175393	175393
Wisconsin	383466	639110	639110	639110
Wyoming	177383	295638	295638	295638
U.S. Total	22040338	36846616	36846616	36846616

III. Summary

Table 6 summarizes the estimated total annual cumulative quantities of biomass resources available by state and delivered price. It is estimated that substantial quantities of biomass (510 million dry tons) could be available annually at prices of less that $50/dt delivered. However, several caveats should be noted. There is a great deal of uncertainty surrounding some of the estimates. For example, while there is substantial confidence in the estimated quantities of mill residues available by state, there is a great deal of uncertainty about the estimated prices of these residues. The value of these feedstocks in their

current uses is speculative and based solely on anecdotal discussions. Given that the feedstock is already being used--much of it under contract or in-house by the generator of the waste--energy facilities may need to pay a higher price than assumed to obtain the feedstock. Additionally, both the quantity and price of urban wastes are highly speculative. The analysis is based solely on one national study and regional averages taken from two additional surveys. There is no indication of the quality of the material present (i.e., whether the wood is contaminated with chemicals, etc.). Because of the ways in which the surveys were conducted, there may be double counting of some quantities (i.e., MSW may contain yard trimmings and C/D wastes as well). Additionally, the analysis assumes that the majority of this urban wood is available for a minimal fee, with much of the cost resulting from transportation. Other industries have discovered that once a market is established, these "waste materials" become more valuable and are no longer available at minimal price. This situation could also happen with urban wastes used for energy if a steady customer becomes available. It should also be noted however, that some studies indicate that greater quantities of urban wastes are available, and are available at lower prices, than are assumed in this analysis (Wiltsee, 1998). Given the high level of uncertainty surrounding the quantity and price estimates of urban wastes and mill residues, and the fact that these wastes are estimated to be the least cost feedstocks available, they should be viewed with caution until a more detailed analysis is completed.

The analysis has assumed that substantial quantities of dead forest wood could be harvested. The harvest of deadwood is a particularly dangerous activity and not one relished by most foresters. Additionally, large polewood trees represent the growing stock of trees, that if left for sufficient time, could be harvested for higher value uses. These opportunity costs have not been considered. And, the sustainability of removing these forest resources has not been thoroughly analyzed.

We estimate the price of agricultural residues to be high largely because of the small quantities that can be sustainably removed on a per acre basis. Improvements in the collection/transport technologies and the ability to sustainably collect larger quantities (due to a shift in no-till site preparation practices for example) could increase quantities and decrease prices over time. Also, the inclusion of some of the minor grain crops (i.e., barley, oats, rye, rice) and soybeans could increase the total quantities of agricultural residues available by state. However, further elucidation of quantities that can sustainably be removed might lower available quantities.

Dedicated energy crops (i.e., switchgrass and short rotation wood crops) are not currently produced--the analysis is based on our best estimates of yield, production costs, and profitability of alternative crops that could be produced on the same land. Improving yields and decreasing production costs through improved harvest and transport technologies could increase available quantities at lower costs.

We have assumed a transportation cost of $8/dry ton for most feedstocks. This cost is based on a typical cost of transporting materials (i.e., switchgrass bales and wood chips) for less than 50 miles (Graham et al, 1996; Bhat et al, 1992; Noon et al, 1996). Finally, the analysis is conducted at a state level and the distribution of biomass resources within the state is not specifically considered. We have simply assumed that the feedstock is available within 50 miles of a user facility. This may not be the case which would result either in the cost of the feedstock being higher to a user facility due to increased

transportation costs, or the quantities of available feedstock being lower to a user facility if the material is simply too far away from the end-user site to be practical to obtain. Biomass resource assessments are needed at a lower aggregation level than the state. Any facility considering using the analysis need to conduct its own local analysis to verify feedstock quantity and prices.

Table 6: Estimated Cumulative Biomass Quantities (dry ton/yr), by Delivered Price and State

	< $20/dry ton	< $30/dry ton	< $40/dry ton	< $50/dry ton
Alabama	840566	6962610	10712357	17681689
Arizona	219736	575227	863091	1100491
Arkansas	402364	4092273	7085549	13604348
California	1587813	6158022	8224305	11298705
Colorado	180661	651769	3356589	3581889
Connecticut	246938	560563	610563	906309
Delaware	38959	94931	194008	461521
Florida	2761950	6753122	6778408	9533398
Georgia	934094	6390823	8540684	16111675
Idaho	204265	2572162	4117282	7165782
Illinois	435047	1038411	26838517	33359162
Indiana	347610	993684	13409571	18606863
Iowa	173802	404337	24582843	32786037
Kansas	737289	1283148	12733412	21343522
Kentucky	454699	1472165	5757811	10809048
Louisiana	516322	3568870	7976754	11834427
Maine	151358	1195597	1571597	2213697
Maryland	204643	543071	899539	1959222
Massachusetts	419272	938787	1026787	1435895

Michigan	505734	2468224	4627235	12163103
Minnesota	990517	2916529	15493892	21247327
Mississippi	598831	4908719	10673390	17930978
Missouri	477547	1345911	8029706	19522892
Montana	69060	1421766	2159358	6761444
Nebraska	114073	210121	18467094	21773296
Nevada	184112	314853	333203	336603
New Hampshire	133579	922298	1061298	2016455
New Jersey	389089	726481	791204	975806
New Mexico	167896	424160	960689	1081589
New York	1168080	3328133	3884648	8438083
North Carolina	669035	4188056	5789513	10855777
North Dakota	326510	558184	2506662	21043177
Ohio	744518	1472864	13018429	18962520
Oklahoma	111173	3873692	7816207	12699956
Oregon	192532	3341220	4126075	9809975
Pennsylvania	571963	2205605	2832294	7427043
Rhode Island	29803	80671	87671	115514
South Carolina	1293900	4468833	6332258	9368065
South Dakota	131982	285637	9601746	16005411
Tennessee	878029	3381715	10720281	15232952
Texas	1227449	4221749	13526432	20747118
Utah	158765	388275	647821	722821
Vermont	40802	392004	513004	1022669
Virginia	599454	3058757	5055411	8714941
Washington	297432	3979387	5938641	9920241

West Virginia	241236	1361393	1971651	3736487
Wisconsin	425466	2450110	11502364	14963398
Wyoming	224383	551638	787223	1465684
U.S. Total	23820338	105496557	314535067	510855005

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1. Logging residues are the unused portion of the growing of stock trees (i.e., commercial species with a diameter breast height (dbh) greater than 5 inches, excluding cull trees) that are cut or killed by logging and left behind. Rough trees are those that do not contain a sawlog (i.e., 50 percent or more of live cull volume) or are not a currently merchantable species. Rotten trees are trees that do not contain a sawlog because of rot (i.e., 50 percent or more of the live cull volume). Salvable dead wood includes downed or standing trees that are considered currently or potentially merchantable. Excess saplings are live trees having a dbh of between 1.0 and 4.9 inches. Small pole trees are trees with a dbh greater than 5 inches, but smaller than saw timber trees. (back to report)

2. Retrieval efficiency accounts for the quantity of the inventory that can actually be recovered due to technology or equipment (assumed to be 40 percent). It is assumed that 50 percent of the resource is accessible without having to construct roads, except for logging residues for which 100 percent of the inventory is assumed accessible. Finally, inventory that lies on slopes greater than 20 percent or where conventional equipment cannot be used are eliminated for cost and environmental reasons. (back to report)

3. The assumed residue factors are--1 ton of corn stover for every 1 ton of corn grain produced; 1.7 tons of wheat straw for every 1 ton of winter wheat grain; and 1.3 ton of wheat straw for every 1 ton of spring and duram wheat grain (Heid, 1984). We assume a grain weight of 56 and 60 lb/bu for corn and wheat grain respectively. Grain moisture factors are assumed to be 1 for corn and .87 for wheat.

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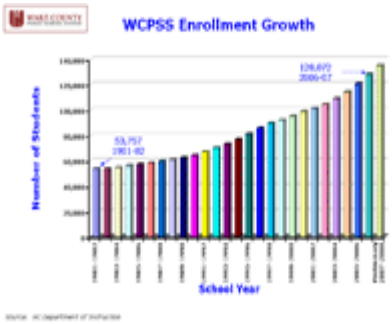
WCPSS Grew by 6,000 Students - It is Now the 19th Largest School System in the United States and the Largest in North Carolina

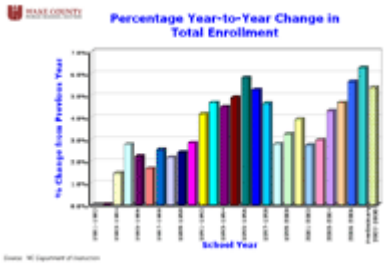
Enrollment in the Wake County Public School System increased to 134,002 on the 20th day of the 2006-07 school year, 5,930 students more than last year. This increase in enrollment made WCPSS the largest school district in NC, passing Charlotte Mecklenburg schools which reported 20th day enrollment of 132,281. This gain also means that WCPSS moves up two spots to 19th largest school district in the nation. |20th day headcount by school|

Level	Membership (MLD 20th-day)			Annual Increase		
	2005-06 (Actual)	2006-07 (Actual)	2007-08	2005-06 (Actual)	2006-07 (Actual)	2007-08
Elementary	58,249	62,395	65,680	3,493	4,146	3,285
Middle	27,759	29,031	29,975	1,047	1,272	944
High	34,496	36,646	38,347	1,896	2,150	1,701
WCPSS Total	**120,504**	**128,072**	**134,002**	**6,436**	**7,568**	**5,930**

Seven new schools opened in 2007-08, bringing the total number of schools to 153. |new schools map | historic school openings | district map | Area Superintendent map |

The following graphs illustrate the total growth of the WCPSS student population and the annual net percentage increase (20th day data) over the last 25 years.

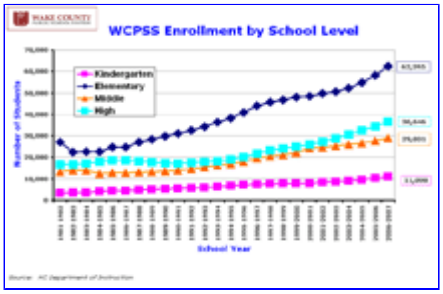


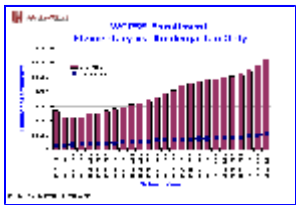


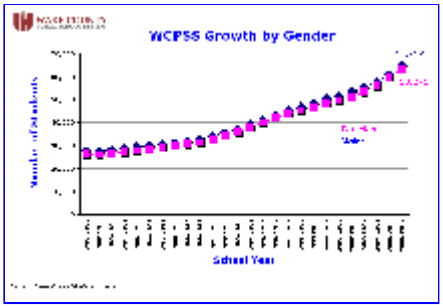
What attracts people to NC, and Wake County in particular, is a growing and vibrant economy with constant creation of jobs, particularly in technology and services, a very favorable and still-affordable housing market, the high quality of WCPSS public schools, and an excellent quality of life.

Historical evidence seems to indicate that the student growth tends to be cyclical in nature and not linear. For example, fluctuations of enrollment can be affected by:
1. Economy – whether the economy and the job market are perceived as good or bad

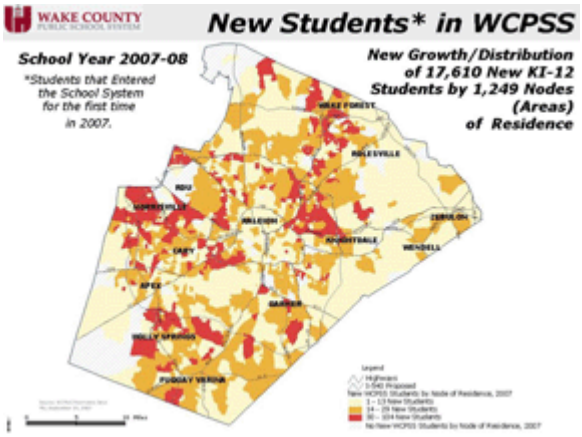
during a particular time period.
2. Housing market - building trends, the mortgage market, and availability of appropriate housing options for new residents; similarly, whether a prospective new resident is able to sell a residence in another area to move into Wake County.
3. The rate of immigration into Wake County.
4. Visibility of Wake County and WCPSS at state and national level, including accolades and awards.
5. School dropout and graduation rates. Students leaving or staying in the system affect enrollment figures, as do new students entering the system for the first time (KI, and 1-12 grades).
6. Other schoolling options (home, private, charter).
7. Natural growth trends (fertility - mortality).







Enrollment History ppt



jpg | ppt |corporate limits | KI

About 17,000 new students entered WCPSS in 2007-08 for the first time, with the net estimated gain being in the 6,000 range. Roughly 80% of the 17,000 are in elementary schools (with majority being at the kindergarten level), 10% are in middle schools, and 10% are in high schools.

New student distribution, by their place of residence, shows similar pattern as last year's. Thirty-seven percent (37%) live within Raleigh city limits, 28% in un-incorporated Wake County areas, 15% within Cary city limits, and 5% within Apex city limits. About 3% live in each Holly Springs and Wake Forest, while Morrisville, Fuquay-Varina, and Garner are home to about 2% of student population each. Finally, Knightdale, Rolesville, Wendell and Zebulon are home to less than 1% each.

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