



**Keeping North Carolina's Farms and Forests Vibrant and Resilient through Adaptive Management:**

**Priorities and Recommendations for Advancing Adaptive Management on Forest Lands**

**January 2017**

# North Carolina Agriculture and Forestry Adaptation Work Group

## About North Carolina Agriculture and Forestry Adaptation Work Group

First convened in December 2014, the North Carolina Agriculture and Forestry Adaptation (NC ADAPT) Work Group is a coalition of leaders from the agriculture and forestry sectors, along with partners from the business, academic, research and government communities. The NC ADAPT Work Group's initial mission was to explore the threats and impacts of increasingly extreme and erratic weather events and changing climatic conditions on North Carolina's agriculture and forestry sectors to determine if these sectors are adequately prepared for what scientists are projecting through mid-century. The NC ADAPT Work Group concluded that climate variability is a threat to agriculture and forestry in North Carolina, preparation is needed, and the state would benefit from the development of a comprehensive adaptive management strategy. The NC ADAPT Work Group's findings and roadmap for constructing an adaptive management plan are outlined in the report, [\*Keeping North Carolina's Farms and Forests Vibrant and Resilient: An Adaptive Management Planning Strategy\*](#).

In August 2015, the NC ADAPT Work Group hosted an Adaptation Summit that brought together a diverse set of stakeholders to begin the process of identifying and forging consensus on the unique adaptation challenges that North Carolina's agriculture and forestry sectors will face going forward. Summit attendees also established a pathway for constructing an adaptive management plan to improve agriculture and forestry resiliency and further enhance the economic viability of these sectors for decades to come. The [\*NC-ADAPT Agriculture and Forestry Adaptation Summit Synopsis\*](#) reflects the spirit that North Carolina stakeholders are ready to engage in the vital discussion of adaptation and preparation for an uncertain future and would be utilizing sound science in the adaptive management planning process.

After examining the challenges and opportunities associated with variable, extreme weather events, the NC ADAPT Work Group turned to developing a North Carolina Agriculture and Forestry Adaptive Management Strategy (NC-STRAT). Four Teams were created to collect feedback from stakeholder meetings, as well as surveys of producers and sector experts to help develop key actions, initiatives and recommendations to address the anticipated impacts of climate change on agriculture and forestry in North Carolina. This document outlines recommendations and actions that producers, researchers, policy makers, and supporting groups can take to build resiliency and reduce risks to not only meet future challenges, but thrive in the midst of them.

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*Solutions from the Land is a not-for-profit entity focused on land based solutions to global challenges. Funds to support the work carried out under this project were provided through a grant from the Z. Smith Reynolds Foundation. The North Carolina Agriculture and Forestry Adaptation Work Group acknowledges and appreciates their contributions that made this work possible.*

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## EXECUTIVE SUMMARY

From the very first seeds that were planted in the ground to the first meat and dairy animals that were domesticated, producers have historically been making adjustments to meet the many challenges of variable and extreme weather events. The history of the United States agriculture is a tale of adaptation and remarkable progress in the face of these challenges.

Recent years have demonstrated just how vulnerable production systems are to changing weather and extreme weather events. An extended dry period from 1998-2000 was followed by a historic drought in 2007 when all of North Carolina's 100 counties experienced moderate to exceptional drought conditions that cost hundreds of millions of dollars. Tropical systems have now adversely impacted North Carolina in back to back years just as the row crop harvest was hitting its stride. The historic floods have also dealt blows to the livestock and forestry sectors and everyone is impacted when key components of the state transportation network are disabled. Estimated total agricultural losses resulting from Hurricane Matthew could total in the hundreds of millions of dollars, but the damage is still being assessed in the east side of the state. Wildfires in western North Carolina driven by late summer drought conditions have burned over 100,000 acres of public and private forest lands and caused thousands to be evacuated. The costs incurred to control these fires increase each day.

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*“There are risks and costs to a program of action, but they are far less than the long-range risks and costs of inaction.” John F. Kennedy*

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The adaptation conversation is nothing new in North Carolina. The [\*Climate-Ready North Carolina: Building a Resilient Future\*](#) strategy developed by the North Carolina Interagency Leadership Team<sup>1</sup> discusses how North Carolina can proactively prepare for projected impacts of climate variability and weather extremes on its economy, infrastructure and natural resources. The report includes a section on the impacts, risks and vulnerabilities to agriculture and forestry, and presents numerous actions that could be implemented in response to predicted changes in climate. The recommendations from the report provided helpful background information for this project.

The NC ADAPT Work Group created four (4) stakeholder Teams – Commodity Crops; Livestock; Forestry; and Specialty Crops. Each Team established their own process to identify adaptation needs, priorities and strategies. Several themes and cross-cutting recommendations were observed and are captured below:

- All production sectors indicate that research on water management, in particular irrigation methods, technology and/or feasibility is important going forward.
- Drought resistant cultivars and adaptive cover cropping systems for improved soil and nutrient management are needed for production and practice systems across all production platforms (i.e. specialty crops, commodity crops, etc.).
- Agriculture and forestry each identify a desire for a “Risk Management Collaborative” to collect and share information on policies and programs, and that will help to steer adjustments in programs that reflect changing conditions.

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<sup>1</sup> North Carolina Interagency Leadership Team, 2012. “Climate-Ready North Carolina: Building a Resilient Future.” <http://climateadaptationnc.nemac.org/Climate Ready North Carolina Building a Resilient Future.pdf>

- Each sector also identify access to new markets as a risk management option for creating product demand and increasing revenues.
- It is important that localized decision-making tools and technical assistance be tailored to each of North Carolina’s recognized geographical regions: Coastal, Piedmont, and Mountain.
- Information is key in managing farms and forests, and producers wish to have continuing faith in Cooperative Extension Service personnel to provide timely and accurate precision agriculture information, utilization support and technical knowledge.
- The best technologies, research findings, programs and planning tools to implement adaptation strategies must find its way to producers. If producers are not involved in the development and delivery of adaptation strategies, the success rate of the adaptation strategies will drop.
- Agriculture and forestry stakeholders recommend that outreach be expanded, knowledge sharing networks created, adaption education enhanced and increased promotion of programs.

The history of agriculture and forestry is one of constant change and continuous improvement. No one can precisely state what climate and weather patterns will be for North Carolina in the future. Scientific research and producer experience does point to growing challenges – some say unprecedented challenges<sup>2</sup> – for our agriculture and forestry sectors, as shifts in weather patterns continue and weather events intensify. For this reason, adaptation has increasingly become a focus of interest. A focus on adaptation measures opens the door to the collection of solutions for addressing production challenges. For instance, solutions which increase an operation’s resilience to climate changes can also create economic and ecological added-value for landowners and society. Practices such as terrestrial carbon sequestration, methane capture and conversion, waste-to-energy, etc. can improve soil health, water quality, wildlife habitat and other natural, societal, financial and operational benefits.

Changes ahead are expected to be unprecedented, but with good planning and through proactive management North Carolina’s agriculture and forestry producers can remain productive and provide many benefits beyond food and fiber. North Carolina’s farmers, foresters and livestock producers will have to adjust to more variable weather and extremes by merging new knowledge, experience, planning and practices with new technologies and decision-making tools. However, they also will need focused support to innovate and adapt to the changes ahead in a way that strengthens production systems, improves profits and reduces environmental impacts. The state’s leadership should support North Carolina’s producers by making investments in public research, and expanding the state’s economic development focus on agriculture and forestry.

The recommendations included in this document mark the beginning of new conversations around resilience and adaptive management. Forestry-specific recommendations for adaptive management measures and practices are found later in this report.

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<sup>2</sup> Walthall, C.L., J. Hatfield, P. Backlund, L. Lengnick, E. Marshall, M. Walsh, S. Adkins, M. Aillery, E.A. Ainsworth, C. Ammann, C.J. Anderson, I. Bartomeus, L.H. Baumgard, F. Booker, B. Bradley, D.M. Blumenthal, J. Bunce, K. Burkey, S.M. Dabney, J.A. Delgado, J. Dukes, A. Funk, K. Garrett, M. Glenn, D.A. Grantz, D. Goodrich, S. Hu, R.C. Izaurralde, R.A.C. Jones, S-H. Kim, A.D.B. Leaky, K. Lewers, T.L. Mader, A. McClung, J. Morgan, D.J. Muth, M. Nearing, D.M. Oosterhuis, D. Ort, C. Parmesan, W.T. Pettigrew, W. Polley, R. Rader, C. Rice, M. Rivington, E. Rosskopf, W.A. Salas, L.E. Sollenberger, R. Srygley, C. Stöckle, E.S. Takle, D. Timlin, J.W. White, R. Winfree, L. Wright-Morton, L.H. Ziska. 2012. [\*Climate Change and Agriculture in the United States: Effects and Adaptation\*](#). USDA Technical Bulletin 1935. Washington, DC. 186 pages.

## INTRODUCTION

Throughout the United States, farmers, foresters, and ranchers are adjusting their operations to reduce the risks associated with increasingly variable and unpredictable weather. In Western states, farmers and ranchers are coping with drought by employing new weather tracking technology, building new water storage and conveyance systems, enhancing conservation to support fragile ecosystems, and creating resilient farm systems through soil health improvement initiatives.<sup>3</sup> In the Northeast states, an observed increase in extreme precipitation events poses greater risk to farms and forests from flooding, erosion and other effects. Producers in this region are reexamining infrastructure needs, land management and operational location.<sup>4</sup> Throughout the Midwest states, average temperatures have risen steadily over the last several decades. A potential effect from higher temperatures is an increase in insect and disease populations that will impact crop and livestock productivity. Producers and scientists are working now to develop measures to respond to these risks.<sup>5</sup>

In addition to weather challenges and climate shifts, producers are facing economic, social and environmental pressures. These challenges include feeding, clothing, housing, and fueling a rapidly growing world, making decisions in increasingly volatile local and global markets, and managing soil, water, and air resources. These pressures are accompanied by high levels of uncertainty, which compel land managers to reevaluate past decisions, seek new information and strategies, and take adaptive actions.

The U.S. Global Change Research Program issued a report that found “changes in climate factors, such as temperature, precipitation, and extreme weather, are key drivers of pathogen introduction, food contamination and foodborne disease, as well as changes in the level of exposure to specific contaminants and chemical residues for crops and livestock.” Furthermore, the expansion of various pests spurred by warmer weather and longer growing seasons could impact the effectiveness of pesticides and/or lead to increased pesticide use.<sup>6</sup>

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<sup>3</sup> Family Farm Alliance, “*Western Farmers and Ranchers as Problem Solvers: A Compilation of Case Studies Highlighting Locally-Driven Solutions to Western Water Resource Challenges*,” White House Water Summit, 22 March 2016, [http://www.familyfarmalliance.org/sites/www.familyfarmalliance.org/assets/files/44715\\_FFAWhiteHouseReport.pdf](http://www.familyfarmalliance.org/sites/www.familyfarmalliance.org/assets/files/44715_FFAWhiteHouseReport.pdf)

<sup>4</sup> Tobin, D., M. Janowiak, D. Hollinger, R.H.Skinner, C. Swanston, R. Steele, R.Radhakrishna, A. Chatrchyan, D. Hickman, J. Bochicchio, W. Hall, M. Cole, S. Hestvik, D. Gibson, P.Kleinman, L. Knight, L. Kochian, L. Rustad, E. Lane, J. Niedzielski, and P. Hlubik, 2015: *Northeast and Northern Forests Regional Climate Hub Assessment of Climate Change Vulnerability and Adaptation and Mitigation Strategies*, T. Anderson, Eds., United States Department of Agriculture, 65 pp. <http://www.climatehubs.oce.usda.gov/sites/default/files/Northeast%20Regional%20Hub%20Vulnerability%20Assessment%20Final.pdf>

<sup>5</sup> Hatfield, J., C. Swanston, M. Janowiak, R. Steele, J. Hempel, J. Bochicchio, W. Hall, M. Cole, S. Hestvik, and J. Whitaker, 2015: *Midwest and Northern Forests Regional Climate Hub Assessment of Climate Change Vulnerability and Adaptation and Mitigation Strategies*, T. Anderson, Eds., United States Department of Agriculture, 55 pp. <http://climatehubs.oce.usda.gov/sites/default/files/pdf/Midwest%20Region%20Vulnerability%20Assessment%202015.pdf>

<sup>6</sup> USGCRP, 2016: *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. Crimmins, A., J. Balbus, J.L. Gamble, C.B. Beard, J.E. Bell, D. Dodgen, R.J. Eisen, N. Fann, M.D. Hawkins, S.C. Herring,

North Carolina farmers, foresters and livestock producers are also subject to these same challenges and pressures. Previous investigations have found that North Carolina producers are also concerned with regulatory uncertainty, changing market structures, plant and animal diseases, invasive species, transportation infrastructure stability, land fragmentation/ownership profiles, land use change, water quality/quantity, energy security/costs and others.<sup>7</sup> Like their counterparts across the country and around the world, North Carolina farmers, foresters and livestock producers recognize the need to be proactive in preparing for what science is telling them to expect in the coming decades – and with good reason.

Climate and extreme weather related hazards and vulnerabilities are a growing threat to North Carolina's agriculture, livestock and forestry sectors. Signals of change in important climate drivers include: 1) Days with daytime temperatures above 95°F are expected to increase by up to 50 days annually, 2) nights below freezing are expected to decrease by up to 20 days annually, and 3) coastal working lands are vulnerable to sea level rise and saltwater intrusion. Reduced farm and forest productivity may result from altered rainfall patterns, increased frequency/severity of extreme events, and heat stress.<sup>8</sup> Appendix I of this report provides a more detailed description of the threats posed to agriculture and forestry by changing climatic conditions as outlined by North Carolina-based scientists.

The precise future effects of climate and extreme weather events on agriculture and forestry are very difficult to predict, and will depend on many parameters. Producers in different regions of the state are expected to cope with climate variability in ways that are economically, agronomically and ecologically compatible with their production system.

Agriculture and forestry are the two leading mainstays of the North Carolina economy, and adaptation options are needed to eliminate or reduce adverse impacts that could result from increasing climate variability. The recommendations in this report are designed to reflect the critical adaptation options that many producers can begin – and in some cases have already begun – to implement on their farms, forests and ranches.

Despite advances in plant and animal genetics, automation and robotics, natural resource conservation, alternative production systems, and many other technologies and tools that have helped to increase food and fiber production, recent weather events have demonstrated just how vulnerable our production system remains to changing weather conditions.

North Carolina began 2015 with above average temperatures and drier than normal conditions until a tropical storm dumped rain across the state. At the end of summer 2015, North Carolina was experiencing significant above-average temperature conditions and below-average precipitation.

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L. Jantarasami, D.M. Mills, S. Saha, M.C. Sarofim, J. Trtanj, and L. Ziska, Eds. U.S. Global Change Research Program, Washington, DC, 312 pp. <http://dx.doi.org/10.7930/JOR49NQX>

<sup>7</sup> Climate Change Adaptation Sensing Meetings with Leaders of North Carolina's Agriculture and Forestry Sectors, December 2013

<sup>8</sup> McNulty, S., S. Wiener, E. Treasure, J. Moore Myers, H. Farahani, L. Fouladbash, D. Marshall, R. Steele, D. Hickman, J. Porter, S. Hestvik, R. Dantzler, W. Hall, M. Cole, J. Bochicchio, D. Meriwether, and K. Klepzig, 2015: *Southeast Regional Climate Hub Assessment of Climate Change Vulnerability and Adaptation and Mitigation Strategies*, T. Anderson, Ed., United States Department of Agriculture, 61 pp.



However, a dramatic shift to historic rainfall amounts and flooding events occurred across the Carolinas when Hurricane Joaquin interacted with an upper level low in October. As 2015 concluded, December recorded record high temperatures for the month. Despite the warmer temperatures, a historically strong El Nino pattern extended the wetness throughout the winter and well into the first months of 2016.<sup>9</sup> Then in October 2016, almost one year to the day of Hurricane Joaquin, Hurricane Matthew brought widespread flash flooding and record river flooding to eastern North Carolina where hourly rainfall estimates from radar were as high as 7 inches per hour. Buildings and homes were flooded, roads washed out, and sections of Interstates 95 and 40 closed due to flooding. In addition, harvests were disrupted, crops lost, livestock mortality was recorded and some manure lagoons flooded. The effects of these severe, unpredictable weather events have real economic impacts.

Before these devastating hurricanes even hit, agriculture and forestry producers came together as the NC ADAPT Work Group recognizing the need to proactively address these challenges and the need to identify priority actions and initiatives to help producers adapt and improve resilience in the face of present and future climate change risks. North Carolina agriculture and forestry is worth protecting and through pragmatic actions, the two sectors will remain the economic backbone of the state's economy.

## **DEVELOPMENT OF ADAPTATION RECOMMENDATIONS**

Adaptation represents a powerful tool in addressing many of the uncertainties facing producers, value chain partners and supporting entities. Adaptation strategies come in many different forms ranging from minor adjustments designed to protect the existing production system to major changes in production and marketing practices. These strategies tend to fall into one of three different groups: 1) actions that protect the existing production system from a specific risk, such as drought, through minor adjustments such as the purchase of insurance or the addition of irrigation; 2) actions that protect the existing production system from a broad range of risks, such as drought, increased pest pressures and nutrient losses, through major adjustments such as crop diversification; and, 3) actions that protect the farm or forestry business as a whole from a broad range of risks through major changes to the existing system such as the a shift from annual to perennial crops or the integration of livestock into annual cropping systems.<sup>10</sup> Resilient systems typically exhibit some characteristics of all three kinds of adaptation strategies.<sup>11</sup>

Effective adaptation strategies will also support four integrated objectives over the long term:

**Profitability** – Adaptation measures must maintain or improve the producer's bottom line.

**Productivity** – Adaptations measures must improve production efficiency and enhance a producer's ability to meet changing demands for food, feed, fiber and fuel.

**Stewardship** – Adaptation measures must restore and maintain the natural resources upon which the resilience of agriculture depends, particularly soil, water, and air quality, and biodiversity.

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<sup>9</sup> SERCH, 2016: [Southeast Climate at a Glance – 2015 Annual Summary](#). Baca, A.

<sup>10</sup> Walthall et. al. Adapting Agriculture to Climate Change, Ch. 7 in, *Climate Change and Agriculture in the United States: Effects and Adaptation*. USDA Bulletin 2935.

<sup>11</sup> National Research Council. Understanding Agricultural Sustainability, Ch. 1, in *Toward Sustainable Agricultural Systems in the 21<sup>st</sup> Century*. 2010. The National Academies Press, Washington, DC.

**Self-determination** – The power to take adaptive action must be in the hands of the land owner and land manager, because they are in the best position to select locally-appropriate adaptation options.

The NC ADAPT Work Group created four (4) stakeholder Teams – Commodity Crops; Livestock; Forestry; and Specialty Crops. Each Team established their own process to identify adaptation needs, priorities and strategies. To help build a record of recommendations, the Forestry Team utilized information and feedback collected from the August 2015 Adaptation Summit Forestry Team Breakout Session and the November 2015 Forestry Team stakeholders meeting and employed other appropriate outreach measures.

Each team explored how research, best management practices, risk management and insurance, decision-making tools, and communications, outreach and education programs could support the long-term viability of the forestry sector in North Carolina, as well as address any short-term immediate issues or needs.

## **PROTECTING NORTH CAROLINA’S FORESTRY RESOURCES**

North Carolina’s timberland is diverse and includes more than 60 commercially-important tree species across 18.6 million acres of forest land. 85% of these forests are privately owned and roughly 64% of these forests are owned by private, non-industrial landowners.<sup>12</sup> Hardwoods are the dominant forest type, occurring on 68% of the state’s timberland acres, compared with 32% in softwood forest types.<sup>13</sup> Forestry and forest products activities have employed nearly 145,000 people and paid \$7.36 billion in labor income in 2013. In total, forest-based industries contributed \$29.4 billion to the economy, including \$10.9 billion in value-added.<sup>14</sup> Furthermore, emerging bioenergy markets, such as wood pellet production for renewable energy generation, are creating new opportunities for woody biomass. Demand for bioenergy resources is expected to increase over the next few years and could develop into a multibillion dollar industry for the state.<sup>15</sup>

Forestland owners in the state know about the impacts of extreme weather events. Ice storms and hurricanes can and have damaged large swaths of timber. A very damaging winter storm affected eastern North and South Carolina in February 2014. This event produced devastating amounts of freezing rain with ice accumulations measured as high as 1.5 inches in areas. Monetary damage to forests in South Carolina alone was estimated at \$360 million. In September 1996 Hurricane Fran, a large category-3 hurricane struck central North Carolina damaging about 8.3 million acres of forest lands statewide with total damages estimated to be \$1.69 billion (2007 dollars).<sup>16</sup>

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<sup>12</sup> North Carolina Forestry Association, <https://www.ncforestry.org/>.

<sup>13</sup> North Carolina Cooperative Extension Service, “Forests and the North Carolina Economy”

<sup>14</sup> North Carolina Cooperative Extension Service, “North Carolina’s Forests and Forest Products Industry by the Numbers, 2013”

<sup>15</sup> North Carolina Forest Service, “2015 Biennial Report,” [http://ncforestservice.gov/NCFS\\_statusreport.pdf](http://ncforestservice.gov/NCFS_statusreport.pdf).

<sup>16</sup> The Center for Integrative Environmental Research, University of Maryland, “Economic Impacts of Climate Change on North Carolina,” <http://cier.umd.edu/climateadaptation/North%20Carolina%20Economic%20Impacts%20of%20Climate%20Change%20Full%20Report.pdf>

In addition, drought conditions experienced in North Carolina likely contribute to increased southern pine beetle activity. From 1991 through 2002, beetle infestations killed at least \$84 million worth of timber in North Carolina.<sup>17</sup> Other invasive insects and tree diseases can cause economic harm to forestland managers. Dead or dying trees when combined with drought conditions can lead to increased chances for wildfires. Wildfires impact both public and private lands. For example, in 2008 and 2011, there were several large fires ([Pains Bay Fire](#), [Evans Road Fire](#), [Juniper Road Fire](#)) in the coastal plain that took weeks, or even months, to suppress collectively burning more than 125,000 acres, and costing tens of millions of dollars to battle.<sup>18</sup> Thus far in 2017, wildfires have burned more than 100,000 acres.

The NC ADAPT Work Group has engaged the full range of forestry value chain partners and stakeholders – from tree geneticists to wood product manufacturers – over the past year. The goal was to increase awareness of climate variability, while identifying specific risk types and associated adaptation actions needed to develop, demonstrate, refine and put resource strategies into practice. **The Forestry Team identified the following areas for key action items:**

### **Region-Specific Decision Support Tools**

As increasing climate variability creates new challenges for forest managers, it is imperative that climate change information and data be incorporated into existing tools, or new tools be created that evaluate stressors for a particular region – Coastal, Piedmont, and Mountain. Each region has its own unique set of climate issues and concerns:

- Which tree and plant communities are most at risk from the predicted climate trends?
- Which tree and plant communities are better adapted to the predicted climate trends?
- What ecosystems (riparian forests, low land forests, bogs, high elevation forests) are at greatest risk?
- What impacts will predicted climate trends have on mammals, birds, fish, insects, invertebrates, and reptiles that depend on these ecosystems?
- What impact will climate change have on the demand for wood products?

**Models are needed to predict the impacts these new factors will have on the different regions. In addition, models should account for forest ownership profiles and objectives (non-industrial private forestland owner; industrial forestland owner; state and federal forestlands.)**

### **Risk and Threats to Forestry Production**

Forest land managers need information on practices and tools to help them in adapting to climate variability and change. In some cases, more research is needed to verify outcomes, and in other cases a communications pipeline is needed to inform foresters of adaptation practices. The primary concerns/risks forest land managers will likely have to contend with based on predicted climate trends and conditions include:

- Larger and more frequent storm events and flooding;

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<sup>17</sup> North Carolina Forest Service, [http://www.ncforestservice.gov/forest\\_health/current\\_concerns.htm](http://www.ncforestservice.gov/forest_health/current_concerns.htm)

<sup>18</sup> Gellerstedt P, NC Forest Service, [The Impact of Wildfires in North Carolina](#), April 29, 2014

- Longer drought periods and higher temperatures (more warm days in the winter and fewer very cold days in the winter);
- More frequent and severe wildfires;
- More frequent and severe disturbances and temperature conditions that will make our forests more susceptible to invasive species, pests and pathogens.

## **Risk/Threat: Larger and More Frequent Storm Events and Flooding**

Key land management and production practices where greater research or action is required to adapt to larger and more frequent storms and flooding include:

- *Invest in genetic improvements to tree seedlings (stronger/straighter) to reduce wind and ice damage.*
- *Investigate and communicate which species are most vulnerable to wind throw and flooding and which species are best adapted to resist wind throw and flooding damage.*
- *Determine the most advantageous initial spacing of trees (wider or narrower).*
- *Evaluate if thinning/harvest rotation times should be shortened or lengthened to account for more frequent storms. Would shortened rotations reduce risk, increase profitability and accelerate new tree planting? Or should longer rotations be considered to capture higher-value markets?*
- *Ascertain if “Thin, Thin, Harvest, Restore, Repeat” is a viable model going forward.*
- *Determine the influence of soil moisture on local climates.*
- *Evaluate the effects of higher temperatures on seasonal weather patterns.*
- *Investigate how changing soil moisture and temperature regimes impact plant nutrient recycling.*
- *Evaluate and promote the use of forested windbreaks or buffers near open areas to reduce wind erosion.*
- *Lower intensity of thinning or windward side of stand, and retain tree buffers at the edge of a clearcut to help protect trees that have not been previously exposed to strong winds.*
- *Review the North Carolina Forest Service (NCFS) Forestry Best Management Practices (BMP) Guidelines regarding erosion and sedimentation reduction.*

### **Infrastructure**

***North Carolina Department of Transportation (NCDOT) and others responsible for road engineering and design should reevaluate road construction and culvert designs. Re-size culverts and drainage ways to accommodate larger flows.*** Formulas used to inform road and culvert designs must adjust to changing rainfall and other climate patterns.

### **Post-Event Assessments and Response Actions**

Damage Assessment Tools and Recovery Plans were identified as critical needs for the sector.

Damage Assessment – ***A designated forestry response/assessment team should be created, similar to how the Federal Emergency Management Agency (FEMA) responds to general post-storm events.***

Response units should be placed in strategic locations prior to a potential major event. While

downed/damaged timber does not have to be removed immediately, damage assessments should be performed quickly and should have a way of being shared with all landowner types.

Recovery Plan – Forestlands typically take too long to clean up and recover after a major event. ***The state of North Carolina needs to have a forest recovery policy in place and database for forestry recovery assistance.*** Policies can include temporary exemptions for load weight limits and mechanisms to encourage the market to utilize downed and damaged timber for alternative uses. Recovery plans should include information on what tree specie(s) should be planted considering changes in general climate conditions and future risks. Forest diversity and density should be part of recovery plans. In addition, storm recovery BMPs may need to be developed and included in Recovery Plans that account for the challenges posed by accelerated harvest recovery efforts.

## **Risk/Threat: Longer Drought Periods/Higher Temperatures**

Forestlands need to be managed, just as croplands and pasturelands are, but recognizing the unique conditions of forest growth. ***Forestland owners need information regarding utilization of best management practices (BMPs) during times of drought and/or higher temperatures.*** Key land management and production practices where greater research or action is required to adapt to longer drought periods and/or higher temperatures include:

- ***Develop and promote seedling species that are heat-resistant and more resilient to drought.***
- ***Determine which tree species may decline in population or benefit from migration as suitable habitat decreases in response to climate changes.***
- ***Diversify tree species in forestland mix.***
- ***Practice shorter or longer harvest rotation.***
- ***Access to a strong and responsive planting force.***
- ***Investigate the impact of drought conditions on microorganisms and their role in soil carbon and nutrient stabilizations, and further explore what management practices are needed to sustain microbial activity.***
- ***Investigate the impact of higher temperatures (especially nighttime temperatures) on pollinations and seed production.***
- ***Investigate the need for updated growth and yield models to reflect potentially longer growing seasons.***

## **Water Management**

Droughts can have a lasting impact on forest health and water quality. Key water retention actions and management practices to reduce the impacts of drought include:

- ***The North Carolina Water Supply Plan should be updated to reflect water resource management practices, and to assure that North Carolina has sustainable water sources to meet future needs.***
- ***As the state's population grows and weather patterns become more unpredictable, state agencies should assess whether more reservoirs need to be built across the state to satisfy future water needs.***
- ***Protect open space around reservoirs.***

- *Determine role of riparian forest buffers and develop practices that improve their adaptation to drought and higher temperatures to maintain and restore hydrology.*
- *Determine vulnerability and impacts to lowland forests.*

### Decision Support Tools

Landowners need access to improved forecast models. ***Plant hardiness zones need to be revised to reflect and predict how new tree species will perform.***

### ***Adaptation in Action: Tree Genes Initiative***

#### **Tree Genes Initiative - Accelerating Stress-Adapted Trees**

*A project co-sponsored by the U.S. Forest Service and the Institute of Forest Biosciences*

The health of North American forests is under threat. Changing climate and increases in pest and disease pressures will economically and ecologically affect important trees, forests, and plantations. Although tree species can naturally migrate, they do so slowly, averaging less than one-half of one kilometer per year. Some climate models predict that trees would need to migrate at 10 times this rate to keep up with suitable habitats. Moreover, warmer winters can permit pests, both native and invasive, to expand rapidly and affect areas more quickly and extensively, while more extreme weather patterns and episodic forest events are likely to increase the intensity of wildfires. Stress-adapted trees can improve the health of all forest types, including commercial plantations and non-commercial natural forestlands. Developing next-generation trees that can withstand climatic and pest threats needs an integrated approach.

The Tree Genes Initiative (TGI) identifies knowledge gaps and roadblocks to the transfer of stress-adapted trees to forestland owners and managers and makes recommendations to help fill and overcome them. TGI is a consortium of over 50 experts from the US and Canada who represent a broad spectrum of interests and have worked with the US Forest Service, the Institute of Forest Biosciences (IFB), and the TGI Steering Committee to develop the report below.

*Forest Tree Adaptation: 8 Gaps and Initial Recommendations* reviews current efforts related to the deployment of stress-adapted trees. While this report recommends changes within the chain of events (value chain) from research to growth and use of stress-adapted trees, it is not meant to be prescriptive. Rather, this report should be used by agencies, organizations, and policy makers to help identify and rectify gaps in their operations. In this report, the TGI consortium identifies and highlights gaps in three fundamental categories: innovation, policies, and markets. More information regarding the TGI and updates to this report are available online at [treegenes.org](http://treegenes.org).

### **Risk/Threat: More Frequent and Severe Wildfires**

Drought and warmer temperatures greatly increase fire risks. The year 2012 demonstrated how devastating this threat can be, with a record number of acres burned in so-called ‘mega-fires’ throughout the Western U.S. However, there are key actions and steps that land managers and state agencies can take to make forests more resilient to wildfire:

- *Educate land managers and the general public on why prescribed fires, managed burns and fuel reduction strategies are important.*
- *Require counties to review, update and revise wildfire prevention/control plans. Support state and local collaboration to appropriate or better access funding needed to implement wildfire plans and prescribed burn activities.*
- *Improve and update tools that help landowners decide the best times to conduct controlled burns. Develop/update Smoke Management Guidelines to improve communications, safety and comfort.*
- *Promote practices that alter forest structure or composition (to fire adapted species such as longleaf pine or oak) to reduce risk or severity of wildfire.*
- *Promote and encourage woody biomass thinning practices where burning is not feasible and develop markets for thinned biomass materials.*
- *Promote and restore fire adaptive ecosystems where best situated.*
- *Work with the insurance industry to promote prescribed burn contractors to treat and protect areas in the suburban/wildland interface.*
- *Work with homeowner associations to construct and pay for more fire lanes/breaks along new development boundaries.*

## **Risk/Threat: Increased Susceptibility to Invasive Species, Pests and Pathogens**

The same weather and climate conditions that increase wildfire risks can also help enable pathogens, pests and invasive species to thrive. Evidence suggests that future climate conditions will further increase the likelihood of invasion into forests and rangelands by nonnative species that do not normally occur there, and that the consequences of those invasions may be magnified. However, many nonnative and invasive species presently occupy only a portion of their potentially available habitats; thus they have the potential to spread widely.<sup>19</sup> To reduce the threats and impacts of invasive species, pests and pathogens on forestlands, the following key actions are recommended:

- *Develop a robust invasive species eradication plan while recognizing it could be too late for some invasive species (kudzu). Secure funding to support the plan. Keep insect, plant, and disease threats in separate categories to avoid confusion.*
- *Educate state agencies (NCDOT, etc.) and forestry stakeholders (loggers, etc.) on the impacts of invasive species, their potential role in the spread of invasive species, and practices that can minimize the movement and spread of invasive species.*
- *Extend thinning cycles and harvest rotations to preserve canopy cover and reduce disturbed sites that can allow invasive plants to take root.*
- *Promote and support the actions of a “hotshot” crew to handle invasive species outbreaks.*
- *Research the costs and benefits of utilizing genetic modification in tree species to protect against invasive species that cannot be controlled (Emerald Ash Borer).*
- *Expand communications pathways that educate forestland owners, the general public and regulatory/research agencies on responsibilities to prevent and control invasive species*

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<sup>19</sup> Kerns, B., Guo, Q. (September 2012). Climate Change and Invasive Plants in Forests and Rangelands. U.S. Department of Agriculture, Forest Service, Climate Change Resource Center. [www.fs.usda.gov/ccrc/topics/invasive-plants/](http://www.fs.usda.gov/ccrc/topics/invasive-plants/)

*introductions, early detection actions, and how climate variability impacts monitoring and planning strategies.*

- *Practice longer harvest rotations and limit road systems to minimize land disturbances that promote invasive species.*
- *Practice biodiversity and promote more mixed stands.*
- *Reduce activities that increases stress on forests.*
- *Promote pest and pathogen resistance in tree improvement programs.*
- *Investigate which pathogens and pests are likely to increase in occurrence should predicted climate changes occur.*

## Other Recommendations

Communications: ***Enhance initiatives and expand outreach/venues to inform and educate landowners and others on how to use climate change planning tools.*** Example of such tools include, the *Pine Integrated Network: Education, Mitigation, and Adaptation project* (PINEMAP) that “enable[s] southern pine landowners to manage forests to increase carbon sequestration; increase efficiency of nitrogen and other fertilizer inputs; and adapt forest management approaches to increase forest resilience and sustainability under variable climates.”<sup>20</sup> Another tool is the *Template for Assessing Climate Change Impacts and Management Options* (TACCIMO), a web-based information delivery tool that connects climate change science with forest management and planning needs so that users can identify potential effects of climate change on key resource areas and provide corresponding management options to abate or adapt to future changes.<sup>21</sup> These tools help users identify potential effects of climate change on key resource areas, and provide corresponding management options to abate or adapt to future changes.

***Develop a central repository of state and federal programs that land owners can access to find funding for forestland adaptation and BMP measures that reduce the impacts of intense wind and precipitation, flood, drought, wildfire and invasive species.***

***Improve forestry knowledge of United States Department of Agriculture (USDA) staff outside the US Forest Service.*** Many programs that are provided by Natural Resources Conservation Service (NRCS), Farm Service Agency (FSA), Risk Management Agency (RMA), and Rural Development (RD) can impact forest practices or forest health.

The NC ADAPT forestry value chain partners and stakeholders understand that ***a solid communication plan and outreach initiative is key to advancing the recommendations outlined above and helping forestland owners understand that business as usual is not sufficient, and that land managers must adapt and manage differently than they have in the past.*** Keeping forests as forests provides not only economic benefits but also environmental and wildlife benefits.

State officials, members of the public and forestry stakeholders may question the costs and benefits of Adaptation Planning, but NC ADAPT leaders agree the health, sustainability, and *resiliency* of North

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<sup>20</sup> Pine Integrated Network: Education, Mitigation, and Adaptation project (PINEMAP). Welcome to PINEMAP. <http://pinemap.org/>.

<sup>21</sup> Template for Assessing Climate Change Impacts and Management Options (TACCIMO). Welcome to TACCIMO. [http://www.taccimo.sgccp.ncsu.edu/tbl\\_sector\\_list.php](http://www.taccimo.sgccp.ncsu.edu/tbl_sector_list.php).



Carolina forests makes economic and ecological sense. Adaptive management will be built upon the foundation of good forest management that we all know.

In many cases, adaptation measures can be easily demonstrated. The importance of forester-to-forester communications cannot be understated. These demonstrations and peer-to-peer interactions will help drive adoption of adaptive management practices.

## PATH FORWARD

Though the recommendations included in this document are the result of a year of work with stakeholders from the forestry value chain, they mark the beginning of new conversations. Changing weather patterns affect North Carolina's forestry sector in complex ways. Geography, specific tree species, landowner expertise, land management resources and fiber markets are just a few of the variables that frame opportunities and threats to our state's forests.

North Carolina's forest land managers are learning to deal with more variable weather and extremes through traditional and non-traditional means. Thoughtful planning, forestry production experience, and comprehensive knowledge of working lands are merged with new technology in the form of GPS, Lidar and information-based decision tools to maximize results under certain circumstances.

North Carolina's producers need new and continuing support to ensure that all sectors of agriculture and forestry remains a vibrant, growing sector of the North Carolina economy. The state's leadership can improve the competitiveness of North Carolina's producers by making investments in research and continuing to support the state's existing economic development, as well as review its regulatory framework for agriculture and forestry. New programs to help farmers deal with changing markets, stressed infrastructure, lack of labor, food safety regulations and extreme weather will yield solid returns from a diverse, dynamic group of agricultural entrepreneurs.

Changes ahead are unprecedented and North Carolina's agriculture and forestry producers can remain productive and provide many community benefits besides food – energy, wildlife habitat, water filtration, carbon sequestration, recreation, etc. – but they can't do it alone. They need focused support from public and private partners to innovate and adapt to the changes ahead in a way that strengthens production systems, improves profits, and reduces environmental impacts.

A communications and outreach program that includes a peer-to-peer information network should be formed to support grower leader dialogues around strategies to advance adaptive management. It is important that forestry thought leaders be committed to serve as discussion facilitators and adaptation mentors and integrate climate-smart forestry concepts that improve resilience and mitigate future risks from changing climatic conditions.

## Appendix I

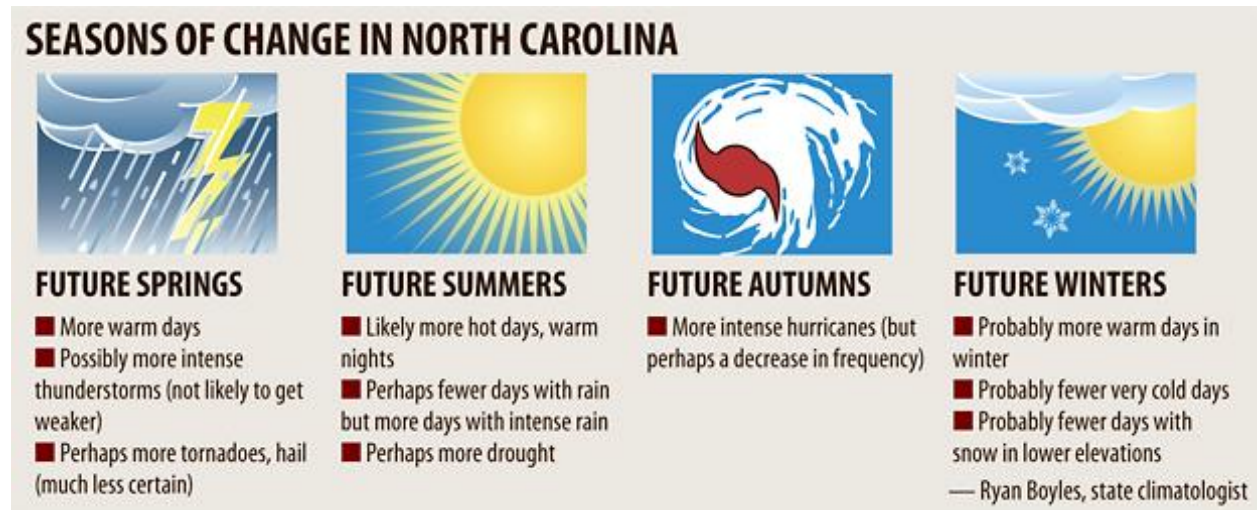
### Extreme and Variable Weather:

## A Threat to North Carolina Agriculture and Forestry

Media reports, public discourse and political biases often portray climate change as something that will happen well into the future or not at all. As farmers, ranchers and foresters who make their living off the land we are already witnessing the effects of changing climatic conditions and recognize that more attention to adaptive management planning is required.

As documented in the [Third National Climate Assessment](#), climate will continue to change over this century and beyond and is projected to have more pronounced impacts on crops and livestock across the country – a trend that threatens farm family well-being nationwide and could diminish the security of our food and fiber supplies.<sup>1</sup>

Here in North Carolina, state climatologists are projecting that changing climatic conditions will result in longer and warmer growing seasons, with more periods of drought punctuated with fewer, more intense rainfalls. Precipitation events will be harder to predict, but most likely will include more frequent flash storms that will cause and accelerate soil erosion, exacerbate nutrient leaching and degrade soil health.



As for seasonal variations that we should anticipate, future winters in the state will likely be defined by more warm days, fewer very cold days and fewer days with snow at lower elevations. Impacts to agriculture could include less pest die off and slower chill accumulation. However, more warm days could mean better pasture performance and increased soil microbe activity.<sup>2</sup>

Future spring seasons will likely include more warm days in February and March, possibly more intense thunderstorms and perhaps more tornadoes and hail. Of particular concern to us is that fruit and vegetable producers could be impacted by an earlier emergence of pests and earlier plant and tree flowering. Warmer days does not necessarily mean an earlier last freeze, thus increased risk of freeze

damage to budding plants is expected. More severe weather could increase the need for crop insurance.<sup>3</sup>

Summers in North Carolina will likely bring more hot days and warmer nights potentially disrupting pollination. Increased instances of drought could be possible and increase fire hazards. Fewer days with rain, but more instances of intense rain when it does rain, could become more common. More intense rains could impact field preparation and result in erosion and nutrient loss. The increased heat and drought could cause plant and animal stress and increase the need for irrigation at critical times in a crop's growing period. But drier periods could reduce fungal risks in crops.<sup>4</sup>

Upcoming autumns could bring more intense hurricanes and later first frosts. North Carolinians are already very much aware of the catastrophic impacts that a hurricane making landfall can deliver. But longer growing seasons could possibly allow for double cropping,<sup>5</sup> longer pasture grazing and more successions for a vegetable producer.

Crop production is influenced by complex relationships with temperature, moisture, nutrient concentrations, weeds, pests, and disease. As temperatures increase, crop production areas may shift to follow optimal growth conditions, though production in any given location will be more influenced by water availability during the growing season.<sup>6</sup> These weather-related impacts on crop growth are likely to increase production costs.

A changing climate can also influence and degrade livestock performance, production and fertility, limiting the production of meat, milk, or eggs. Changes in core body temperatures, feed and forage types and nutrient content will likely influence management needs.<sup>7</sup> Livestock manure management systems can be compromised if weather events exceed design specifications and best management practices cannot be implemented.

The changing climate can also alter tree species ranges and has the potential to alter forest ecosystems structure as evidenced by the mountain pine beetle epidemic in the West. When combined with sustained drought conditions, these impacts pose challenges to maintaining healthy forests and the supply of goods and services upon which society depends, such as clean drinking water, forest products, outdoor recreation opportunities, and wildlife habitat.

<sup>1</sup> [Third National Climate Assessment - Agriculture](#), page 152.

<sup>2,3,4,5</sup> Ryan Boyles, "Climate and Agriculture in the Carolinas", 25x25 NC Ag and Forest Adaptation Workgroup Presentation, December 2, 2014.

<sup>6,7</sup> [Third National Climate Assessment - Agriculture](#).

## APPENDIX II

# Preparedness Planning in North Carolina

Efforts have been underway for a number of years to consider the potential impacts of climate change on North Carolina. These reports summarize the research and provide recommendations to address this threat. A list of the reports developed to date can be found at [http://climateadaptationnc.nemac.org/NC\\_Climate\\_Reports.html](http://climateadaptationnc.nemac.org/NC_Climate_Reports.html).

The North Carolina Climate Action Plan Advisory Group [\*Recommended Mitigation Options for Controlling Greenhouse Gas Emissions\*](#) (2008) contained both mitigation and adaptation measures. Chapter 6 of the report details the challenges and opportunities of the agriculture and forestry sectors to reduce and mitigate GHG emissions.

The Legislative Commission on Global Climate Change (Commission) was established in Session Law 2005-442 to conduct an in-depth study of issues related to global climate change. In its [\*Final Report to the General Assembly and the Environmental Review Commission\*](#) (2010), the Commission concludes that the actions taken by states can have a significant effect on global greenhouse gas levels and that the General Assembly should not wait for national or international action before responding to these threats. The Commission recommended that North Carolina develop a comprehensive Climate Change Adaptation Plan that includes numerous elements, including a focus on “adaptation needs resulting from sea-level rise, as well as changes in rainfall and temperature that could alter traditional industries such as agricultural, forestry, and fishing.”

Session Law 2010-180 required state agencies to determine whether the impacts of global climate change are being considered in state regulatory and planning programs. Each agency considered the projected impacts of global climate variability and change, as well as recent extreme events, in this evaluation. This report, [\*Agency Planning and Regulatory Program Information Related to Climate Change\*](#) (2011), includes responses for 77 planning and regulatory programs within the eight specified departments, including the Department of Agriculture and Consumer Services.

The [\*Climate-Ready North Carolina: Building a Resilient Future\*](#) (2012) developed by the North Carolina Interagency Leadership Team discusses how North Carolina can proactively prepare for projected impacts of climate variability and weather extremes on its economy, infrastructure and natural resources. The report includes a section on the impacts, risks, and vulnerabilities to agriculture and forestry and includes numerous actions that could be implemented in response to potential changes in climate.

*“Agriculture has had and will continue to have the ability to adapt to new conditions. The ability to change with a changing climate will depend on a strong research base that can supply required information.” (Reilly et al., 2001).*

From the report:

Because of its dependence on the natural environment, agriculture and agribusiness must be capable of adapting to a variety of broadly changing conditions, including potential changes in climate. Responding to climate variability “is manifest in nearly every dimension of farm management. Included are technologies such as crop drying, irrigation, drainage and tiling, and storage; shading and cooling for livestock; selection and breeding of livestock and crops that are hardy or hardier under a wider range of climatic conditions.” (Reilly et al., 2001).

Even in the absence of global warming, there is strong reason for proactive planning given North Carolina’s known vulnerabilities to hurricanes, winter storms, flooding, and drought. Maintaining and enhancing the ability of farmers and private landowners to provide an adequate, wholesome supply of food, natural fiber and wood products given potential changes in climate, technology and market conditions must be a continuing priority. Private firms, as well as numerous federal, state, and local agencies, provide assistance to producers in response to the variety of risks faced by the agricultural sector.

### **Adaptive Response Options**

“Agriculture is considered one of the sectors most adaptable to changes in climate. However, increased heat, pests, water stress, diseases, and weather extremes will pose adaptation challenges for crop and livestock production.” (Legislative Commission on Global Climate Change 2010). In order to remain in business, farmers must make production decisions in response to market incentives, available technology and the capacity of the natural resource to sustain production.

There are numerous actions that could be implemented in response to potential changes in climate:

- Promote research and technological innovation for new crop types/varieties and improved pesticides/herbicides to adapt to changing growing conditions.
- Provide education/outreach to the farming community regarding Climate Ready North Carolina: Building a Resilient Future recommendations for adaptation of new crops, varieties, or technologies.
- Conduct research regarding breeds of livestock most suitable for current climatic conditions, as well as educate/advise the livestock sector of adaptive strategies for dealing with variation in climate.
- Encourage livestock producers to select breeds that are genetically adapted to prevalent climatic conditions.
- Provide adequate disaster response resources in response to natural disasters.
- Minimize risk of disaster through adequate education, planning, emergency response capacity and appropriate disaster insurance.
- Ensure availability of flood/crop insurance in order to maintain land in agricultural production instead of a more intensive land use that has the potential to be more susceptible to flooding events and will have higher damages when flooding events occur.
- Provide for maintenance of drainage infrastructure to minimize flood severity and duration.
- Encourage adoption of agricultural best management practices to conserve water, reduce erosion, and increase soil productivity.
- Provide technical and financial assistance to producers to encourage adoption of water storage/water use efficiency technologies.
- Increase available on-farm water storage capacity to minimize drought impacts.
- Improve the availability of irrigation infrastructure in order to relieve drought/heat stress.
- Adopt more efficient irrigation technology to minimize drought stress and maximize the benefits of available water.