



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

Priorities and Recommendations for Advancing Adaptive Management for Commodity Crop Producers

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.

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 Team¹ 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.
- Each sector also identify access to new markets as a risk management option for creating product demand and increasing revenues.

¹ 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

- 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 challenges² – 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. Commodity crop-specific recommendations for adaptive management measures and practices are found later in this report.

² 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.³ 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.⁴ 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.⁵

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.⁶

³ 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

⁴ 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>

⁵ 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>

⁶ 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.⁷ 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.⁸ 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.

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>

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

⁸ 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 2016.⁹ 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.¹⁰ Resilient systems typically exhibit some characteristics of all three kinds of adaptation strategies.¹¹

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.

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

¹⁰ 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.

¹¹ National Research Council. Understanding Agricultural Sustainability, Ch. 1, in *Toward Sustainable Agricultural Systems in the 21st 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 Commodity Crop Team utilized information and feedback collected from the August 2015 Adaptation Summit Commodity Crop Team Breakout Session and the Commodity Crop Producer Survey 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 commodity crop industry in North Carolina, as well as address any short-term immediate issues or needs.

PROTECTING NORTH CAROLINA'S CROP PRODUCTION

North Carolina is one of the most productive states for growing commodity crops. As the number one producer of tobacco in the country, and ranking number four in upland cotton, number six in peanuts and number eight in total commodity cash receipts, commodity crops production is a key part of North Carolina's agriculture economy generating nearly \$3.5 billion of value in 2015. To maintain growth in North Carolina's overall economy, commodity crop producers need to continue to change and adapt so they are better prepared for what the future holds. However, the future is increasingly more unpredictable, and that can make the work of any farmer more difficult. Farmers are beginning to see changes to the growing conditions that they depend on. Warmer winters, hotter summers, heavy rains, and other changes to the climatic conditions present a major financial risk to every farmer in the state. These same farmers are eager to develop new strategies and tools to remain economically viable amidst these changes, so that their children and children's children can maintain their family legacy.

In order to better understand the adaptation needs of commodity crop producers (corn, soy, small grains, cotton, etc.) the Commodity Crops Team utilized an informal web-based survey tool. The survey was distributed statewide with the help of commodity crop producer organizations, state extension specialists, and NC ADAPT project leaders. The survey asked farmers to describe any major changes in weather variability or extremes that they have observed over the time that they have been farming, how they have adapted to those changes, and what kinds of new knowledge and tools would best support their adaptation efforts. The information collected was used to inform the development of actions, initiatives and recommendations that are needed to help North Carolina commodity crop producers adapt to challenging weather conditions and improve resilience in the face of extreme weather events. The full Commodity Crops Producer Survey and responses can be found in Appendix III.

The Commodity Crops Producer Survey received 26 completed surveys, which were generally skewed towards relatively small-scale operations that sell to local grain dealers. About half of the respondents manage less than 500 acres of commodity crops. Although the response rate was too low to make any conclusions about commodity crop producers as a whole, some respondents reported making changes to adapt to increased variability in precipitation, and more frequent heavy rainfalls and dry periods. The

most common adaptations were to change the timing of field work, adjusting crop mix, adding cover crops to their crop rotation, and making adjustments to soil and fertility management. However, these changes in farming practices also created societal benefits through the implementation of new soil and/or water conservation practices. Respondents also reported that they would invest in infrastructure, drought resistant cultivars, modify nutrient management and diversify crops if changing weather patterns became more extreme in the future.

Crop production challenges that were identified included weeds, insects and disease management. For the most part, the Commodity Crops Producer Survey results were consistent with findings from national climate adaptation surveys. That is, producers have observed the greatest challenges as increased variability in weather with increased precipitation intensity and hot/dry periods.

Selected Commodity Crop Producer Survey Respondent Comments:

- “Drought harms me most of all. You can wait out wet. You can’t wait out drought.”
- “Increase fed/state monetary support to improve water storage and irrigation.”
- “Staying in contact with others in the agriculture community is very important for information and success. Hopefully the state and local governments will continue to provide arenas and avenues for this kind of connection.”

One notable survey finding was that respondents indicated that farm management “experience” and “knowledge” are the resources/tools most relied upon to reduce weather-related production risks. However, a majority of respondents indicated that they were **not** confident that they had the resources to manage through weather extremes. But respondents indicated they had significant interest in learning more about production and conservation practices that increase the productivity of the land while at the same time provide adaptive management benefits.

The Commodity Crops Team reviewed the results of the Commodity Crops Producer Survey and discussions from the August 2015 Adaptation Summit – Commodity Crops Breakout Session that focused on major issues such as market access, soil and water use and management, and social barriers. Also examined were risk management tools, research priorities, and conservation systems that would help build on-farm resiliency. **The Commodity Crops Team focused on the following issues as areas for action:**

New and Existing Markets

- While local climate variability may require adaptation measures to be implemented by North Carolina producers, farmers in North Carolina see an opportunity to market their crops to areas around the world. **To facilitate a strong export market, ports much be maintained, improved and protected.**
- The state’s livestock production sector creates strong demand from small and coarse grains. North Carolina is a grain deficient state because livestock consumes more than the state can produce. MB Grain Agronomics is supporting an expansion of grain sorghum production as a new cropping choice due to its drought resistance. A new wheat seed program is beginning as well. Markets for the adaptive management options are needed. **Alternatives to corn grains**

should have greater access to the livestock feed market as viable and cost-effective alternatives come to market.

Soil and Water Management

- Improving water management is envisioned as a method to minimize the impacts of extreme weather conditions. **Research is needed on water use and irrigation methods and rates.**
- Management strategies must recognize the diverse production regions of the state, and not pursue a one-size-fits-all management program for North Carolina. **Precision agriculture technology has a tremendous role to play in natural resource management and should be continuously calibrated to reflect local conditions.**
- **It has been observed that the national literature on cover crops is poor and outdated. More dialogue regarding cover crop economics and education is needed.** SmithfieldGro is working with row crop farmers on cover crop mix planning and helping to explain the purpose and benefits of cover crops. NC State University is also conducting research on the benefits of cover crops.
- There is growing societal pressures that could push farmers not to use genetically modified organism (GMO) seed and to produce non-GMO crops. There are examples of large farms around the country that have successfully incorporated non-GMO varieties and are able to adapt to climate and weather challenges. **Farmers must receive the proper technical support from Extension and seed companies if they wish to adapt to non-GMO varieties, while also avoiding adverse impacts to soil and water quality.**

Barriers to Technology Adoption

- It is clear that users of precision agriculture technologies rely upon the University/Extension system for information. **University/Extension must be supported with adequate funding resources to deliver precision agriculture information and utilization support.** Information-intensive technology options are abundant, yet farmers may remain unconvinced they will be cost-effective tools if additional management is required to make practical use of the technology. Also, awareness of how technologies can be leveraged may be lacking. It is clear that precision agriculture technologies have been more readily adopted by farms with larger acreage rather than small-acre farms. Larger farms are more willing to experiment with technology.
- **There must be a reasonable assurance that investments in new technologies will make a quick return.** The average age of the principle farm operator in North Carolina is 59 years old. If there is speculation that a farmer will be retired or out of farming before an investment is recovered, the adoption of new technology or practice may be delayed or avoided.

Research and Farmer Support

- There is difficulty in finding traits that adapt well to North Carolina conditions. **Identify heat and drought tolerant cultivars, such as sorghum, that are close in nutrition to corn. More research is needed to identify and focus on cultivars that fit well with North Carolina's regional climate, soils, water resources, etc.**

- The Plant Sciences Initiative at NC State University will consolidate much of the agriculture resources under one facility. Bond funding has been secured and construction will begin soon. ***Research at the Plant Sciences Initiative should drive farmer adaptability.***
- Variable rate nutrient applications are being studied by the public sector and private industry. ***While this technology has shown promise, the technology needs better positioning, sensing and calibration protocols, especially better calibration to North Carolina’s climatic/geographical conditions.***

Adaptation in Action: SmithfieldGro

A collaboration to improve productivity, profitability, and sustainability with North Carolina grain farmers.

Grain and animal agriculture are inextricably linked, though those ties are sometimes obscured by the black box of the commodity grain market. Smithfield Hog Production Division is rebuilding those connections by providing agronomic assistance to local grain farmers in North Carolina. The program, called Smithfield Agronomics or “SmithfieldGro,” assists grain farmers to adopt practices that optimize commercial fertilizer use and boost soil health such as variable rate fertilization and cover crops. These practices can also improve crop productivity and farm profits, while improving the resilience of farm production systems and reducing nutrient losses to water and air. What’s in it for Smithfield? Providing this service builds relationships with local grain growers, which should increase local grain purchases and reduce Smithfield’s cost of bringing in grain from the Midwest.

Smithfield developed SmithfieldGro along with the Environmental Defense Fund, and is now expanding on that collaboration through a new USDA Natural Resources Conservation Service (NRCS) initiative called the Regional Conservation Partnership Program (RCPP). The RCPP provides a dedicated pot of cost-share funds for farmers implementing practices such as nutrient management, conservation tillage, and cover crops. The RCPP project also brings new partners to the effort, including the NC Farm Bureau and several grower organizations. These new outreach partners and additional funds will allow more North Carolina grain farmers to implement sustainable farming practices.

Other Recommendations

Encourage collaboration across all stakeholders to promote and educate farmers on the myriad risk management tools that exist for incorporating adaptation measures and building resiliency. Tools are available at federal agencies, private sector organizations and universities.

PATH FORWARD

Though the recommendations included in this document are the result of a year of work with stakeholders from the commodity crops sector, they mark the beginning of new conversations. Changing weather patterns affect North Carolina’s commodity crop sector in complex ways. Geography,

specific crops produced, farmer expertise, farm resources and markets are just a few of the variables that frame opportunities and threats to our state's commodity crops farms.

North Carolina's commodity crop growers are learning to deal with more variable weather and extremes through traditional and non-traditional means. Thoughtful planning, food and fiber 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 commodity crop thought leaders be committed to serve as discussion facilitators and adaptation mentors and integrate climate-smart agriculture concepts that improve resilience and mitigate future risks from changing climatic conditions.

APPENDIX I

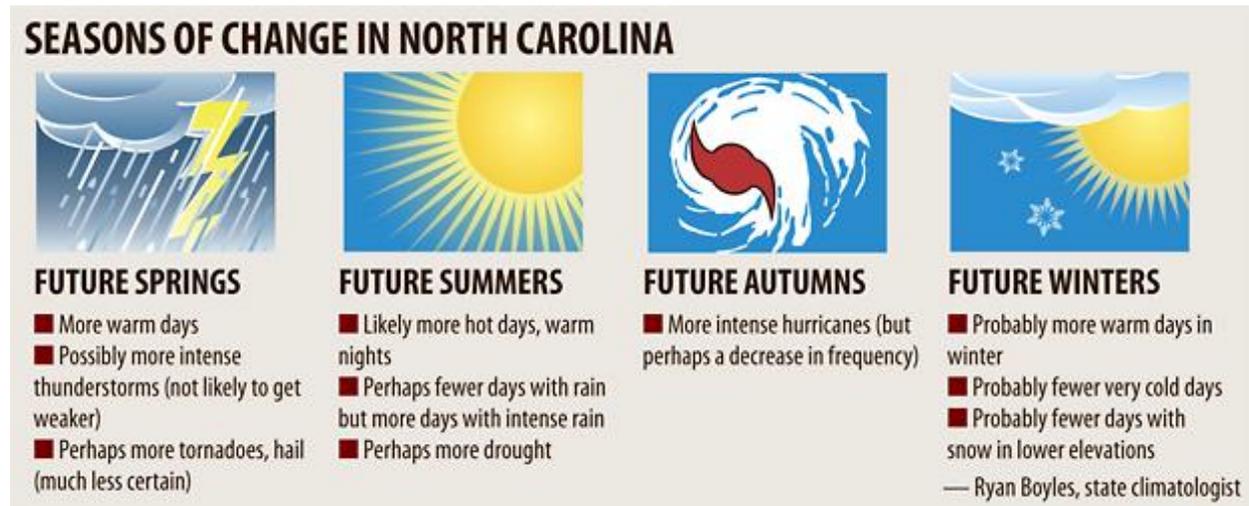
Extreme and Variable Weather:

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.¹

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.²

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.³

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.⁴

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,⁵ 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.⁶ 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.⁷ 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.

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

^{2,3,4,5} Ryan Boyles, "Climate and Agriculture in the Carolinas", 25x25 NC Ag and Forest Adaptation Workgroup Presentation, December 2, 2014.

^{6,7} [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.

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.

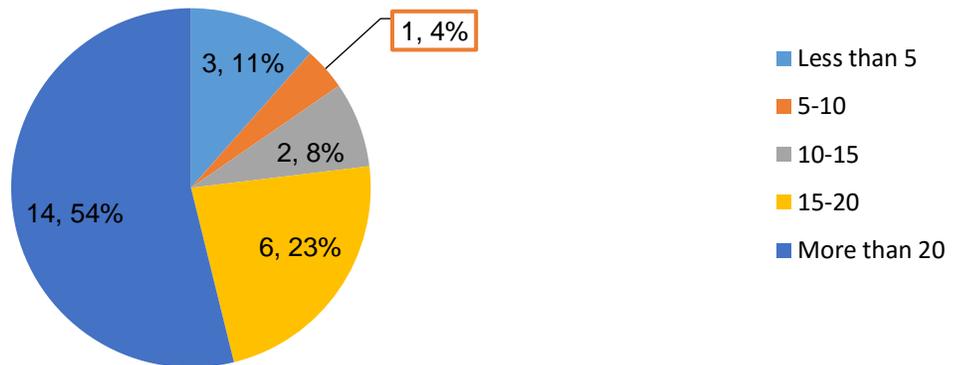
There are numerous actions that could be implemented in response to potential changes in climate:

- 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.

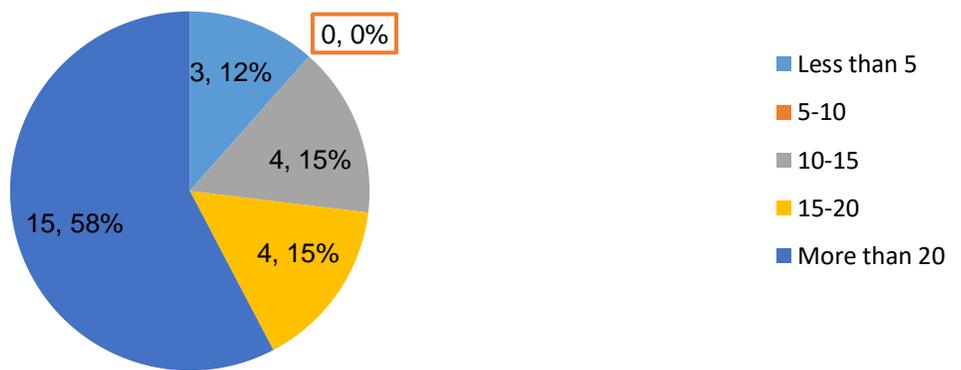
APPENDIX III

Commodity Crop Producer Survey and Survey Results

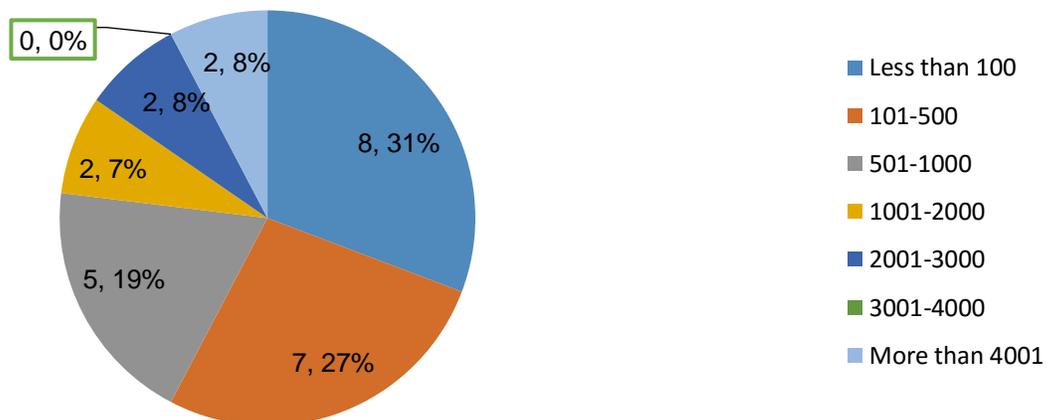
1. About how many years of experience do you have as a commodity crops farmer?



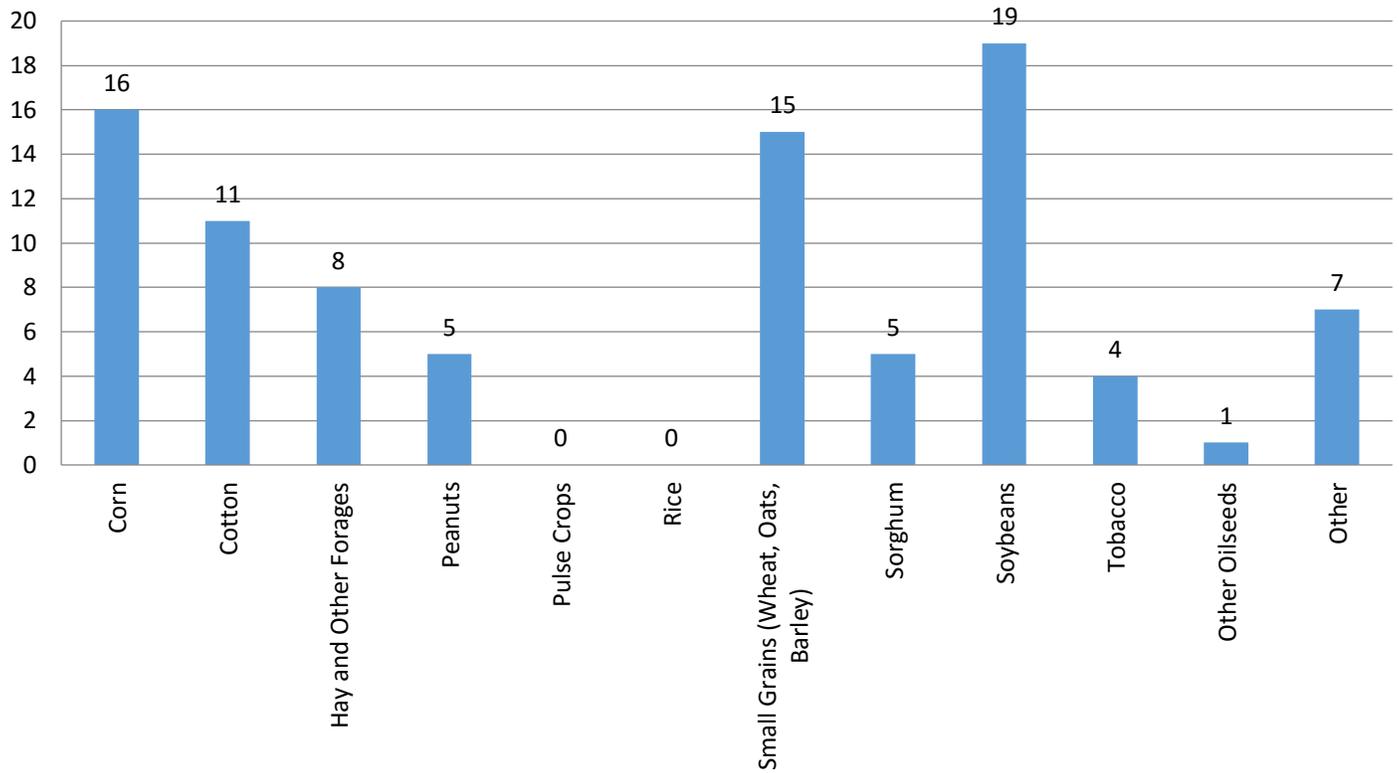
2. About how many years have you been farming at, or near, your current location?



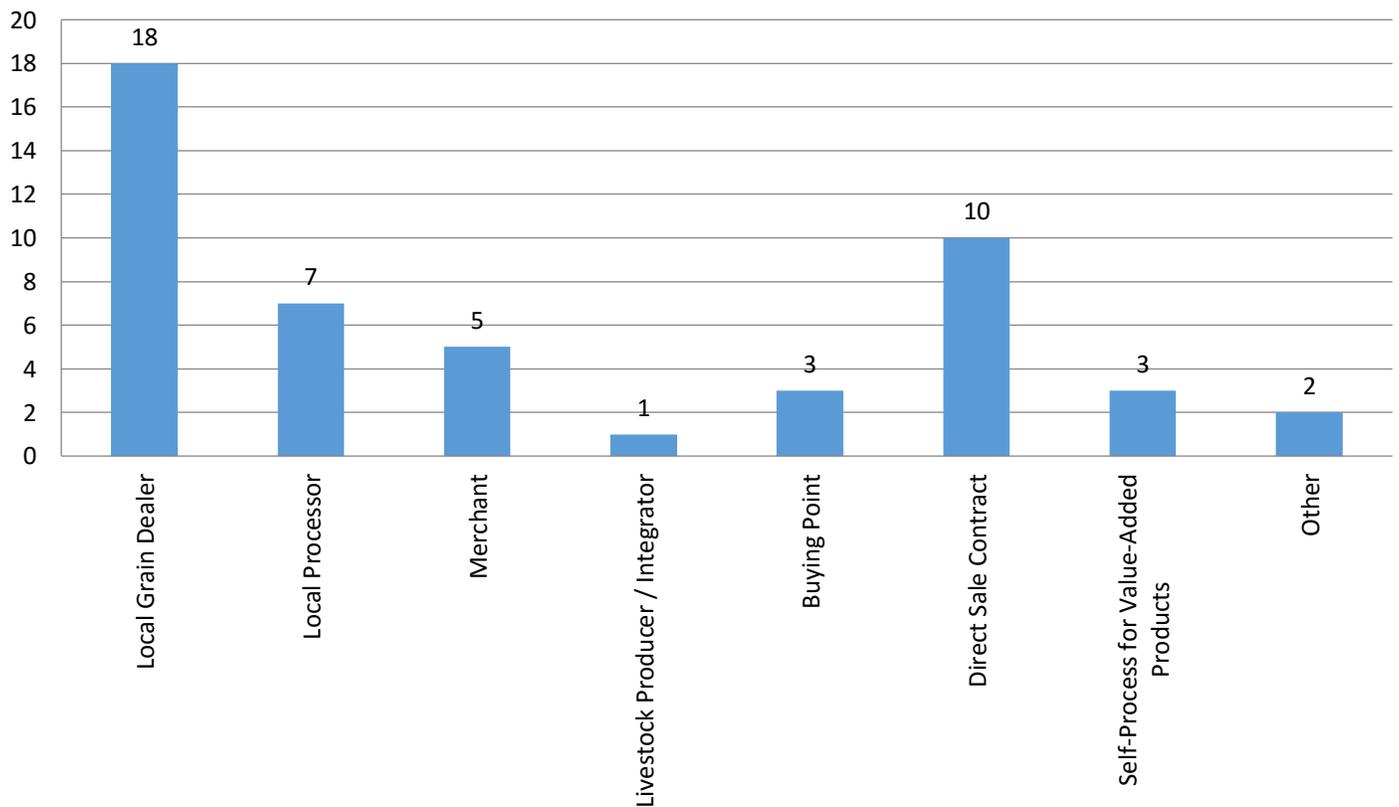
3. How many acres of commodity crops do you typically farm each year?



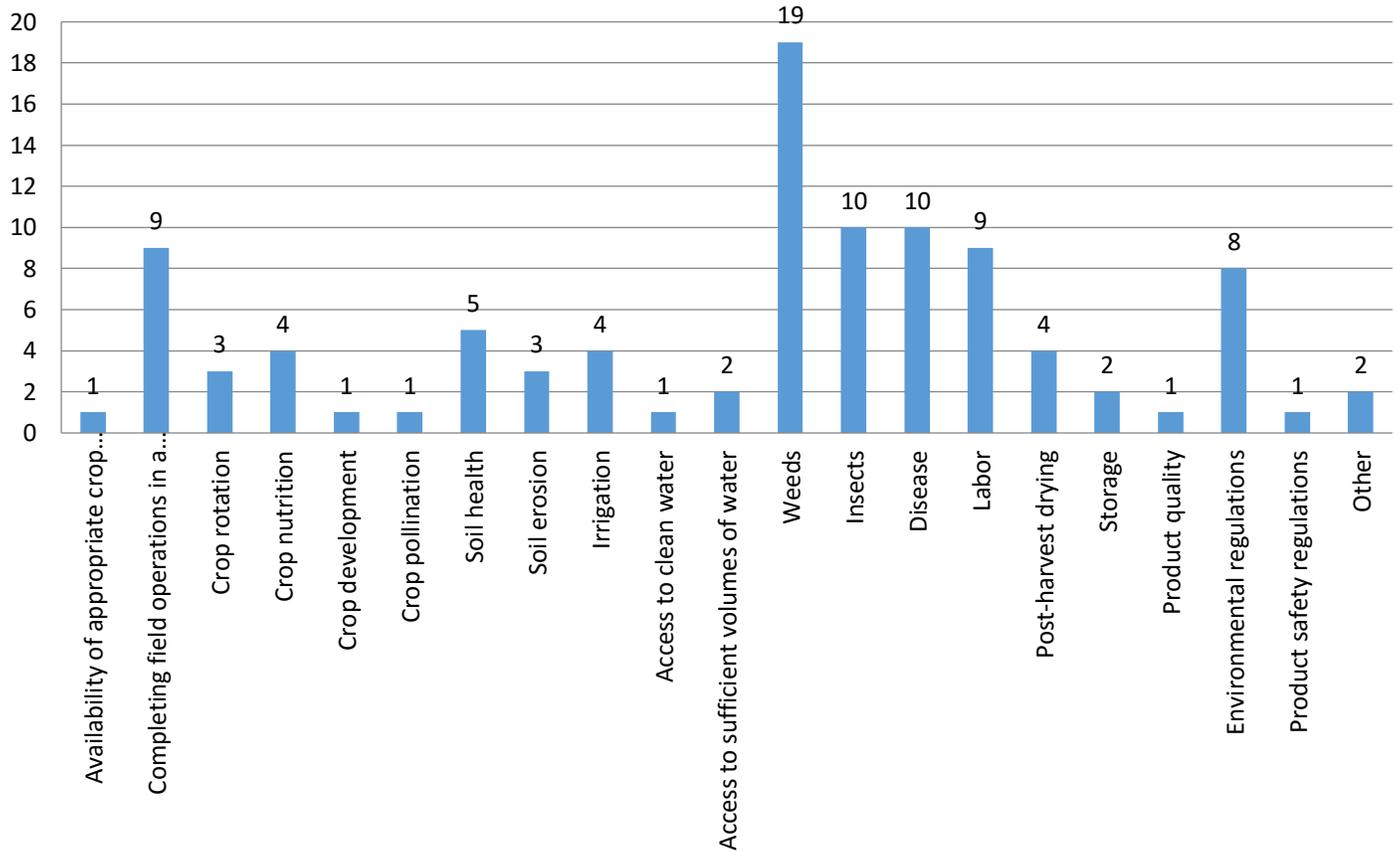
4. What are the principle commodity crops that you produce? Select all that apply. If you select other please detail in the space provided.



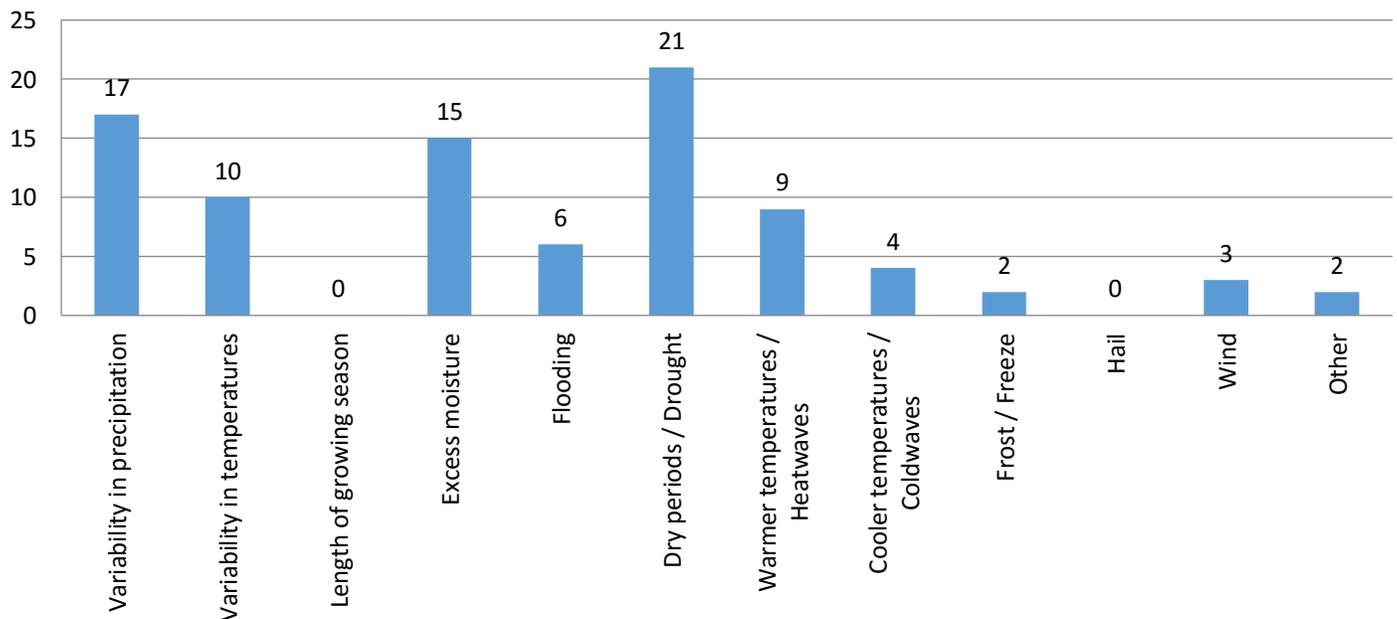
5. Where do you market your products? Select all that apply.



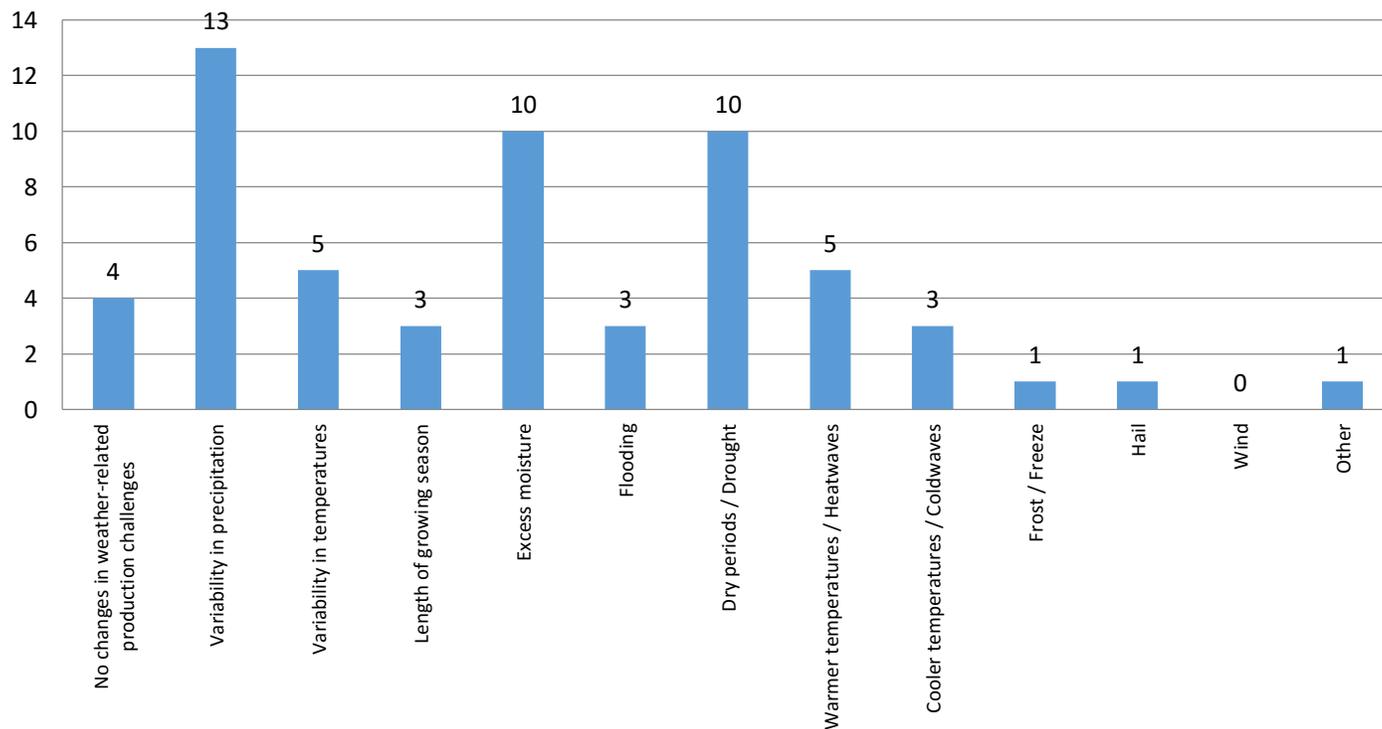
6. Think now about your experience farming over the years. What are some of the most difficult crop production challenges that you've experienced? Select up to 5 items representing the most difficult crop production challenges from the list below.



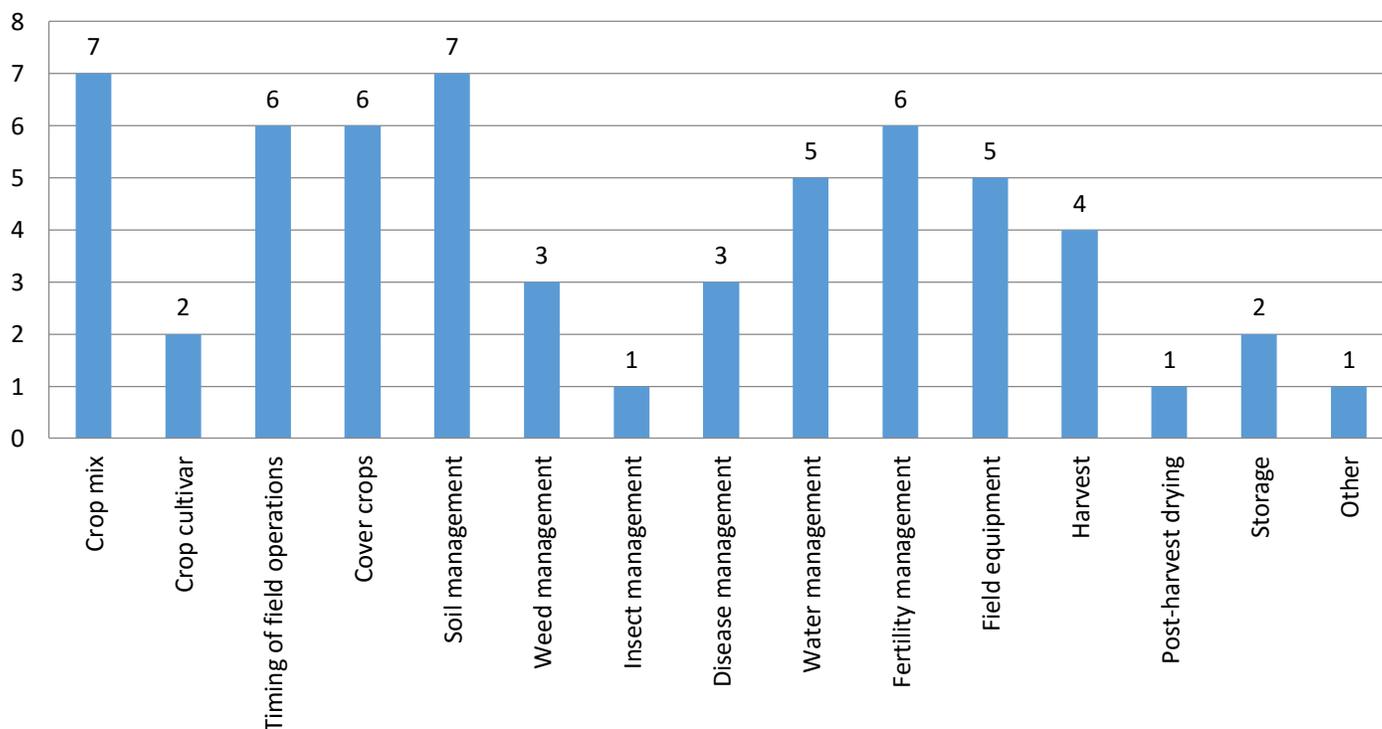
7. Think again about your experience farming over the years. What are some of the most difficult weather-related production challenges that you have experienced during that time? Select up to 5 items from the list below.



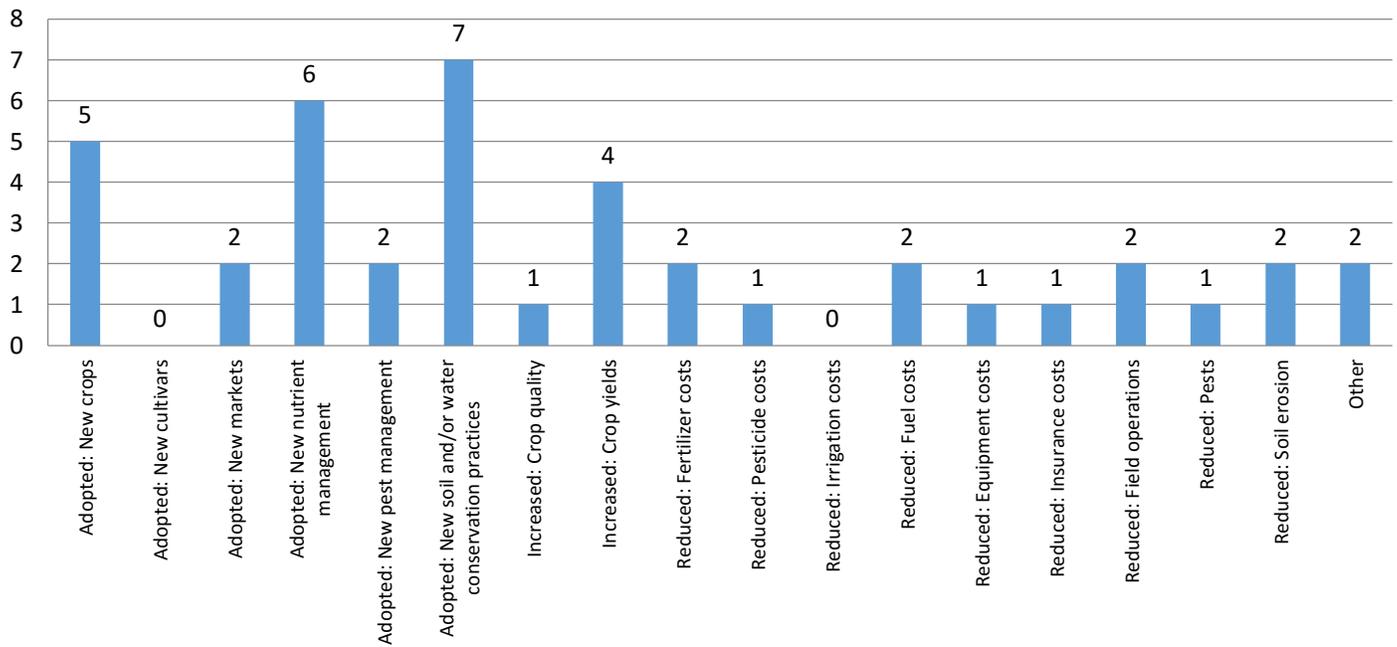
8. Think again about your experience farming over the years. Have you noticed any changes in weather-related production challenges? Select any items that apply from the list below.



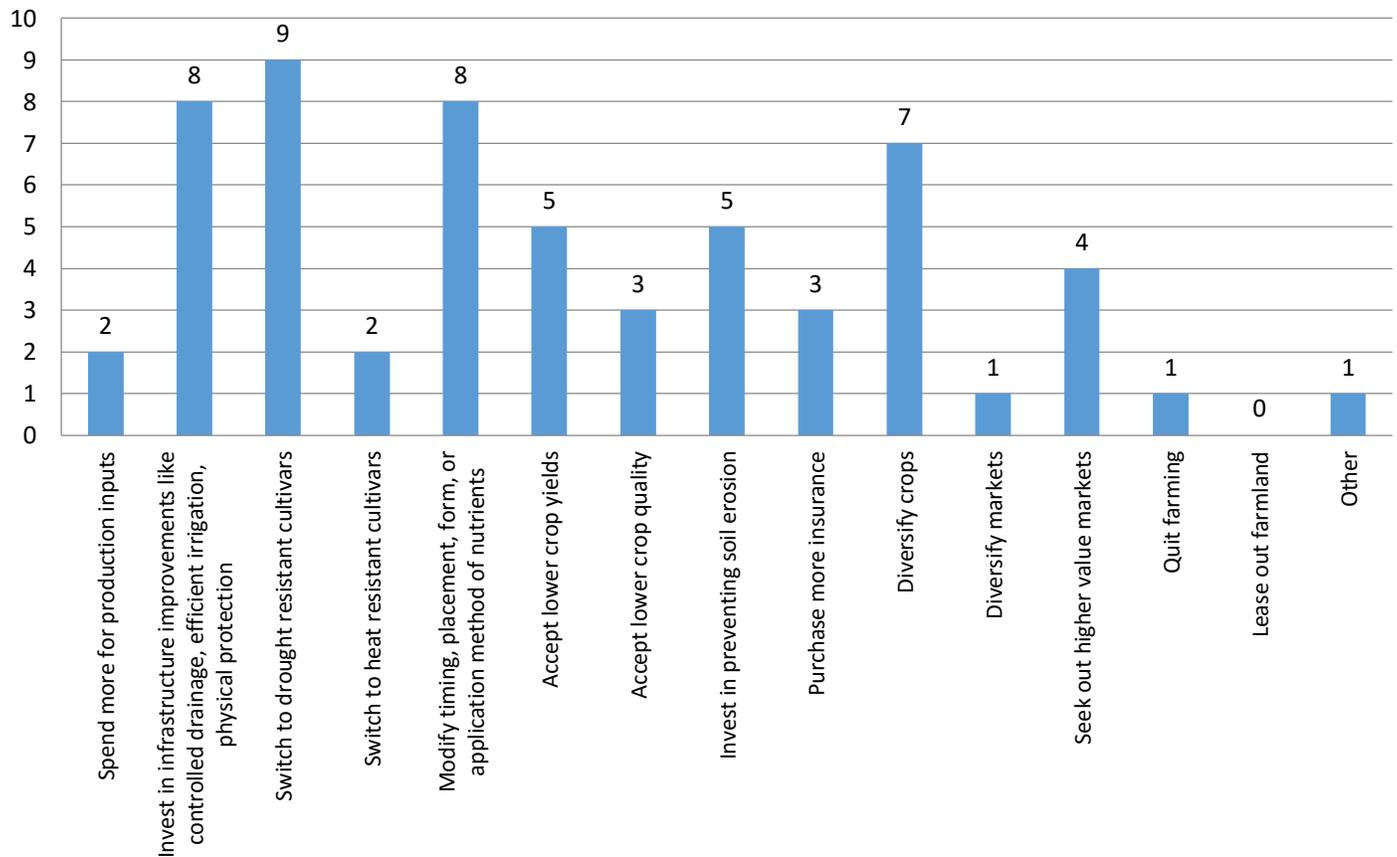
9. Have these changes in weather-related production challenges caused you to make any major changes in farming practices? Select any items that apply from the list below.



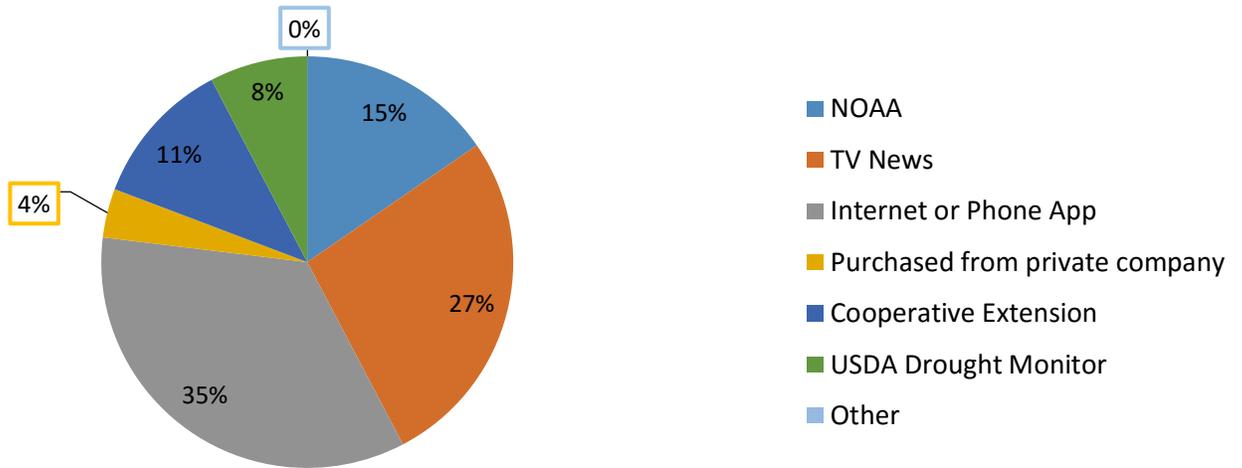
10. Have these changes in weather-related conditions or challenges created any new production opportunities for you? Select any items that apply from the list below.



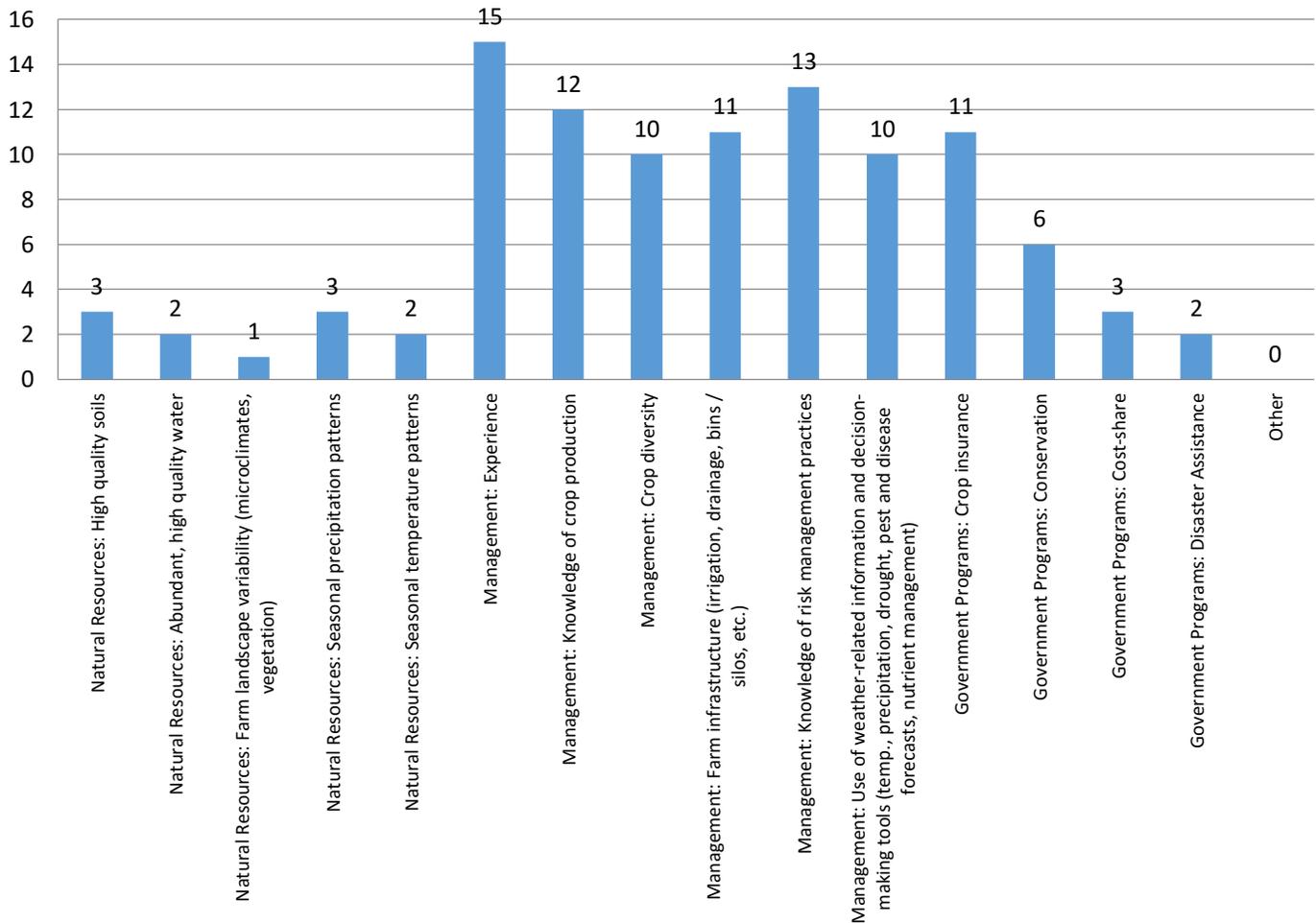
11. If the changes you have noticed in weather variability or extremes continue or grow more intense how will you most likely respond? Select any items that apply from the list below.



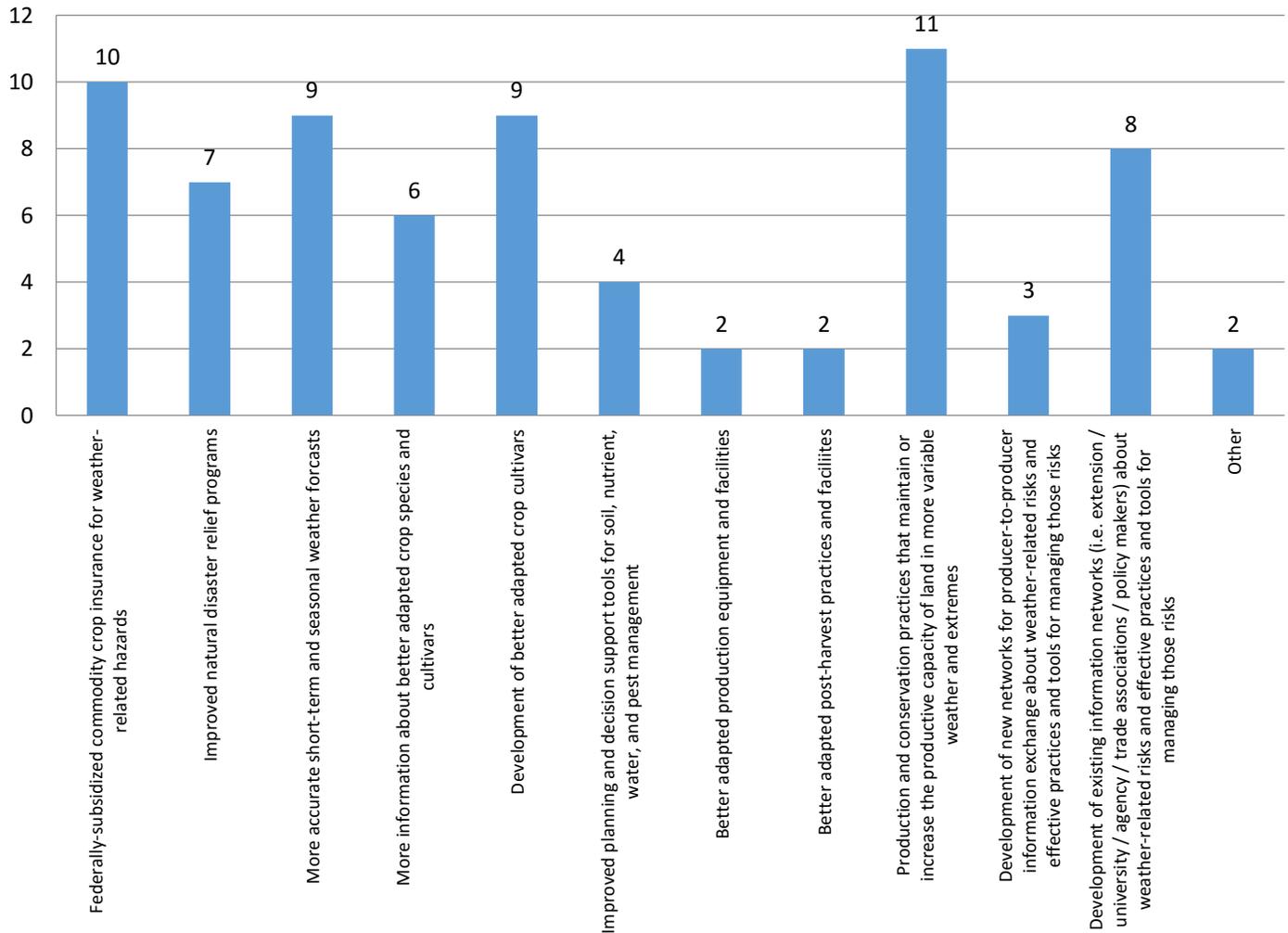
12. What sources of weather information do you use in planning and management decisions?



13. Of all the resources available to you as a farmer, which ones among those listed below do you use most often to reduce weather-related production risks? Select any items that apply from the list below.



14. Think again about all of the resources available to you to manage current weather-related risks. What improvements in information, management practices or technologies would be most likely to improve your success in managing weather-related risks? Sel



15. Are you confident that you have access to the resources you need to successfully manage risks associated with current weather variability and extremes?

