



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

Priorities and Recommendations for Advancing Adaptive Management in the Livestock Sector

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.

PROJECT LEADERS, TECHNICAL PROFESSIONALS AND SUPPORT STAFF

NORTH CAROLINA AGRICULTURE AND FORESTRY ADAPTATION WORK GROUP MEMBERS

R.C. Hunt – Wilson, NC - Livestock Producer – Project Co-Chair
Chip Miller – Mt Gilead, NC - Forest Products – Project Co-Chair
Guy Davenport – Creswell, NC - Corn Producer
Michael Dickey – Burlington, NC - Nursery/Horticulture
Tony Doster – Wilmington, NC - Industrial Forest Lands
Scott Goodwin – Greensboro, NC - Ag Inputs/Crop Protection
David Halley – Holly Springs, NC - Consulting Forester
Jeff Harris – Williamston, NC - Conservation District Officer
David Heath – Dover, NC - Soybean Producer
Keith Larick – Raleigh, NC – NC Farm Bureau Federation
Jeffrey Lee – Benson, NC - Sweet Potato Producer
Maggie Monast – Raleigh, NC - Environmental Defense Fund
Tandy Jones – Pittsboro, NC - Livestock Producer

EX-OFFICIO

North Carolina State University

Dr. Deborah Thompson – College of Agriculture and Life Sciences

Dean Mary Watzin – College of Natural Resources

North Carolina Department of Agriculture and Consumer Services

Dr. Richard C. Reich – Assistant Commissioner, Agricultural Services

Mr. Barry New – NC Forest Service

TENCHNICAL RESOURCE PROFESSIONALS

Dr. Ryan Boyles – State Climate Office of NC

Adam Costanza – Institute of Forest Biosciences

Dr. Steve McNulty – USDA Southeast Regional Climate Hub

Sarah Weiner – USDA Southeast Regional Climate Hub

Dr. Mark Megalos – NCSU Department of Forestry and Environmental Resources

Dr. Deanna Osmond - NCSU Department of Crop and Soil Science

Dr. Paul Ulanich – NC Biotechnology Center

Dr. Clay Altizer – NC Forest Service

Dr. Laura Lengnick – Cultivating Resilience, LLC

Debbie Hamrick – NC Farm Bureau Federation

SUPPORT STAFF/FACILITATION

Ernie Shea – Solutions from the Land

Brent Bailey – Solutions from the Land

Ethan Gilbert – Solutions from the Land

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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 recommended 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. Livestock-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 Livestock Team utilized information and feedback collected from the August 2015 Adaptation Summit Livestock Team Breakout Session and the Livestock 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 livestock industry in North Carolina, as well as address any short-term immediate issues or needs.

PROTECTING NORTH CAROLINA'S LIVESTOCK SECTOR

North Carolina ranks as number two in the nation for the production of hogs and pigs, farm-raised trout and for all poultry and eggs cash receipts. The state is number three in the nation for turkeys, number four in the nation for broiler chickens and number five for farm-raised catfish.¹² The value of livestock, poultry and their products in 2015 was \$8.3 billion. These numbers just go to show the economic importance of animal agriculture in the state of North Carolina. However, this industry depends on inputs from other sectors that can be drastically affected by unpredictable extreme weather events. These same extreme situations can lead to other issues within the livestock industry in terms of mitigating pollutant runoff and dealing with diseases. In order for North Carolina livestock producers to continue to benefit from the economic advantages they possess in this industry it is important that they assess the challenges that the livestock sector will face in the future and prepare to handle them today.

As with other Teams, the Livestock Team utilized an informal web-based survey tool to gather information to be used to inform the development of the actions, initiatives, and recommendations that are needed to help North Carolina livestock producers adapt to challenging weather conditions and improve resilience in the face of extreme weather events. The survey was distributed statewide with the help of livestock industry organizations, general farm organizations, and NC ADAPT project leaders. The full Livestock Producer Survey and responses can be found in Appendix III.

Overall, the Livestock Producer Survey garnered 103 total responses and 83 completed surveys. Survey respondents were dominated by small-scale cattle operations that sell calves at local public sales (62 respondents) although virtually all livestock production sectors were represented in the survey. About half of the cattle producers responding to the survey reported 20 years or more experience managing cattle.

¹² North Carolina Agricultural Statistics, "2015 Annual Statistics Book," <http://www.ncagr.gov/stats/2015AgStat/index.htm>.

Selected Livestock Producer Survey Respondent Comments:

- “Summer drought and winter moisture has caused reduced stocking and increased pasture renovation costs which results in less profit.”
- “If we get what California has had in terms of drought, I am certainly not prepared.”
- “The most acute effect of weather extremes for our swine production operation relates to its associated impacts on our manure management system. Secondary effects include wide fluctuations in commodity prices for feedstuffs due to variable crop yields.”
- “The policy makers should have the least to say in these matters since they know the least about the subject.”
- “Centralizing what programs are presently available or might be available in the future. Word of mouth about ... this program, or that program is how most of my information is gathered, then I investigate as far as being applicable to my production. I think I miss out on a lot of knowledge and assistance.”

Although the response rate was too low to make any conclusions about livestock producers as a whole, some respondents reported making changes to adapt to increased variability in precipitation and more frequent dry periods. The most common adaptations were to make changes in stocking rate, as well as adopt new soil and water conservation practices. Respondents reported that they would invest in pasture management and change stocking rates if changing weather patterns became more extreme in the future. The Livestock Producer Survey results were consistent with findings from similar national surveys.

The Livestock Team reviewed the results of the Livestock Producer Survey and discussions from the August 2015 Adaptation Summit Livestock Team Session that focused on issues surrounding water security, use and management, as well as animal heat stress, biosecurity and impacts to aquaculture. The Livestock Team examined some of the issues, concerns, as well as opportunities that can arise from higher temperatures and more erratic weather events. **The Livestock Team identified the following issues of having particular importance:**

Waste Management

- With the potential for more frequent intense rainfall events, confined swine farm owners will have greater difficulty in managing excess rainfall and storm water that enters wastewater lagoons. Overtopping and the structural integrity of lagoons becomes a threat with increased precipitation, and saturated spray fields will prevent wastewater application. It will become more costly to pump/remove/transport excess water from lagoons as options for mitigation of lagoon levels are limited. ***Farmers request more information and regulatory flexibility in the use of cover crops to mitigate nutrient/manure management challenges.*** Cover crops that have the ability to quickly uptake nutrients, suppress weeds and pathogens, break up compaction, reduce soil erosion, and produce large amounts of biomass need to be identified, evaluated and deployed.

Adaptation in Action: Reducing Swine CAFO Flooding Exposure

When Hurricane Floyd made landfall on September 16, 1999, it caused the most disastrous floods in living memory for the eastern region of North Carolina. The effect of Floyd's historic rainfall was compounded by soils that were already saturated from Hurricane Dennis, which preceded Floyd by just ten days. After Floyd hit, every river basin east of Raleigh experienced 500-year flood levels.

The impacts of Floyd was 55 CAFOs endured flooding and 6 lagoons were breached and 21,474 swine deaths were recorded. A voluntary "lagoon buyout" program from 2000 to 2008 was one successful state-led effort to remove many of the vulnerable CAFOs in floodplains from operation using state-funded grants. After Floyd, the state bought out 42 hog operations located in the floodplain, essentially removing 103 waste lagoons. Other lagoons were relocated to higher ground and, in some cases, re-engineered to withstand inundation.

Hurricane Matthew hit North Carolina on October 9, 2016, and brought with it another 500-year flood event and, in some cases, exceeded the flooding of Floyd. This time, the impact was 11 CAFOs endured flooding and no lagoons were breached. Swine mortality was approximately 2,800. The impact on hog farms from this storm was much less significant.

A spokesman for the North Carolina Department of Agriculture and Consumer Services said the buyout was the main reason for the difference. Better forecasting also played a role, giving farmers time to move hogs to other areas or to market. Feed and fuel supplies were also pre-positioned. The foresight and partnership of the state's swine industry with state and federal resources helped to avoid significant losses.

Water Resources and Management

Water availability will likely be a challenge during extreme hot weather events. The variable landscape makes it difficult to access groundwater resources in certain parts of the state. Furthermore, while valuable advances in irrigation technology have taken place, the technology may be cost-prohibitive to implement, and local concerns over further reducing strained groundwater resources in areas will discourage investments in irrigation. Recommendations for improving water management options in North Carolina include the following:

- ***Work with the NCDA&CS Division of Soil and Water Conservation to identify and approve new irrigation technology methods that can be cost-shared.***
- ***Conduct a statewide analysis of groundwater resources, impacts and future demand.***
- ***Analyze the potential pathways for conflict over water availability (public health vs. wildlife habitat vs. agriculture vs. energy, etc.) and initiate a long-term strategy for resolving conflict.***
- ***Continue fiscal funding and support for the North Carolina Agricultural Water Resources Assistance Program (AgWRAP) with a primary goal of increasing water storage and availability for agricultural purposes.***¹³

¹³ See AgWRAP Fiscal Year 2016 Detailed Implementation Plan, http://www.ncagr.gov/SWC/costshareprograms/AGWRAP/documents/2015_09_AgWRAP_DIP.pdf

- **Promotion of management practices that encourage herd “optimization” and that will help ranchers manage through weather extremes.** These practices could include herd grading techniques; forage management as a drought and run off mitigation tool; and, winter cover crops on row crop land to expand/diversify grazing options.

Heat Stress

- Both confined and pasture-based livestock are subject to heat stress at times of extreme temperature events. However, confined livestock may be the most resilient sector of agriculture because of the controlled and consistent growing conditions that confined operations afford. **New management strategies need to be identified and verified to accommodate for potential future changes/shifts in climate.**

The USDA Southeast Regional Climate Hub (SERCH) has developed an alert for Cattle Heat Stress that monitors USDA-Agriculture Research Service and National Oceanic and Atmospheric Administration-National Weather Service forecasts of daily Temperature-Humidity Index (THI) thresholds and sends an email alert to the rancher when heat stress conditions are possible for his/her location.¹⁴ Learn more about this tool in the sidebar on the following page.

Aquaculture

- **State agencies, university extension, and marketing organizations must coordinate promotion and support of aquaculture in North Carolina to reduce land conversion.** More frequent drought events and overall warmer temperatures hold great concern for members of the state aquaculture industry. Producers fear that there could be more value and greater economic returns in the form of real estate sales rather than in aquaculture production. The loss of domestic aquaculture production would reduce gross farm sales and invite greater residential/commercial sprawl.

Biosecurity

- Biosecurity management will likely become more important and more challenging. The new “FDA Veterinary Feed Directive” will take some of the decision-making authority out of the hands of producers. Higher temperatures and variable weather could cause greater numbers of flies and other disease/parasite vectors. Additionally, the impact of migrating birds and their ability to carry avian influenza is not well understood. The potential for diseases to migrate from other regions of the country is a worrisome development as environmental stressors pose a serious risk to animal health and vector control. **Livestock disease monitoring must be strengthened and pertinent information shared quickly among the impacted livestock sector.**

¹⁴ See Cattle Heat Stress Forecast, <http://www.ars.usda.gov/Main/docs.htm?docid=21306>

Adaptation in Action: SERCH Cattle Heat Stress Alert

Cattle heat stress occurs when high ambient temperature and high relative humidity causes cattle to reach a point where they cannot cool their bodies adequately. The Temperature Humidity Index (THI) incorporates both environmental temperature and humidity in order to determine a more accurate representation of effective temperature.

Signs of cattle heat stress:

Visible signs of heat stress in cattle include decreased food intake, decreased activity, seeking shade, panting (increased respiratory rate), and sweating.

Heat stress impacts on cattle:

- Long-term decreases in milk production and birthing rates in dairy cattle
- Reduced dry matter intake, which inherently reduces rate of weight gain
- Pregnancy rates decrease above 70 THI and additionally above 74°F
- Reduced fertility in both female and male cattle

Adaptive management options for reducing heat stress impacts:

- Provide lots of available drinking water, shade, airflow, and remove fly habitats
- Alternating feeding times and sprinkling can help minimize the effects of heat stress
- Applying 1/3 gallon of water to a cow's back every five minutes with fans providing air flow was very effective in decreasing heat stress
- Follow weather trends and begin preventative measures before heat waves hit

Use the **Cattle Heat Stress Alert from USDA-SERCH** or the **ThermalAid app developed by the University of Missouri** to identify, monitor, and reduce heat stress in cattle to improve welfare and performance.

Other Recommendations

The Livestock Team also discussed risk management tools and practices that could be adopted to make North Carolina livestock producers more resilient and successful. Suggestions included:

- ***Research and review the livestock management practices and programs of other states with similar or warmer climates.***
- ***Research and promote the use of locally adapted forage and feed grain seed varieties for improved pasture and grazing performance.*** Many varieties seem to focus on Midwestern performance characteristics.
- ***Research how conservation tillage and manure nutrient management can co-exist. Develop steps for building conservation tillage measures into normal farming practices that utilize manure-based nutrients.***
- Livestock producers in North Carolina see an opportunity to market their livestock and meats products to national and international areas that may be more inversely impacted by climate

and weather challenges, yet have a population with a growing demand for a protein-rich diet. ***New or expanded access to markets impacted by climate challenges is needed.***

- Innovations are needed in livestock production systems that positively impact the bottom line. ***Programs developed and offered by Extension Service, commodity groups, USDA-Natural Resources Conservation Service, Division of Soil and Water Conservation, etc. need effective communication and outreach strategies to ensure promotion and participation among the farm and ranching community.***
- With longer warm periods, the potential for longer grazing seasons exists. ***Land managers need to embrace practices and markets that can take advantage of longer grazing seasons.***
- North Carolina has one of the fastest growing populations and economies in the nation.¹⁵ However, without proper planning to address this growth and utilization of natural resources, North Carolina could create the same challenges that other parts of the country are dealing with because of the lack of planning and resource awareness. But few are willing to engage in the planning process. ***While financial or operational challenges may discourage long-term planning, North Carolinians must look beyond the present to address threats to agriculture, livestock and forest resiliency. The sector currently has a window of opportunity that it must not squander.***

PATH FORWARD

Though the recommendations included in this document are the result of a year of work with stakeholders from the livestock sector, they mark the beginning of new conversations. Changing weather patterns affect North Carolina's livestock sector in complex ways. Geography, specific livestock produced, grower expertise, farm resources and markets are just a few of the variables that frame opportunities and threats to our state's livestock farms.

North Carolina's livestock producers 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.

¹⁵ PolitiFact North Carolina, <http://www.politifact.com/north-carolina/statements/2016/apr/29/pat-mccrory/mccrory-north-carolina-has-had-countrys-fastest-gr/>

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 livestock 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

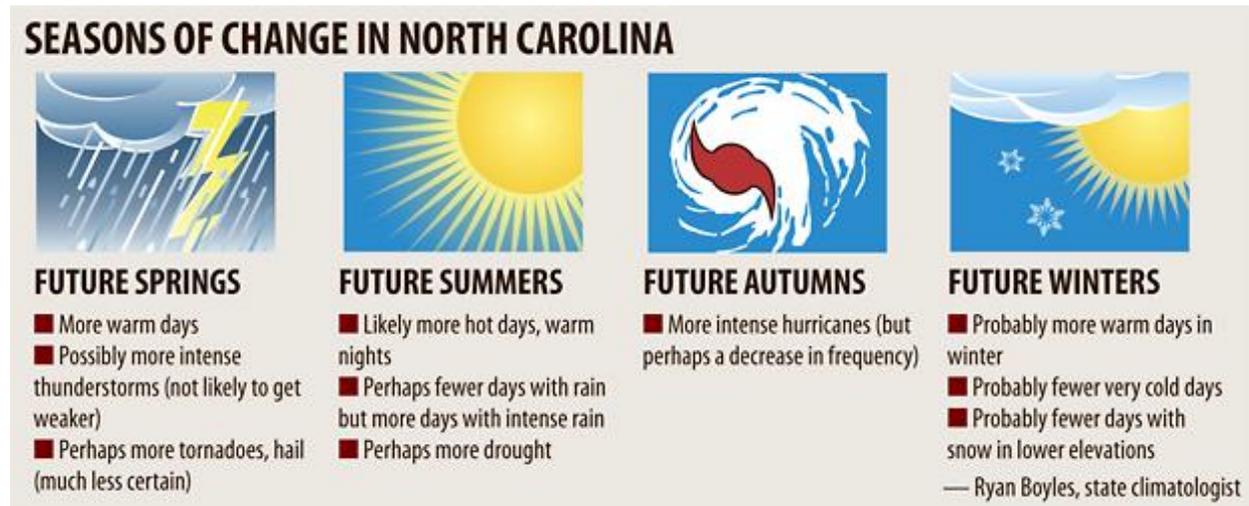
Extreme and Variable Weather:

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.

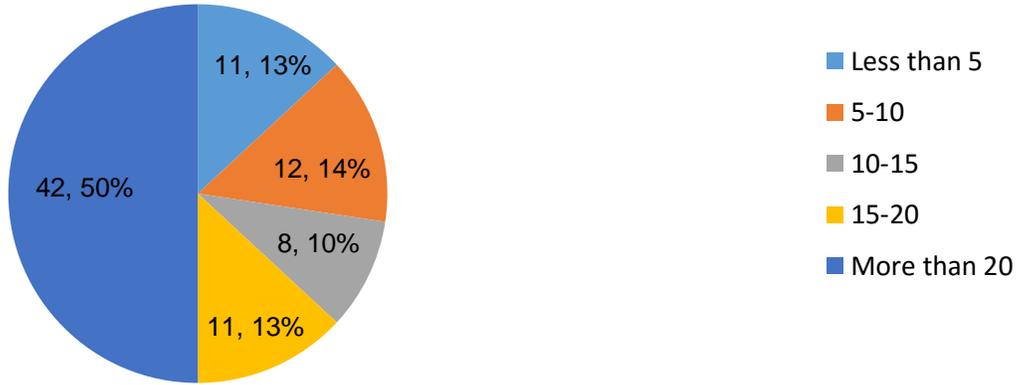
There are numerous actions that could be implemented in response to potential changes in climate:

- 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.

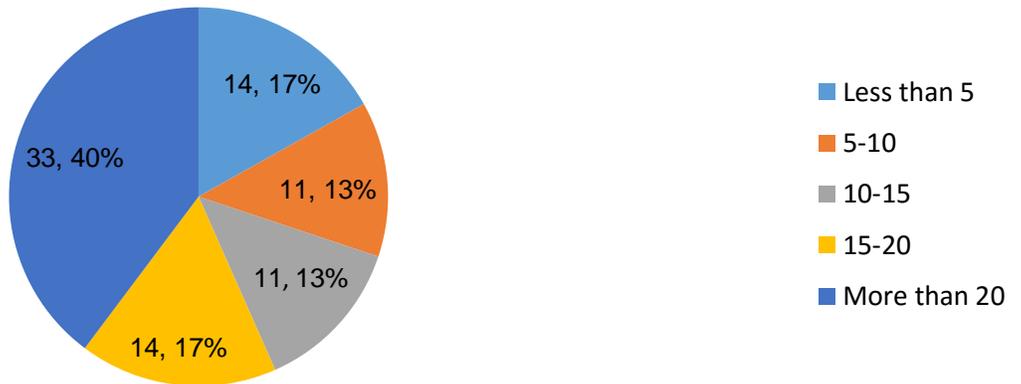
APPENDIX III

Livestock Producer Survey and Survey Results

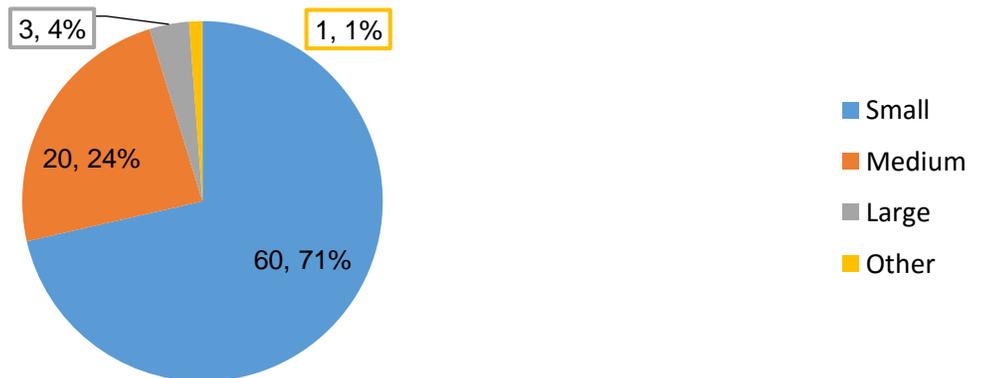
1. About how many years of experience do you have as a livestock producer?



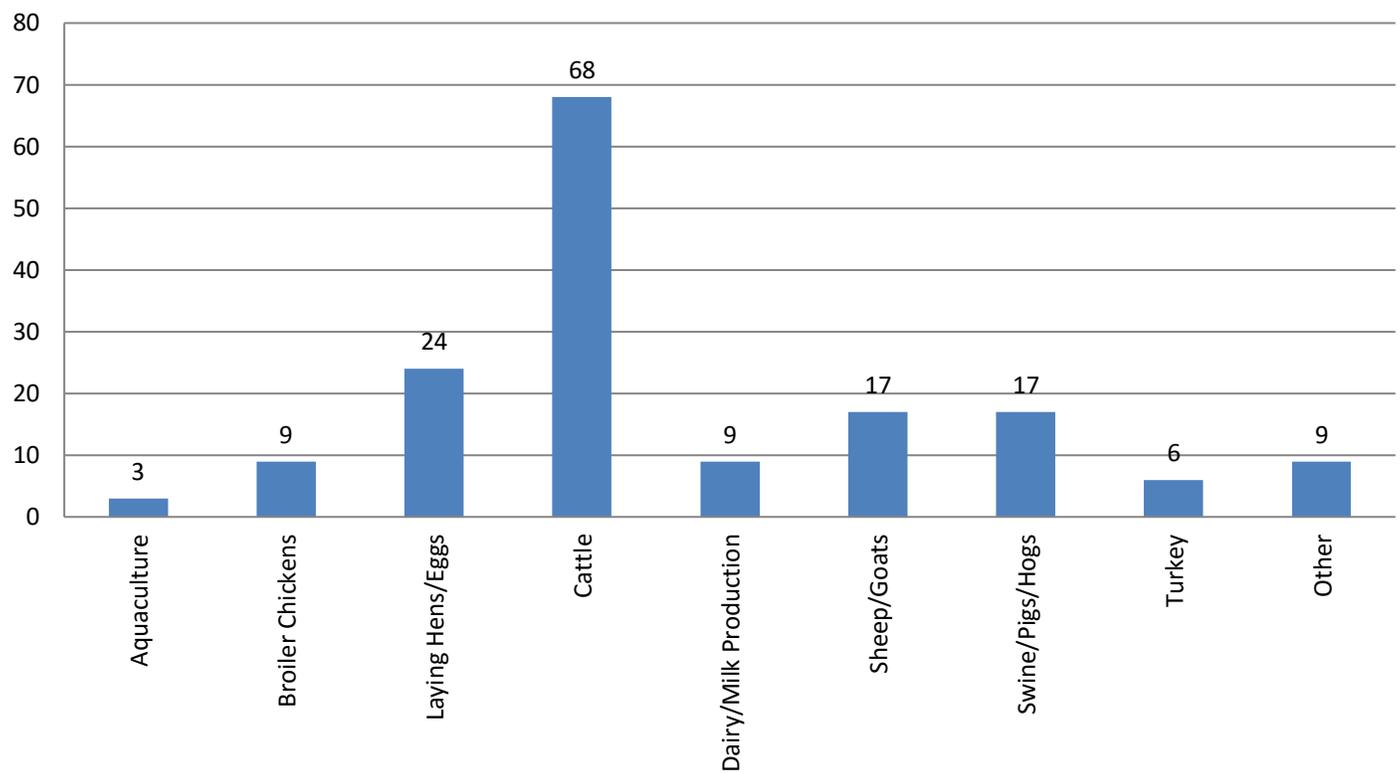
2. About how many years have you been managing livestock at, or near, your current location?



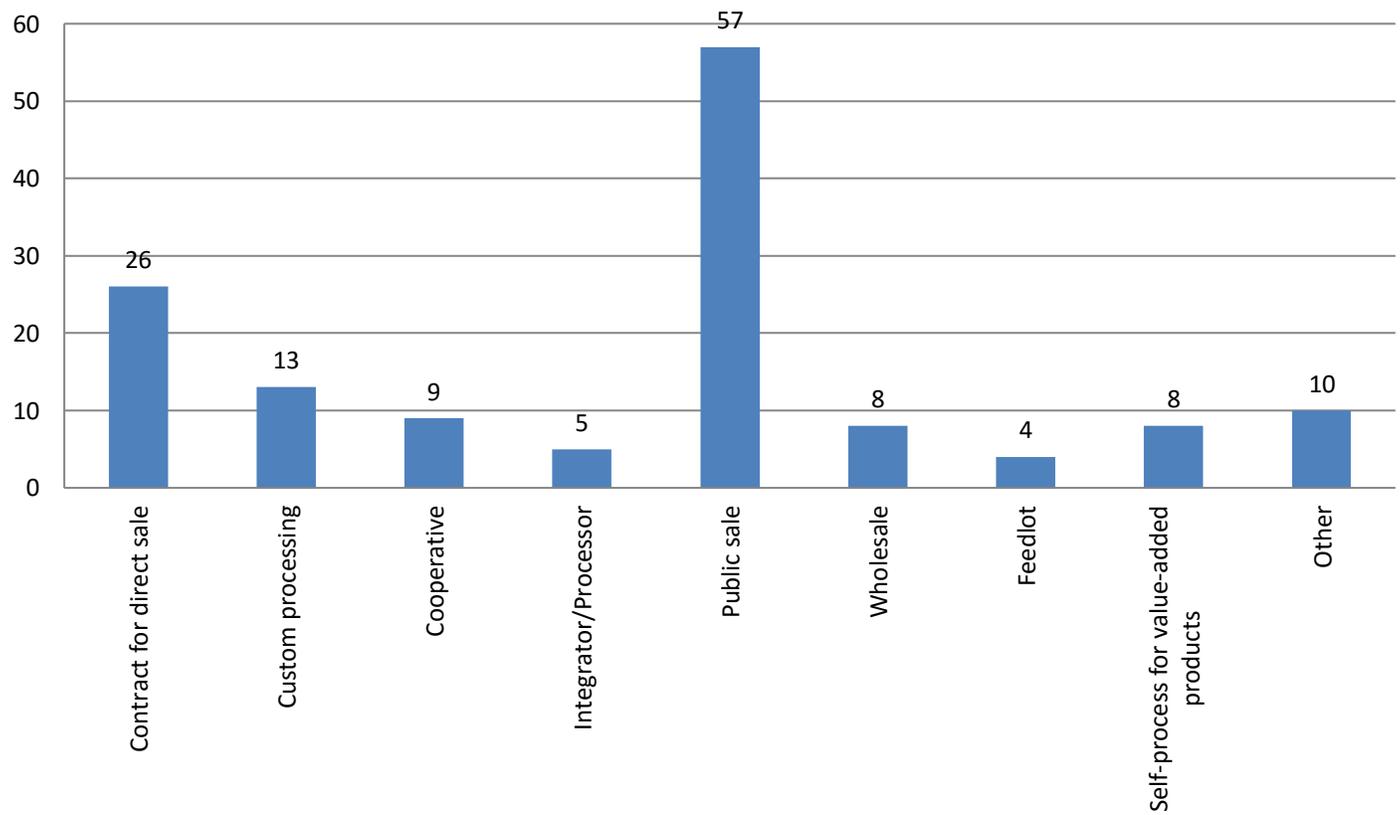
3. Based on industry averages, do you consider yourself to be a small, medium or large-sized farm?



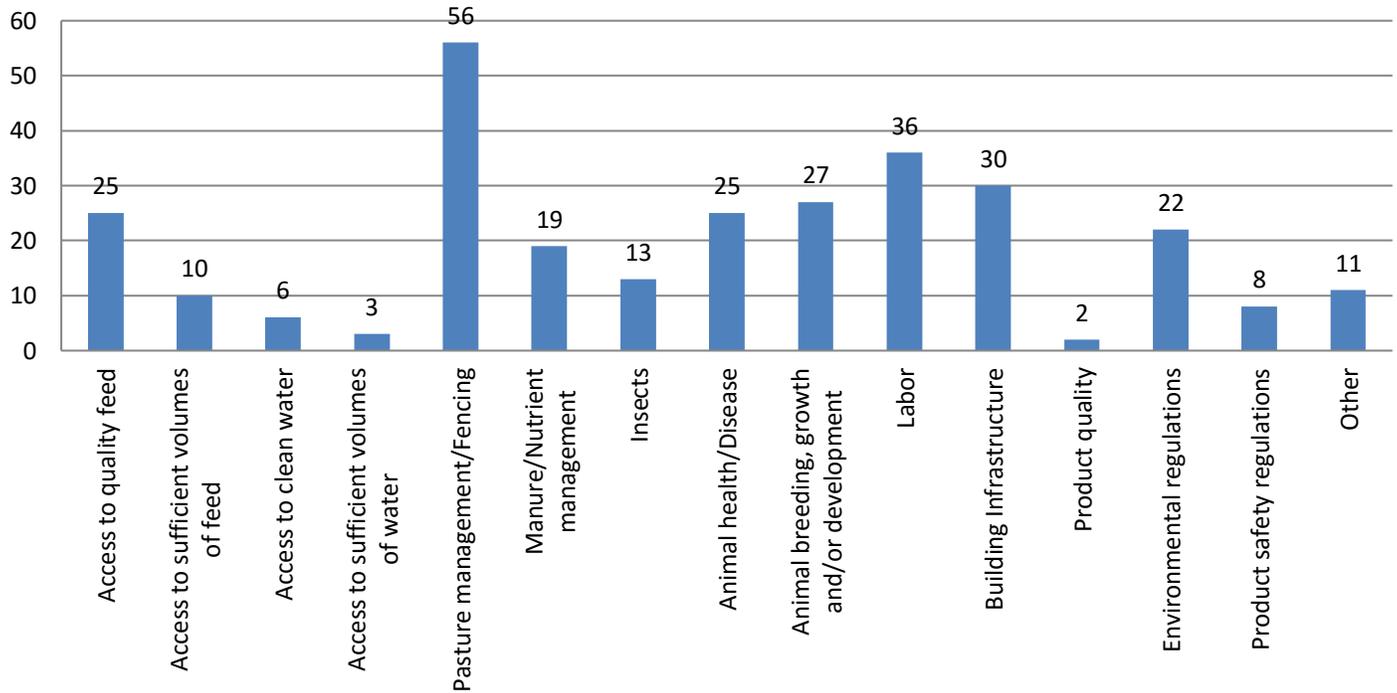
4. What are the principle livestock types that you manage? Select all that apply. If you select other please detail in the space provided.



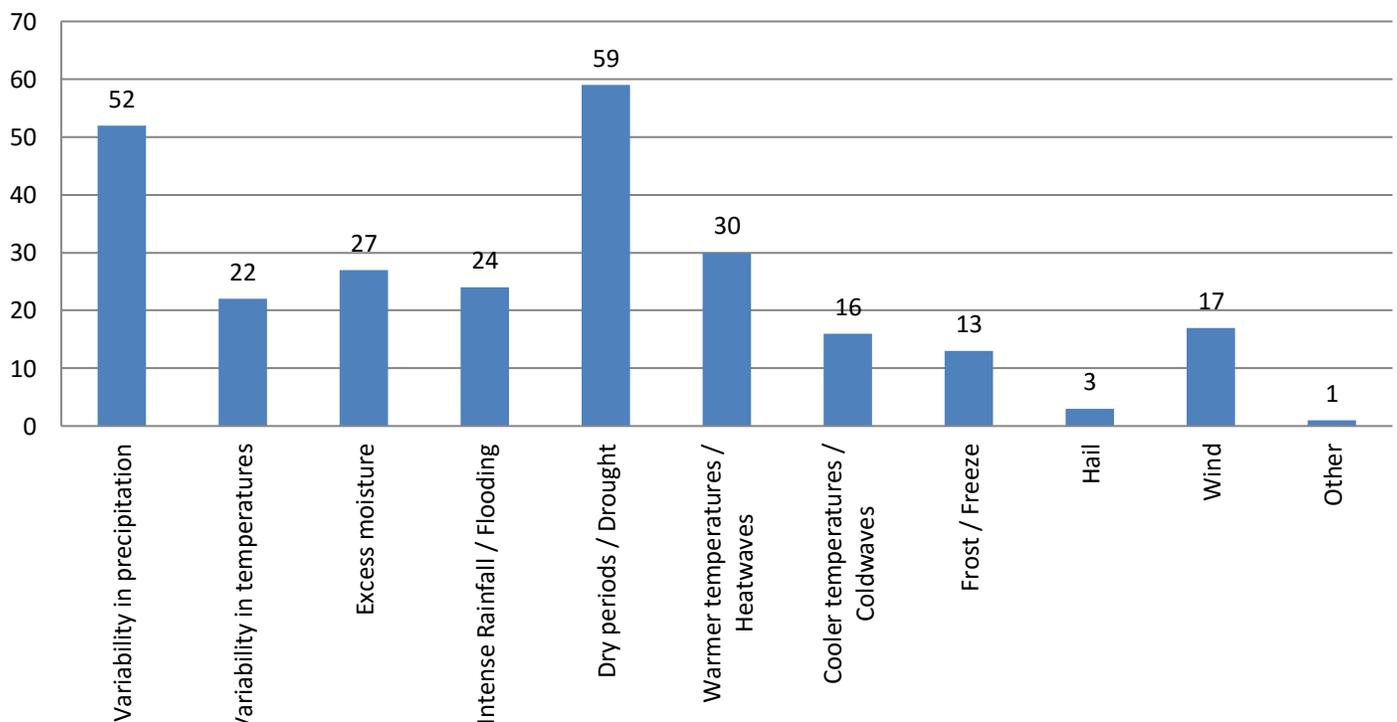
5. Where do you market your livestock or products? Select all that apply.



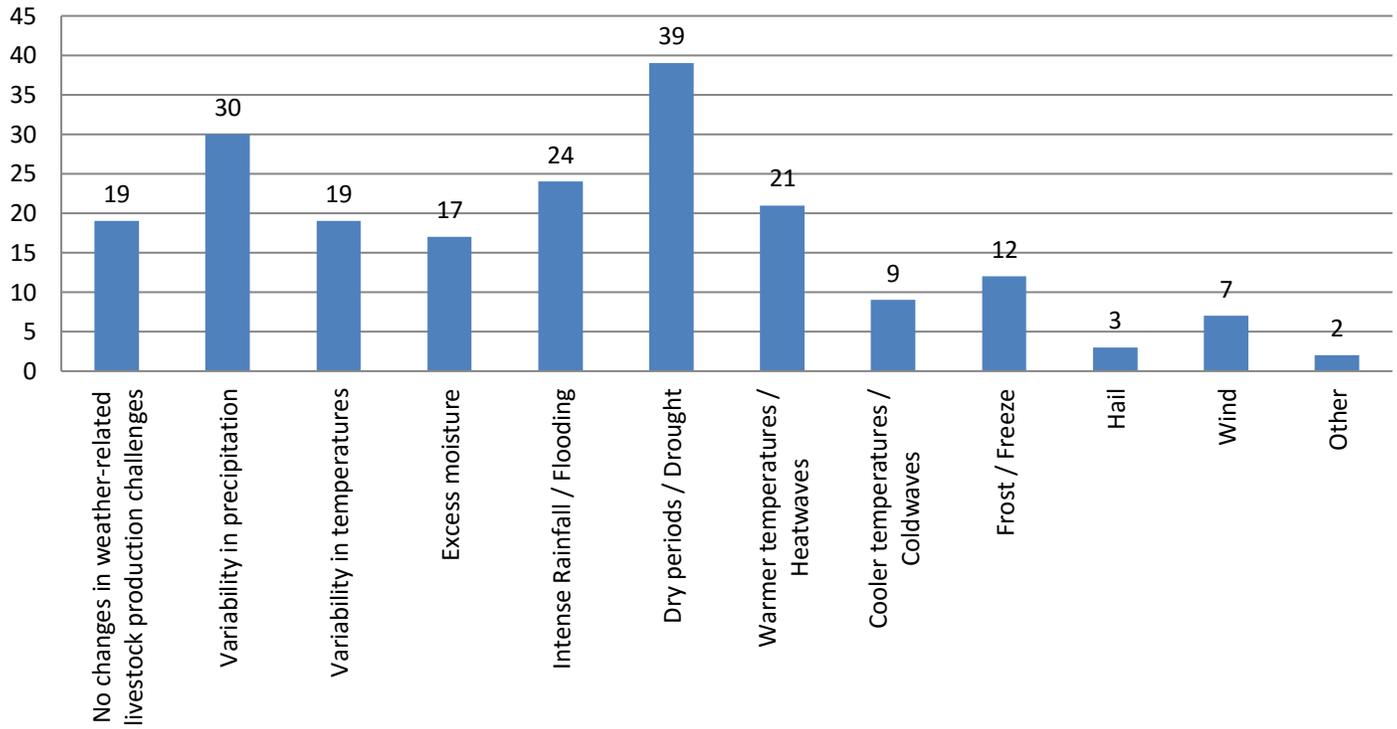
6. Think now about your experience managing livestock production over the years. What are some of the most difficult production challenges that you've experienced? Select up to 5 items representing the most difficult livestock production challenges from



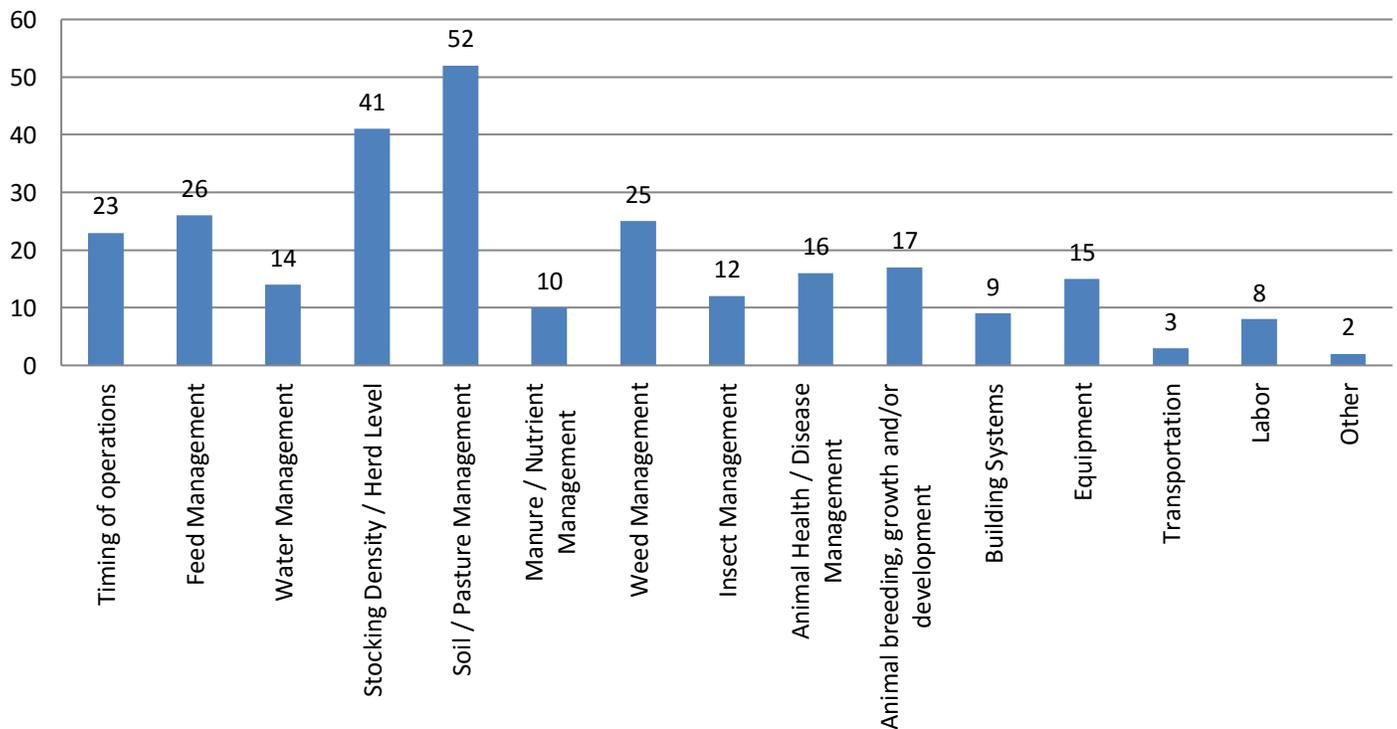
7. Think again about your experience managing livestock over the years. What are some of the most difficult weather-related production challenges that you have experienced during that time? Select up to 5 items from the list below.



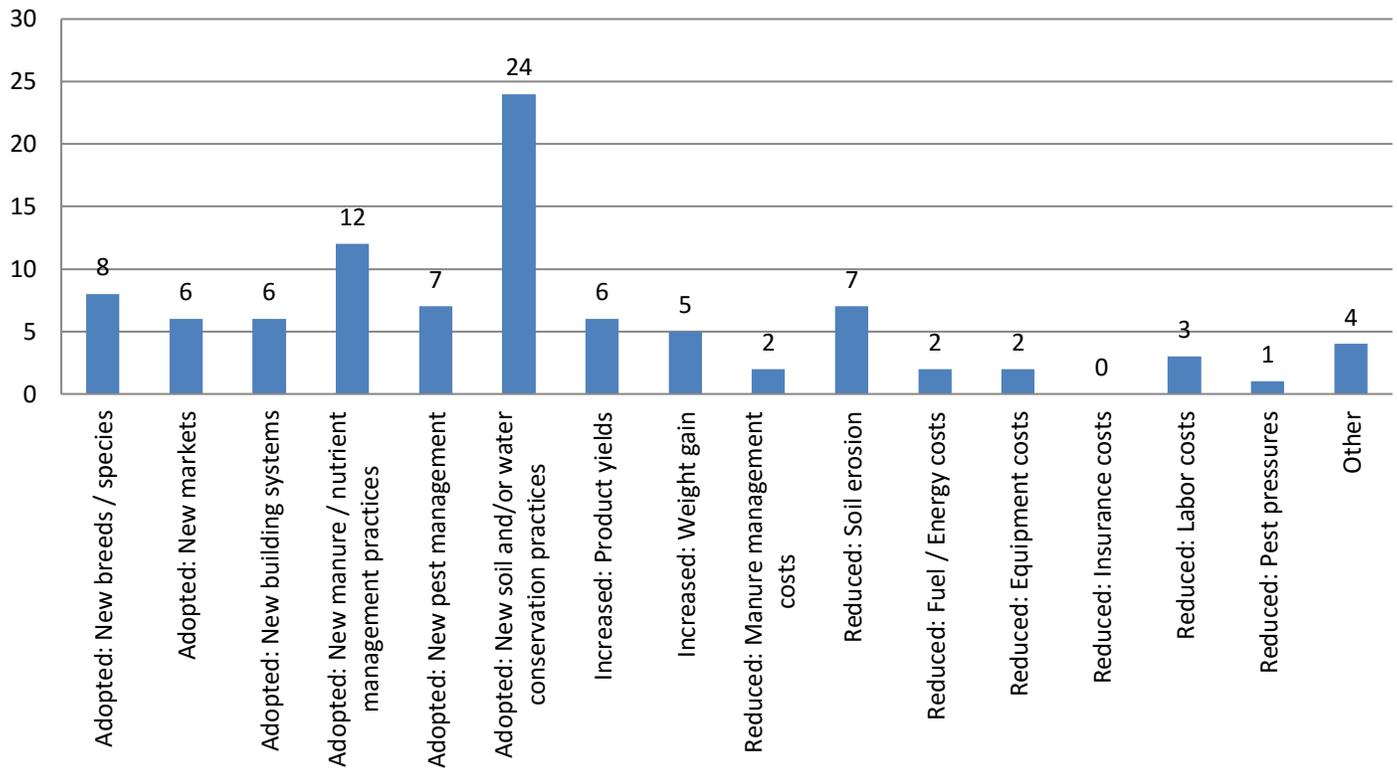
8. Think again about your experience managing livestock over the years. Have you noticed any weather-related changes that could present challenges to livestock production? Select any items that apply from the list below.



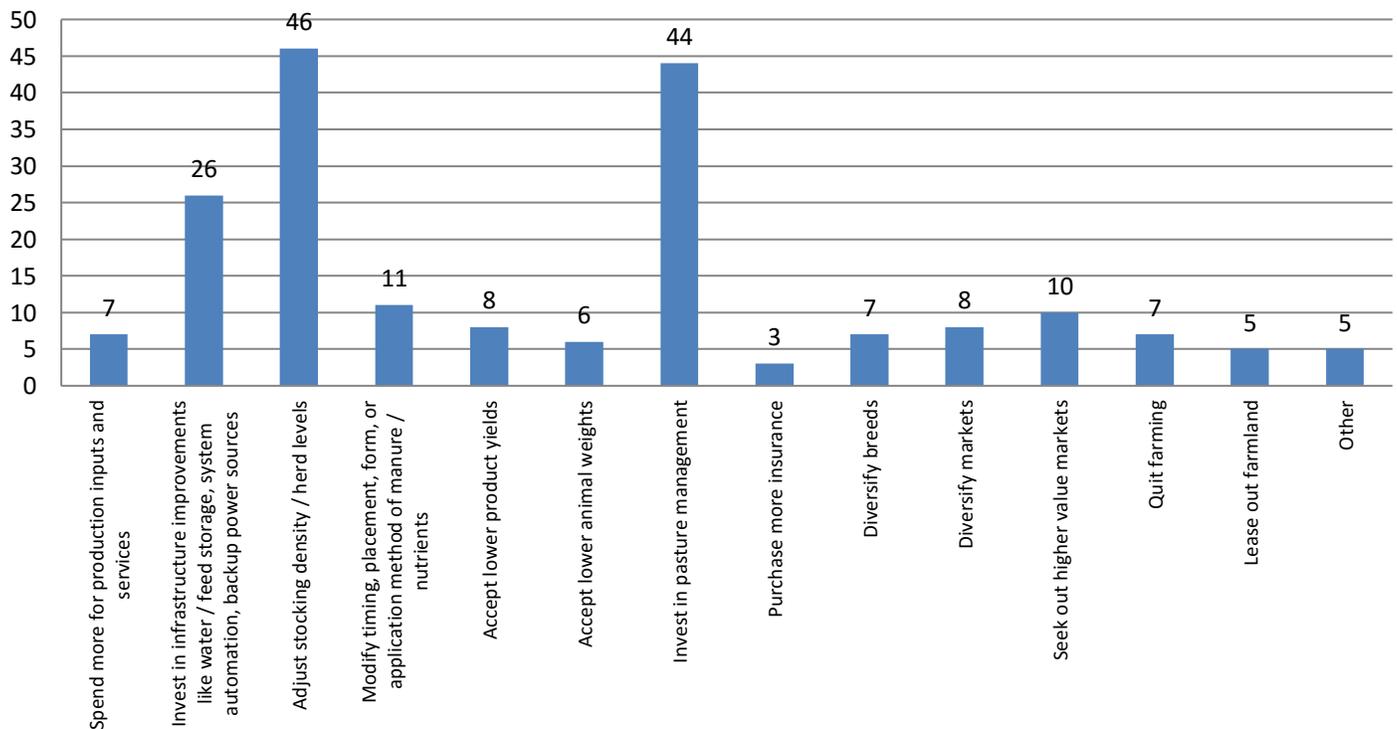
9. Have these weather-related changes that could present livestock production challenges caused you to make any major changes in farm management practices? Select any items that apply from the list below.



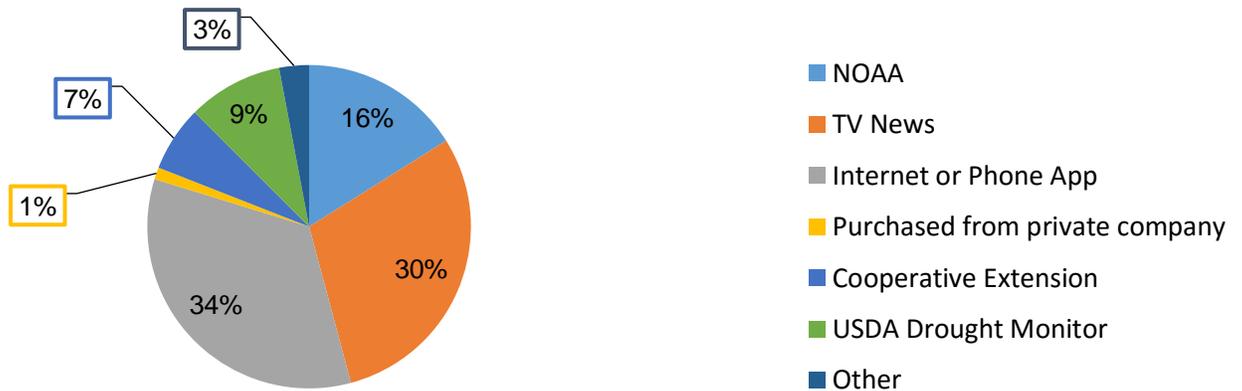
10. Have these changes in weather-related conditions or challenges created any new production opportunities for you? Select any items that apply from the list below.



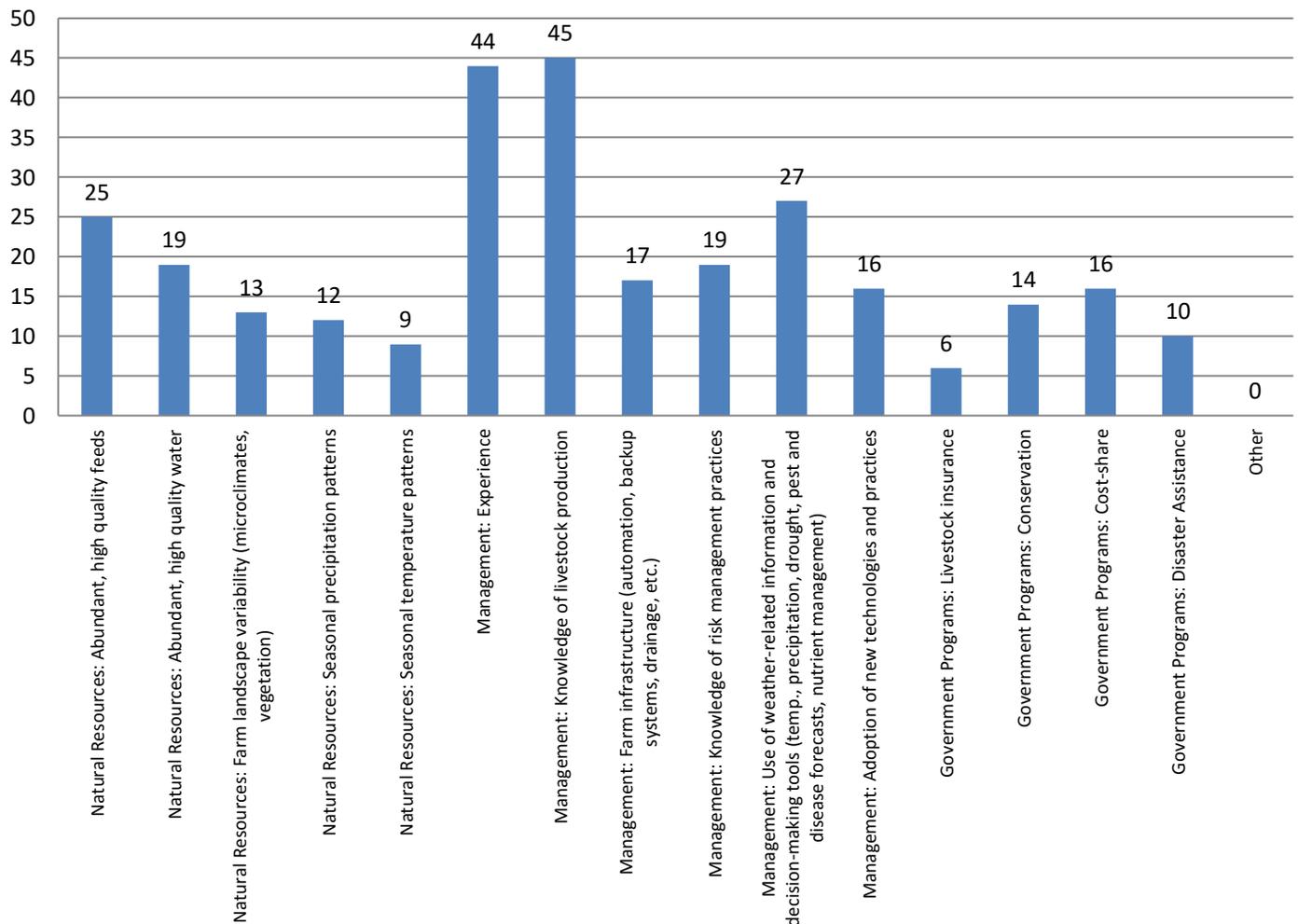
11. If the changes you have noticed in weather variability or extremes continue or grow more intense how will you most likely respond? Select any items that apply from the list below.



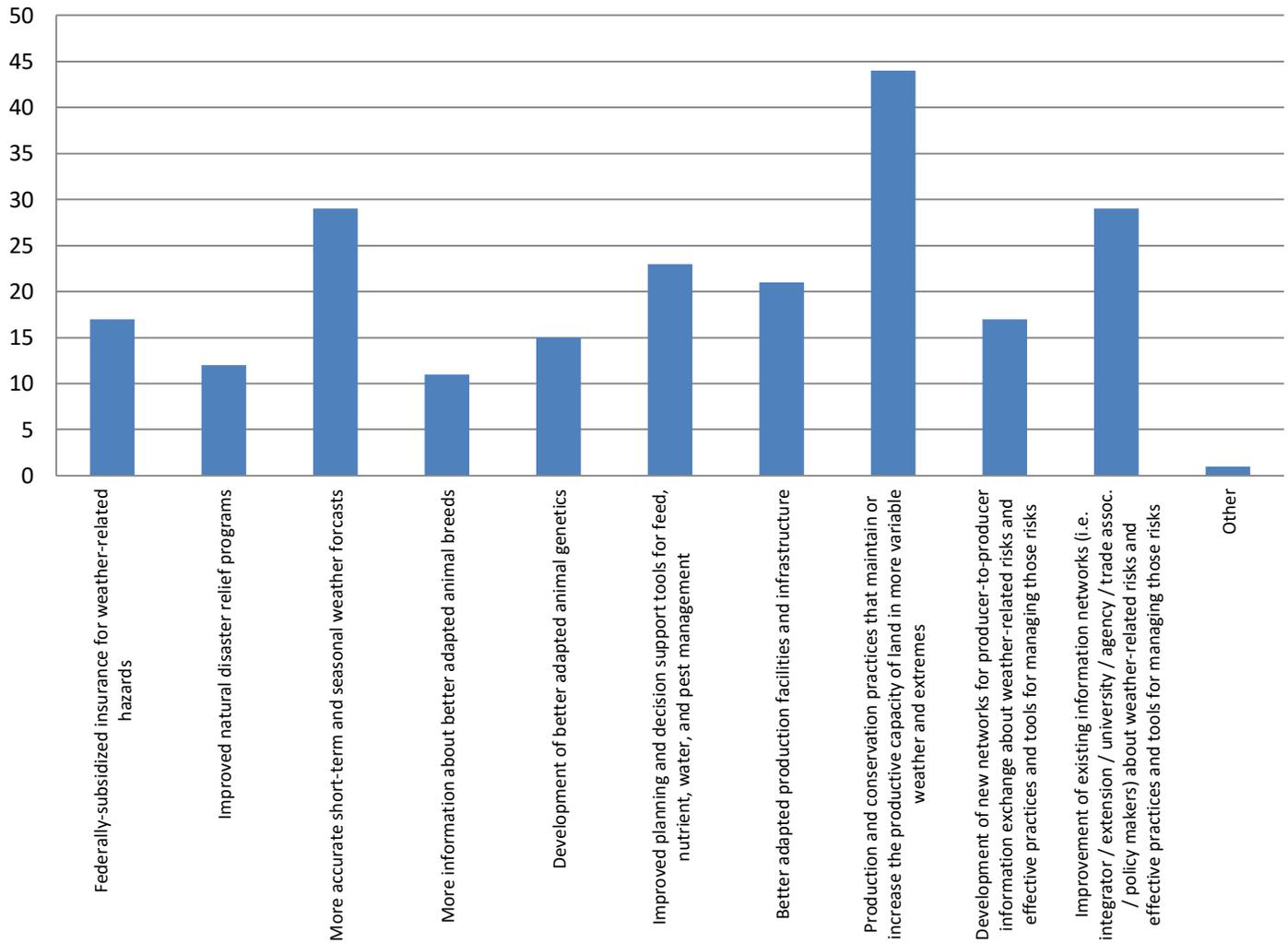
12. What sources of weather information do you use in planning and management decisions?



13. Of all the resources available to you as a livestock producer, 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?

