Agriculture, Food, and Natural Resources (AFNR) Frameworks 2021

Preface: Introduction

Three Component Model of School-Based AFNR Education

Classroom and Laboratory Instruction—Academic Skill Development—Contextual project-, problem-, and inquiry-based instruction through classroom and laboratory settings such as a school greenhouse, farm, or natural resources lab. Advanced inquiry-based curricula known as Curriculum for Agricultural Science Education (CASE; cf. Project Lead The Way) is available through the National Council for AFNR Education (The Council).

Supervised Agricultural Experience (SAE)—Technical Skill Development and Work-Based Learning—A student-led, instructor-supervised, Work-Based Learning (WBL) experience that results in measurable outcomes within a predefined, agreed upon set of AFNR Technical Standards and Career Ready Practices aligned to a Career Plan of study. SAE teaches technical skills and knowledge within the psychomotor domain of learning. SAE includes both experiential learning (i.e., pre-WBL) and WBL (federally defined as sustained interactions with industry or community professionals in real workplace settings, to the extent practicable, or simulated environments, at an educational institution that foster in-depth, firsthand engagement with the tasks required in a given career field, that are aligned to curriculum and instruction; Sec. 3 [20 U.S.C. 2302] 55).

The National FFA Organization (FFA)—Social Emotional Skill Development and Student Leadership—A student-led, instructor-supervised, Career and Technical Student Organization (CTSO) that results in measurable outcomes within a predefined, agreed upon set of AFNR social-emotional standards and Career Ready Practices aligned to a Career Plan of study. FFA teaches social-emotional and leadership skills and knowledge within the affective domain of learning. FFA includes programs that teach essential employability skills such as critical thinking, communication, and leadership. FFA was founded in 1928 and is federally defined as intracurricular (within the curriculum; cf. extracurricular: external, co-curricular: alongside) and an integral

(necessary to form the whole) component of School-Based AFNR Education (Public Law No. 116-7).

Purpose

Just as the industries of agriculture and natural resources vary throughout our state, nation, and around the world, so too will our School-Based AFNR Education programs. While academic standards in math, science, language arts, and social studies are set at the state level, each district in Minnesota must establish, align, revise, and review its own standards in career and technical education (Minn. § 120B.022, Subd. 1; Minn. § 120B.021, Subd. 4, d). To aid with setting local standards within AFNR, the Minnesota Department of Education has aligned and adapted the National AFNR Career Cluster Content Standards, to create the Minnesota AFNR Standards and Frameworks. Local entities are encouraged to adapt the standards to meet the needs of their community, AFNR industry sector, and local needs. Districts should use the standards within this document as a framework or guide for the development of well-planned curricula and assessments for AFNR Career and Technical Education (CTE) programs, in conjunction with local advisory committees to decide what is most relevant and right for their students in providing that all-important link between the school and the AFNR business community. These standards help shape the design of each of the three intracurricular (within the curriculum; cf. extracurricular: external, co-curricular: alongside) and integral (necessary to form the whole) components School-Based AFNR Education (Public Law No. 115-224; Public Law No. 116-7; Minn. R. 3505).

AFNR is a highly technical and ever-changing sector of the global economy upon which everyone is dependent. We will continue to meet national and global demand for a safe and abundant food, fiber, and fuel supply if we invest in the growth and development of students pursuing careers in AFNR. Strong, relevant AFNR CTE programs that are informed by industry and education stakeholders are one way we can meet workforce needs now and in the future. The AFNR Career Cluster Content Standards provide agriculture and natural resources teachers with a high-quality, rigorous set of standards to guide what students should know, feel, and be able to do after completing a program of study in any of the following AFNR career pathways:

- Agribusiness Systems (ABS)
- Animal Systems (AS)
- Biotechnology Systems (BS)
- Food Products and Processing Systems (FPP)
- Natural Resources and Environmental Service Systems (NRES)

- Plant Systems (PS)
- Power, Structural, and Technical Systems (PST)

The AFNR Career Cluster Content Standards were originally developed as part of the 2003 United States Department of Education (ED) Career Clusters Project. In 2009, and again in 2015, The Council reviewed and revised the content standards. Since its beginning in December 1983, The Council has provided leadership for stakeholders in agriculture, food, fiber, and natural resources and School-Based AFNR Education. In 2016, the CTE Unit (Perkins, Secondary Education), within the Career and College Success Division at the Minnesota Department of Education (MDE) developed the AFNR curriculum frameworks. Select AFNR educators from Minnesota schools developed the statewide AFNR frameworks by aligning the AFNR Career Cluster Content Standards of The Council to Minnesota Academic Science (2009) and Economic Standards (2011), and CTE courses offered in local Minnesota districts (i.e., Minnesota Perkins Table C, AFNR Courses). In 2021 a second committee revised the frameworks to further integrate industry-wide AFNR Cluster skills, Career Ready Practices for leadership development, and Minnesota Work-Based Learning frameworks.

Acknowledgements

The State of Minnesota commends those that provided input and assistance to this project for their leadership, thoughtful input, and dedication.

The National Association of State Directors of CTE (NASDCTE) and National CTE Foundation (NCTEF) have provided permission to for Minnesota to use the Common Career and Technical Core (CCTC) Standards in support of this project. Further, their insights and input about the revised standards has been valuable in shaping the final product. NASDCTE and NCTEF are the owners and developers of the Common Career and Technical Core (CCTC) Standards.

2016

The development process relied upon input from 20 AFNR teachers and state leaders representing educators at the secondary and post-secondary level. Mr. Joel Larsen, State Supervisor of Agricultural Education at the Minnesota Department of Education, managed the grant. Mr. Carl Aakre and Ms. Leah Bott worked as project directors to develop the frameworks and lead the team. The input from these educators was fundamental to achieving the project goals. Educators on the development team included:

- Mr. Carl Aakre, Curriculum for Agricultural Science Education
- Mr. Paul Aarsvold, Plainview-Elgin-Millville
- Mr. Brian Boomgaarden, Pipestone
- Ms. Leah Bott, Lake Superior (Silver Bay)
- Mr. TJ Brown, Springfield
- Ms. Darcy Dahna, Windom
- Mr. Dan Dylla, United South Central (Wells)
- Ms. Stacy Fritz, Chatfield
- Ms. Sue Gorman, Goodhue
- Ms. Angie James, St. James
- Mr. Joel Larsen, Minnesota Department of Education
- Mr. Kerry Lindgren, Staples-Motley
- Mr. Jacob Oyster, Sebeka
- Mr. John Roberts, Holdingford
- Mr. Barry Schmidt, Tri City United (Montgomery)
- Mr. Paul Skoglund, Tracy
- Mr. Eric Sawatzke, Dassel-Cokato
- Mr. Tracy Tebben, New London-Spicer
- Mr. Mike Thofson, Lake Crystal-Wellcome Memorial
- Ms. Liz Tianglia, Owatonna

2021

The revision process relied upon input from nine AFNR teachers and state leaders representing districts across the state and with specific content area expertise relative to each AFNR pathway. Dr. Zane Sheehan, State Supervisor of Agricultural Education at the Minnesota Department of Education, managed the grant. Ms. Leah Bott, project director, and Ms. Lavyne Rada, project editor, revised the frameworks and led the team. The input from these educators was fundamental to achieving the project goals. Educators on the revision team included:

- Ms. Leah Bott, Lake Superior (Silver Bay)
- Ms. Darcy Dahna, Mountain Lake (Plant)
- Mr. Stephen Funk, Park Rapids (Natural Resources, Environmental Services)
- Mr. Mike Miron, Forest Lake (Agribusiness, WBL/SAE, FFA)
- Ms. Lisa Orren, Redwood Falls (Animal)
- Ms. Lavyne Rada, MN FFA Association
- Dr. Zane Sheehan, Minnesota Department of Education
- Mr. Al Stemper, Foley (Power/Technical)
- Ms. Steph Wohluter, Martin County West (Sherburn; Food, Biotechnology)

Structure of Standards

Within each pathway, the standards are organized as follows:

Standards

These are the standards set forth for each of the respective content areas outlined above in the 2012 version of the Common Career and Technical Core Standards. These statements are owned by the NASDCTE and NCTEF and are used here with permission. They define what students should know and be able to do after completing instruction in a program of study for this pathway.

Performance indicators

These statements distill each performance element into more discrete indicators of the knowledge and skills students should reach through a program of study. Attainment of the knowledge and skills outlined in the performance indicators is intended to show an acceptable level of proficiency with the related performance element at the conclusion of a program of study in this area.

Benchmarks

The statements are sample measurable activities that students might carry out to show attainment of each performance indicator at three levels of proficiency: (a) awareness, (b) intermediate, and (c) advanced. The measurements are non-exhaustive and provided as examples to show a logical progression of knowledge and skill development about content areas related to the performance indicator. Local entities may decide the proper timing for attainment of each level of proficiency based upon local CTE program structures.

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Main Contents

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Secondary/Multidisciplinary AFNR Pathways

Main Contents

Secondary/Multidisciplinary AFNR Pathways, Continued

Section 1 – Cluster-Wide Frameworks: AFNR Industry Skills

Introduction

AFNR Industry Skills—encompasses the study of fundamental knowledge and cognitive skills related to all AFNR professions. Students completing a program of study in any AFNR pathway will demonstrate knowledge and skills of: (1) AFNR issues, trends, policy, and technology, (2) nature and scope of AFNR, (3) safety, health, and environmental practices, (4) stewardship of natural resources, (5) career opportunities in AFNR, and (6) interaction among AFNR systems. Schools must implement industry standards into all AFNR pathways.

Section Contents

MN.AFNR.01: AFNR Issues, Trends, Policy, and Technology

Analyze how issues, trends, technologies, and public policies impact systems in the Agriculture, Food, and Natural Resources Career Cluster.

Performance Indicator MN.AFNR.01.01

Research, examine, and discuss issues and trends that impact AFNR systems on local, state, national, and global levels.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AFNR.01.01.01.a. Examine historical, and current data to identify issues impacting AFNR systems.	AFNR.01.01.01.b. Analyze and summarize AFNR issues and their impact on local, state, national, and global levels.	AFNR.01.01.01.c. Evaluate and explain AFNR issues and their impacts to audiences with limited AFNR knowledge.
AFNR.01.01.02.a. Research and summarize trends impacting AFNR systems.	AFNR.01.01.02.b. Analyze current trends in AFNR systems and predict their impact on local, state, national, and global levels.	AFNR.01.01.02.c. Evaluate and explain emerging trends and the opportunities they may create within the AFNR systems.

Performance Indicator MN.AFNR.01.02

Examine technologies and analyze their impact on AFNR systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AFNR.01.02.01.a. Research technologies used in AFNR systems.	AFNR.01.02.01.b. Apply appropriate use of technologies in AFNR workplace scenarios.	AFNR.01.02.01.c. Solve problems in AFNR workplaces or scenarios using technology.
AFNR.01.02.02.a. Compare and contrast AFNR systems before and after the integration of technology.	AFNR.01.02.02.b. Analyze how technology is used in AFNR systems to maximize productivity.	AFNR.01.02.02.c. Evaluate the importance of technology use and how it impacts AFNR systems.

Performance Indicator MN.AFNR.01.03

Identify public policies and examine their impact on AFNR systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AFNR.01.03.01.a. Summarize public policies affecting AFNR systems.	AFNR.01.03.01.b. Analyze and assess at least two public policies that impact each AFNR system.	AFNR.01.03.01.c. Evaluate a public policy within AFNR systems and defend or challenge it.
AFNR.01.03.02.a. Identify influential historical and current public policies that impact AFNR systems.	AFNR.01.03.02.b. Create and propose a hypothetical policy that will impact current AFNR systems.	AFNR.01.03.02.c. Create a plan for implementing a new public policy that will positively impact AFNR systems.

MN.AFNR.02: Nature and Scope of AFNR

Evaluate the nature and scope of the Agriculture, Food, and Natural Resources Career Cluster and the role of agriculture, food, and natural resources (AFNR) in society and the economy.

Performance Indicator MN.AFNR.02.01

Examine the components of the AFNR systems and assess their impact on the local, state, national, and global society and economy.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AFNR.02.01.01.a. Research and describe different types of geographic data used in AFNR systems.	AFNR.02.01.01.b. Analyze and interpret AFNR related geographic data using a variety of systems and technologies [e.g., geographic information system (GIS), global positioning system (GPS)].	AFNR.02.01.01.c. Evaluate geographic data and select necessary data sets to solve problems within AFNR systems.
AFNR.02.01.02.a. Identify and examine economic data related to AFNR systems (e.g., commodity markets, food marketing, food, and nutritional assistance programs).	AFNR.02.01.02.b. Analyze and interpret a set of economic data and explain how it impacts an AFNR system.	AFNR.02.01.02.c. Devise a strategy to solve a problem in an AFNR system using a set of economic data.

Performance Indicator MN.AFNR.02.02

Examine technologies and analyze their impact on AFNR systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AFNR.02.02.01.a. Identify and summarize the components within AFNR systems (e.g., Animal Systems: health, nutrition, genetics; Natural Resources Systems: soil, water).	AFNR.02.02.01.b. Assess components within AFNR systems and analyze relationships between systems.	AFNR.02.02.01.c. Devise and implement a strategy for explaining components of AFNR systems to audiences with limited knowledge.
AFNR.02.02.02.a. Define and summarize societies on local, state, national, and global levels and describe how they relate to AFNR systems.	AFNR.02.02.02.b. Assess how people within societies on local, state, national and global levels interact with AFNR systems on daily, monthly, or yearly basis.	AFNR.02.02.02.c. Evaluate how society traditions, customs or policies have resulted from practices with AFNR systems.
AFNR.02.02.03.a. Examine and summarize the components of the agricultural economy (e.g., environmental, crops, livestock).	AFNR.02.02.03.b. Assess the economic impact of an AFNR system on a local, state, national, and global level.	AFNR.02.02.03.c. Evaluate how positive or negative changes in the local, state, national, or global economy impacts AFNR systems.

MN.AFNR.03: Safety, Health, and Environmental Practices

Examine and summarize the importance of health, safety, and environmental management systems in AFNR workplaces.

Performance Indicator MN.AFNR.03.01

Identify and explain the implications of required regulations to maintain and improve safety, health, and environmental management systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AFNR.03.01.01.a. Research and explain the implications of regulatory, safety, and health standards on AFNR systems (e.g., safety data sheets, bioterrorism).	AFNR.03.01.01.b. Execute health, safety, and environmental procedures to comply with regulatory and safety standards.	AFNR.03.01.01.c. Evaluate how AFNR organizations/businesses promote improved health, safety, and environmental management and determine steps to maintain compliance with regulatory and safety standards in AFNR situations.
AFNR.03.01.02.a. Summarize the importance of safety, health, and environmental management in the workplace.	AFNR.03.01.02.b. Analyze existing required regulations within an AFNR workplace.	AFNR.03.01.02.c. Construct and implement methods to evaluate compliance with required safety, health, and environmental management regulations.

Performance Indicator MN.AFNR.03.02

Develop and implement a plan to maintain and improve health, safety, and environmental compliance and performance.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AFNR.03.02.01.a. Research and identify components required in health and safety performance plans.	AFNR.03.02.01.b. Analyze the effectiveness of health and safety performance plans of an AFNR workplace.	AFNR.03.02.01.c. Create and implement a plan to improve safety, health, and environmental management regulations in an AFNR workplace.
AFNR.03.02.02.a. Examine and categorize examples of environmental compliance plans from AFNR workplace.	AFNR.03.02.02.b. Develop plans to improve environmental compliance and performance within an AFNR system.	AFNR.03.02.02.c. Devise and implement a strategy to educate employees on environmental compliance and performance in an AFNR workplace.

MN.AFNR.03: Safety, Health, and Environmental Practices, Continued

Examine and summarize the importance of health, safety, and environmental management systems in AFNR workplaces.

Performance Indicator MN.AFNR.03.03

Apply health and safety practices to AFNR workplaces.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AFNR.03.03.01.a. Research and summarize the purposes and objectives of health and safety policies and procedures relevant to AFNR careers.	AFNR.03.03.01.b. Analyze and evaluate the impact of current health and safety practices of AFNR workplaces.	AFNR.03.03.01.c. Create and implement a health and safety policy plan for AFNR workplaces.
AFNR.03.03.02.a. Identify emergency response procedures for health and safety issues at AFNR workplaces.	AFNR.03.03.02.b. Assess various emergency response plan requirements for an AFNR workplaces and/or facility.	AFNR.03.03.02.c. Create and implement a plan to communicate appropriate responses for health and safety situations within an AFNR workplace.
AFNR.03.03.03.a. Examine and categorize examples of how to avoid health or safety risks in AFNR workplaces.	AFNR.03.03.03.b. Assess and apply first aid knowledge and procedures relevant to AFNR workplaces.	AFNR.03.03.03.c. Conduct a survey and evaluate results of AFNR workplaces to identify structure of health and safety practices and number of employees certified in first aid training.
AFNR.03.03.04.a. Examine and categorize the risk level of contamination or injury as associated with AFNR tasks in the workplace.	AFNR.03.03.04.b. Assess the safety priorities and select appropriate responses for different levels of contamination or injury at an AFNR workplace.	AFNR.03.03.04.c. Create a plan to mitigate the level of contamination or injury identified as a risk in the workplace.

MN.AFNR.03: Safety, Health, and Environmental Practices, Continued

Examine and summarize the importance of health, safety, and environmental management systems in AFNR workplaces.

Performance Indicator MN.AFNR.03.04

Use appropriate protective equipment and demonstrate safe and proper use of AFNR tools and equipment.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AFNR.03.04.01.a. Identify and differentiate the appropriate protective equipment for the safe use and operation of specific tools and equipment (e.g., personal protective equipment).	AFNR.03.04.01.b. Analyze and demonstrate adherence to protective equipment requirements when using various AFNR tools and equipment.	C3.06.04.01.c. Design and implement plans to ensure the use of appropriate protective equipment when using various AFNR tools and equipment.
AFNR.03.04.02.a. Identify standard tools, equipment, and safety procedures related to AFNR tasks.	AFNR.03.04.02.b. Complete the set up and adjustment for tools and equipment related to AFNR tasks.	C3.06.04.02.c. Evaluate and select appropriate tools and equipment to complete AFNR tasks.
AFNR.03.04.03.a. Read and interpret operating instructions related to operation, storage, and maintenance of tools and equipment related AFNR tasks.	AFNR.03.04.03.b. Assess and demonstrate appropriate operation, storage, and maintenance techniques for AFNR tools and equipment.	C3.06.04.03.c. Devise and implement operation, storage and maintenance plans or schedules for AFNR tools and equipment.

MN.AFNR.04: Stewardship of Natural Resources

Demonstrate stewardship of natural resources in AFNR activities.

Performance Indicator MN.AFNR.04.01

Identify and implement practices to steward natural resources in different AFNR systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AFNR.04.01.01.a. Define stewardship of natural resources and distinguish how it connects to AFNR systems.	AFNR.04.01.01.b. Analyze available practices to steward natural resources in AFNR systems (e.g., wildlife and land conservation, soil and water practices, ecosystem management).	AFNR.04.01.01.c. Devise strategies for stewarding natural resources at home and within community.
AFNR.04.01.02.a. Read and interpret the definition of sustainability and summarize how it relates to AFNR activities.	AFNR.04.01.02.b. Analyze and assess sustainability practices that can be applied in AFNR systems (e.g., energy efficiency, recycle/reuse/repurpose, green resources).	AFNR.04.01.02.c. Evaluate sustainability policies and plans and prepare summary of potential improvements for AFNR businesses or organizations.

Performance Indicator MN.AFNR.04.02

Assess and explain the natural resource related trends, technologies, and policies that impact AFNR systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AFNR.04.02.01.a. Research and examine historical and current natural resources trends and technologies.	AFNR.04.02.01.b. Analyze natural resources trends and technologies and explain how they impact AFNR systems (e.g., climate change, green technologies, water resources).	AFNR.04.02.01.c. Defend or challenge natural resources trends and technologies based upon an assessment of their impact on AFNR systems.
AFNR.04.02.02.a. Research and summarize influential historical and current natural resources policies that impact AFNR systems.	AFNR.04.02.02.b. Create and defend a hypothetical natural resources policy that will impact current AFNR systems (e.g., for water resources, land use, air quality).	AFNR.04.02.02.c. Design and implement strategies for implementing a new natural resources policy that will positively impact AFNR systems.

MN.AFNR.05: Career Opportunities in AFNR

Describe career opportunities and means to achieve those opportunities in each of the Agriculture, Food, and Natural Resources career pathways.

Performance Indicator MN.AFNR.05.01

Evaluate and implement the steps and requirements to pursue a career opportunity in each of the AFNR career pathways (e.g., goals, degrees, certifications, resumes, cover letter, portfolios, interviews).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AFNR.05.01.01.a. Identify and summarize the steps to pursue a career in an AFNR pathway (e.g., self-assessment, set goals).	AFNR.05.01.01.b. Create a personal plan outlining goals and steps to obtain a career in an AFNR pathway.	AFNR.05.01.01.c. Evaluate progress toward AFNR career goals and identify opportunities for improvement and necessary adjustments to one's plan of action
AFNR.05.01.02.a. Examine the educational, training, and experiential requirements to pursue a career in an AFNR pathway (e.g., degrees, certifications, training, internships).	AFNR.05.01.02.b. Analyze personal skillset and create a plan for obtaining the required education, training, and experiences to obtain a career in an AFNR pathway.	AFNR.05.01.02.c. Implement one's personal plan of action for obtaining the required education, training, and experiences and evaluate progress to identify opportunities for improvement and necessary adjustments.
AFNR.05.01.03.a. Research and summarize specific tools (e.g., resumes, portfolios, cover letters) and processes (e.g., interviews, applications) needed to pursue a career in an AFNR pathway.	AFNR.05.01.03.b. Assess personal goals, experiences, education, and skillsets and organize them to produce the appropriate tools and develop the skills to effectively communicate about one's qualifications for an AFNR career.	AFNR.05.01.03.c. Evaluate, update, and improve a set of personal tools to reflect current skills, experiences, education, goals, etc. and complete the processes needed to pursue and obtain a career in an AFNR pathway.

Performance Indicator MN.AFNR.05.02

Examine and choose career opportunities that are matched to personal skills, talents, and career goals in an AFNR pathway of interest.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AFNR.05.02.01.a. Examine and categorize careers in each of the AFNR pathways.	AFNR.05.02.01.b. Assess personal skills and align them with potential career opportunities in AFNR pathways.	AFNR.05.02.01.c. Interpret and evaluate the results of a personal career assessment and connect them to potential careers in AFNR pathways.
AFNR.05.02.02.a. Research and describe careers in each of the AFNR pathways and choose potential careers connecting to personal interests and skills.	AFNR.05.02.02.b. Assemble and analyze examples of careers and related statistics on a local, state, national, and global level.	AFNR.05.02.02.c. Conduct interviews with career professionals within AFNR pathways and summarize the results.

MN.AFNR.06: Interaction Among AFNR Systems

Analyze the interaction among Agriculture, Food, and Natural Resources (AFNR) systems in the production, processing, and management of food, fiber, and fuel and the sustainable use of natural resources.

Performance Indicator MN.AFNR.06.01

Examine and explain foundational cycles and systems of AFNR.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AFNR.06.01.01.a. Research and explain the foundational cycles in AFNR (e.g., water cycle, nutrient cycle, carbon cycle).	AFNR.06.01.01.b. Analyze and explain how foundational cycles affect production, processing, and management of food, fiber, and fuel.	AFNR.06.01.01.c. Teach others about the impact of foundational cycles within AFNR systems.
AFNR.06.01.02.a. Examine and describe examples of systems within AFNR (e.g., sustainability, gate-to-plate).	AFNR.06.01.02.b. Analyze AFNR systems and determine their impact on producing and processing food, fiber, and fuel.	AFNR.06.01.02.c. Evaluate AFNR systems and predict how the systems may change or adapt in the future of food, fiber, and fuel production based on current trends and data.

Performance Indicator MN.AFNR.06.02

Analyze and explain the connection and relationships between different AFNR systems on a national and global level.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AFNR.06.02.01.a. Summarize how AFNR systems connect and relate on a national and global level (e.g., soil, water, economic).	AFNR.06.02.01.b. Analyze differences between AFNR systems on a national and global scale.	AFNR.06.02.01.c. Evaluate how AFNR systems impact each other on a national and global level.
AFNR.06.02.02.a. Examine and summarize changes that happen in AFNR systems on a national and global level (e.g., using less irrigation water, reduction of inputs).	AFNR.06.02.02.b. Analyze the connections and relationships impacted when there is a change in an AFNR system on a national and global level.	AFNR.06.02.02.c. Evaluate how changes in one AFNR system can benefit cost components of other systems on a national and global level.

Section 2 – Cluster-Wide Frameworks: FFA Social-Emotional Skills

Introduction

Leadership Development and the National FFA Organization (i.e., FFA). FFA is a student-led, instructor-supervised, Career and Technical Student Organization (CTSO) that results in measurable outcomes within a predefined, agreed upon set of AFNR social-emotional learning (SEL) standards and Career Ready Practices aligned to a Career Plan of study. FFA teaches SEL and leadership skills and knowledge within the affective domain of learning. FFA includes programs that teach essential employability skills such as critical thinking, communication, and leadership. FFA was founded in 1928 and is federally defined as intracurricular (within the curriculum; cf. extracurricular: external, co-curricular: alongside) and an integral (necessary to form the whole) component of School-Based AFNR Education (Public Law No. 116-7). Leadership/FFA is a required component of an AFNR program, formalized in the FFA Federal Charter in 1950 (Public Law No. 116-7) and reinforced in the federal Perkins Career and Technical Education (CTE) Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires leadership (i.e., FFA) as a component of CTE Program Approval (Minn. R. 3505).

FFA Social Emotional Skills and Career Ready Practices—encompasses fundamental affective skills and social-emotional learning (SEL) practices that all students should acquire to be career ready such as: (1) responsibility, (2) academic and technical skill productivity, (3) healthy choices and maintaining personal finances, (4) communication, (5) decision-making, (6) creativity and innovation, (7) research practices, (8) critical-thinking and problem solving, (9) integrity, ethical leadership, and management, (10) career planning, (11) technology use, and (12) cultural/global competency. Schools must implement leadership standards into all AFNR pathways.

Section Contents

MN.FFA.01: Responsibility

Act as a responsible and contributing citizen and employee. Career-ready individuals understand the obligations and responsibilities of being a member of a community, and they demonstrate this understanding every day through their interactions with others. They are conscientious of the impacts of their decisions on others and the environment around them. They think about the near-term and long-term consequences of their actions and seek to act in ways that contribute to the betterment of their teams, families, community, and workplace. They are reliable and consistent in going beyond the minimum expectation and in participating in activities that serve the greater good.

Performance Indicator MN.FFA.01.01

Model personal responsibility in the workplace and community.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.01.01.01.a. Define personal responsibility and distinguish how it applies in workplace and community (e.g., make educated choices, listen, and follow directions, ask for help when needed, meet expected standards).	FFA.01.01.01.b. Analyze and predict how personal responsibility impacts the workplace and community.	FFA.01.01.01.c. Evaluate past workplace and community situations and determine how personal responsibility positively or negatively impacted outcomes.
FFA.01.01.02.a. Distinguish personal levels of responsibility, which can be applied in the workplace and community.	FFA.01.01.02.b. Assess personal level of responsibility and examine opportunities for improvement.	FFA.01.01.02.c. Model personal responsibility in workplace and community situations.

MN.FFA.01: Responsibility, Continued

Act as a responsible and contributing citizen and employee.

Performance Indicator MN.FFA.01.02

Evaluate and consider the near-term and long-term impacts of personal and professional decisions on employers and community before taking action.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.01.02.01.a. Classify the near- and long-term impacts of personal decisions on self and others (e.g., decisions involving health, relationships, money, perceptions, education).	FFA.01.02.01.b. Assess the pros and cons of personal decisions based on their anticipated impact on self and others.	FFA.01.02.01.c. Make and defend personal decisions after analyzing their near- and long-term impacts on self and others.
FFA.01.02.02.a. Classify professional decisions by their near- and long-term impact on employers and community (e.g., decisions involving: financials, business goals, processes, customer satisfaction, corporate image).	FFA.01.02.02.b. Analyze the pros and cons of professional decisions based upon impact on employers and community.	FFA.01.02.02.c. Make and defend professional decisions after evaluating their near- and long-term impacts on employers and community.

Performance Indicator MN.FFA.01.03

Identify and act upon opportunities for professional and civic service at work and in the community.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.01.03.01.a. Define and categorize opportunities for professional service at work and in the community (e.g., serve on committees, attend meetings).	FFA.01.03.01.b. Assess available professional service opportunities at workplaces and in community (e.g., trainings, organizing events).	FFA.01.03.01.c. Devise, implement, and evaluate strategies for involvement in professional service opportunities at work and in the community (e.g., coaching/mentorship, presentations at meetings).
FFA.01.03.02.a. Identify civic service opportunities in workplaces and the community (e.g., organizations, fundraising).	FFA.01.03.02.b. Assess available civic service opportunities at workplaces and in the community (e.g., community events, attend meetings).	FFA.01.03.02.c. Devise, implement, and evaluate strategies for personal involvement in civic service at work and in the community (e.g., volunteer at food pantry, community clean-up, join organizations or committees).

MN.FFA.02: Application of Skills

Apply appropriate academic and technical skills. Career-ready individuals readily access and use the knowledge and skills acquired through experience and education to be more productive. They make connections between abstract concepts with real-world applications, and they make correct insights about when it is appropriate to apply the use of an academic skill in a workplace situation.

Performance Indicator MN.FFA.02.01

Use strategic thinking to connect and apply academic learning, knowledge, and skills to solve problems in the workplace and community.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.02.01.01.a. Distinguish opportunities to apply academic learning to solve problems in the workplace (e.g., identify how to: increase productivity, reduce costs, lower inputs).	FFA.02.01.01.b. Assess workplace problems and identify the most appropriate academic knowledge and skills to apply.	FFA.02.01.01.c. Apply academic knowledge and skills to solve problems in the workplace and reflect upon the results achieved.
FFA.02.01.02.a. Distinguish opportunities to apply academic learning to solve problems in the community (e.g., identify how to: stop businesses from closing, increase access to emergency services, eliminate hunger).	FFA.02.01.02.b. Assess community problems and identify the most appropriate academic knowledge and skills to apply.	FFA.02.01.02.c. Apply academic knowledge and skills to solve problems in the community and reflect upon results achieved.

Performance Indicator MN.FFA.02.02

Use strategic thinking to connect and apply technical concepts to solve problems in the workplace and community.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.02.02.01.a. Identify opportunities to apply technical concepts to solve problems in the workplace (e.g., identify how to: increase sales, better customer service, reduce inputs, reduce waste, ensure sustainability).	FFA.02.02.01.b. Assess workplace problems and distinguish the most appropriate technical concepts to apply.	FFA.02.02.01.c. Apply technical concepts to solve problems in the workplace and reflect upon the results achieved.
FFA.02.02.02.a. Identify opportunities to apply technical concepts to solve problems in the community (e.g., identify how to: ensure safe routes to schools, reduce vandalism, reduce air pollution).	FFA.02.02.02.b. Assess community problems and identify the most appropriate technical concepts to apply.	FFA.02.02.02.c. Apply technical concepts to solve problems in the community and reflect upon results achieved.

MN.FFA.03: Health and Well-Being

Attend to personal health and financial well-being. Career-ready individuals understand the relationship between personal health, workplace performance, and personal well-being; they act on that understanding to regularly practice healthy diet, exercise, and mental health activities. Career-ready individuals also take regular action to contribute to their personal financial well-being, understanding that personal financial security provides the peace of mind required to contribute more fully to their own career success.

Performance Indicator MN.FFA.03.01

Design and implement a personal wellness plan.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.03.01.01.a. Examine and summarize components in a personal wellness plan (e.g., healthy diet, exercise, mental health activities).	FFA.03.01.01.b. Assess the risks and benefits of implementing a personal wellness plan.	FFA.03.01.01.c. Create, implement, and continually evaluate a personal wellness plan.
FFA.03.01.02.a. Research the impact of personal wellness plans in workplaces and communities.	FFA.03.01.02.b. Analyze the relationship between personal wellness and workplace performance.	FFA.03.01.02.c. Evaluate personal wellness plans in workplace and community organizations and the effectiveness of the plans.

Performance Indicator MN.FFA.03.02

Design and implement a personal financial management plan.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.03.02.01.a. Research and examine components in a personal financial management plan (e.g., income, expense, budgeting, savings, credit).	FFA.03.02.01.b. Analyze management tools available for managing personal finances (e.g., software, calendars, banks, financial institutions).	FFA.03.02.01.c. Appraise and select management tools to include in a personal financial management plan.
FFA.03.02.02.a. Examine and categorize personal financial practices (e.g., earning, spending, use of management tools, credit).	FFA.03.02.02.b. Analyze the effectiveness of a personal financial management plan and explain how this practice may contribute to future financial independence.	FFA.03.02.02.c. Design, implement, and evaluate a personal financial management plan

MN.FFA.04: Communication

Communicate clearly, effectively, and with reason. Career-ready individuals communicate thoughts, ideas, and action plans with clarity, whether using written, verbal, or visual methods. They communicate in the workplace with clarity and purpose to make maximum use of their own and others' time. They are excellent writers; they master conventions, word choice, and organization, and use effective tone and presentation skills to articulate ideas. They are skilled at interacting with others; they are active listeners and speak clearly and with purpose. Career-ready individuals think about the audience for their communication and prepare accordingly to ensure the desired outcome.

Performance Indicator MN.FFA.04.01

Speak using strategies that ensure clarity, logic, purpose, and professionalism in formal and informal settings.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.04.01.01.a. Identify and categorize strategies for ensuring clarity, logic, purpose, and professionalism in verbal and non-verbal communication (e.g., vocal tone, organization of thoughts, eye contact, preparation).	FFA.04.01.01.b. Analyze use of verbal and non-verbal communication strategies in workplace situations.	FFA.04.01.01.c. Evaluate other's verbal and non-verbal communications (e.g., speeches, presentations, oral reports) and propose recommendations for improvement in clarity, logic, purpose, and professionalism.
FFA.04.01.02.a. Examine and assess personal ability to speak with clarity, logic, purpose, and professionalism in formal and informal settings (e.g., speeches, interviews, presentations).	FFA.04.01.02.b. Apply strategies for speaking with clarity, logic, purpose, and professionalism in a variety of situations in formal and informal settings.	FFA.04.01.02.c. Evaluate personal strengths and areas for growth with regard to speaking formally and informally with clarity, logic, purpose, and professionalism, and identify ways to improve.

MN.FFA.04: Communication, Continued

Communicate clearly, effectively, and with reason.

Performance Indicator MN.FFA.04.02

Produce clear, reasoned, and coherent written and visual communication in formal and informal settings.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.04.02.01.a. Research and summarize the purpose of different forms of written and visual communication in formal and informal settings (e.g., letters, emails, reports, social media, graphics, diagrams).	FFA.04.02.01.b. Compare and contrast the structure of different forms of written and visual communication.	FFA.04.02.01.c. Evaluate the effectiveness of different forms of written and visual communication for achieving their intended purpose.
FFA.04.02.02.a. Identify and examine methods for producing clear, reasoned, and coherent written and visual communication that are appropriate to the task, purpose, and audience (e.g., audience analysis).	FFA.04.02.02.b. Apply techniques for ensuring clarity, logic, and coherence to edit written and visual communications (e.g., emails, reports, presentations, technical documents, diagrams).	FFA.04.02.02.c. Compose clear and coherent written documents and visuals (e.g., agendas, audio-visuals, drafts, forms) that are adapted to the audience needs in both formal and informal settings.

Performance Indicator MN.AFNR.04.03

Model active listening strategies when interacting with others in formal and informal settings.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.04.03.01.a. Research and summarize components of active listening (e.g., eye contact, have an open mind, restate).	FFA.04.03.01.b. Apply active listening strategies (e.g., be attentive, observe non-verbal cues, ask clarifying questions).	FFA.04.03.01.c. Evaluate personal effectiveness and devise a plan to improve active listening skills.
FFA.04.03.02.a. Observe and identify use of active listening strategies in formal (e.g., speeches, presentations) and informal (e.g., conversations, meetings) settings.	FFA.04.03.02.b. Apply and evaluate personal level of active listening strategies in formal and informal settings.	FFA.04.03.02.c. Model active listening strategies in formal and informal settings.

MN.FFA.05: Decision Making

Consider the environmental, social, and economic impacts of decisions. Career-ready individuals understand the interrelated nature of their actions and regularly make decisions that positively impact and mitigate negative impact on other people, organizations, and the environment. They are aware of and utilize new technologies, understandings, procedures, materials, and regulations affecting the nature of their work as it relates to the impact on the social condition, the environment, and the profitability of the organization.

Performance Indicator MN.FFA.05.01

Assess, identify, and synthesize the information and resources needed to make decisions that positively impact the workplace and community settings.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.05.01.01.a. Examine and describe the steps in the decision-making process used in the workplace and community.	FFA.05.01.01.b. Analyze how the process of decision making is used in workplace and community situations.	FFA.05.01.01.c. Evaluate workplace and community decision-making processes and devise strategies for improvement.
FFA.05.01.02.a. Examine and explain the relationship between information, resources, and good decision making in workplace and community situations.	FFA.05.01.02.b. Analyze past workplace and community situations to determine if appropriate information and resources were used to make an effective decision.	FFA.05.01.02.c. Evaluate workplace and community situations and recommend the information and resources needed to support good decisions.
FFA.05.01.03.a. Classify the types of information (e.g., data, research, procedures, regulations) and resources (e.g., human, financial, technology, time) that may be used to make workplace and community decisions.	FFA.05.01.03.b. Analyze workplace and community decisions and assess the information and resources used to make those decisions.	FFA.05.01.03.c. Synthesize information and resources and apply to workplace and community situations to make positive decisions.

Performance Indicator MN.FFA.05.02

Make, defend, and evaluate decisions at work and in the community using information about the potential environmental, social, and economic impacts.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.05.02.01.a. Examine areas in the workplace and community where decisions will make a positive impact.	FFA.05.02.01.b. Apply a structured decision-making process to improve workplace and community situations.	FFA.05.02.01.c. Evaluate and defend decisions applied in the workplace and community situations.
FFA.05.02.02.a. Examine information about environmental, social, and economic impacts when making decisions in the workplace and community.	FFA.05.02.02.b. Assess past decisions made in workplace and community and analyze their effects on environmental, social, and economic situations.	FFA.05.02.02.c. Evaluate workplace and community situations and propose decisions based upon the positive impact made on society, the economy and the environment.

MN.FFA.06: Creativity and Innovation

Demonstrate creativity and innovation. Career-ready individuals regularly think of ideas that solve problems in new and different ways, and they contribute those ideas in a useful and productive manner to improve their organization. They can consider unconventional ideas and suggestions as solutions to issues, tasks, or problems, and they discern which ideas and suggestions will add greatest value. They seek new methods, practices, and ideas from a variety of sources and seek to apply those ideas to their own workplace. They take action on their ideas and understand how to bring innovation to an organization.

Performance Indicator MN.FFA.06.01

Synthesize information, knowledge, and experience to generate original ideas and challenge assumptions in the workplace and community.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.06.01.01.a. Identify and summarize steps for generating ideas used in the workplace and community.	FFA.06.01.01.b. Synthesize information, knowledge, and experiences to generate ideas for workplace and community situations.	FFA.06.01.01.c. Evaluate workplace and community situations and devise strategies to apply original ideas.
FFA.06.01.02.a. Define "assumption" and identify different types and sources of assumptions that could impact effectiveness in workplace and community situations.	FFA.06.01.02.b. Analyze how assumptions can impact outcomes in a variety of workplace and community situations.	FFA.06.01.02.c. Devise and apply strategies (e.g., ask questions, brainstorm ideas, present facts and information) to challenge common assumptions in workplace and community situations.

Performance Indicator MN.FFA.06.02

Assess a variety of workplace and community situations to identify ways to add value and improve the efficiency of processes and procedures.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.06.02.01.a. Identify and categorize the types of processes and procedures used in workplaces and the community (e.g., health and safety, email, compliance).	FFA.06.02.01.b. Analyze how processes and procedures are implemented in workplace and community situations (e.g., employee evaluations, vacation, leave time).	FFA.06.02.01.c. Evaluate past workplace and community situations and determine how processes and procedures impacted outcomes.
FFA.06.02.02.a. Identify and summarize methods used to increase efficiency and add value to workplace and community processes and procedures (e.g., individual input, scheduled reviews).	FFA.06.02.02.b. Predict and communicate potential gains in efficiency and value-added from implementing an improved process or procedure.	FFA.06.02.02.c. Construct and implement methods to improve workplace and community processes and procedures.

MN.FFA.06: Creativity and Innovation, Continued

Demonstrate creativity and innovation.

Performance Indicator MN.FFA.06.03

Use appropriate protective equipment and demonstrate safe and proper use of AFNR tools and equipment.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.06.03.01.a. Examine workplace and community situations to identify opportunities for improvement through the introduction of new ideas and innovations.	FFA.06.03.01.b. Assess and communicate the risks and benefits of applying new ideas and innovations to the workplace and community.	FFA.06.03.01.c. Design a plan of action to introduce a new idea or innovation into the workplace and community.
FFA.06.03.02.a. Identify individuals and organizations (i.e., stakeholders) that need to provide input and feedback on new ideas or innovation prior to implementation in the workplace or community.	FFA.06.03.02.b. Elicit and assimilate input and feedback from individuals and organizations about new ideas or innovations for the workplace or community.	FFA.06.03.02.c. Evaluate and execute strategies for using stakeholder input and feedback to improve a plan of action for introducing a new idea or innovation into the workplace or community.

MN.FFA.07: Research Strategies

Employ valid and reliable research strategies. Career-ready individuals are discerning in accepting and using new information to make decisions, change practices, or inform strategies. They use a reliable research process to search for new information. They evaluate the validity of sources when considering the use and adoption of external information or practices. They use an informed process to test new ideas, information, and practices in their workplace situation.

Performance Indicator MN.FFA.07.01

Select and implement reliable research processes and methods to generate data for decision-making in the workplace and community.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.07.01.01.a. Identify and summarize reliable research processes and methods used to generate data for decision-making.	FFA.07.01.01.b. Analyze how different research methods are used to generate data in a variety of situations.	FFA.07.01.01.c. Evaluate business' and organizations' use of research methods and processes and propose recommendations for improvement.
FFA.07.01.02.a. Identify the data requirements for potential decisions in the workplace and community and determine possible research strategies to use to generate the necessary data.	FFA.07.01.02.b. Assess the positives and negatives of using different research strategies and methods to generate data for workplace and community decisions and use this information to select appropriate methods.	FFA.07.01.02.c. Design plans for use and implementation of reliable research methods to generate data for decision making in workplace and community situations.

Performance Indicator MN.FFA.07.02

Evaluate the validity of sources and data used when considering the adoption of new technologies, practices, and ideas in the workplace and community.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.07.02.01.a. Identify and summarize types of data sources available to research new technologies and practices for workplaces and community organizations (e.g., blog, research, news).	FFA.07.02.01.b. Assess data sources for reliability and validity.	FFA.07.02.01.c. Propose valid and reliable data sources to use when considering the adoption of new technologies, practices, and ideas.
FFA.07.02.02.a. Categorize potential technologies, practices and ideas that could be adopted by workplaces and community organizations.	FFA.07.02.02.b. Assimilate data to assist in making a decision about the adoption of a new technology, practice, or idea by workplaces and community organizations.	FFA.07.02.02.c. Create and defend proposals for new technologies, practices, and ideas using valid and reliable data sources.

MN.FFA.08: Critical Thinking

Utilize critical thinking to make sense of problems and persevere in solving them. Career-ready individuals readily recognize problems in the workplace, understand the nature of the problem, and devise effective plans to solve the problem. They are aware of problems when they occur and take action quickly to address the problem. They thoughtfully investigate the root cause of the problem prior to introducing solutions. They carefully consider the options to solve the problem. Once a solution is agreed upon, they follow through to ensure the problem is solved, whether through their own actions or the actions of others.

Performance Indicator MN.FFA.08.01

Apply reason and logic to evaluate workplace and community situations from multiple perspectives.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.08.01.01.a. Identify and summarize steps to think critically (e.g., identify problem, gather information, brainstorm solutions).	FFA.08.01.01.b. Apply steps for critical thinking to a variety of workplace and community situations.	FFA.08.01.01.c. Evaluate how applying critical thinking skills can impact workplace and community situations.
FFA.08.01.02.a. Examine and identify opportunities to apply reason, logic, and multiple perspectives to solve problems in workplace and community situations.	FFA.08.01.02.b. Assess solutions to workplace and community problems for evidence of reason, logic, and consideration of multiple perspectives.	FFA.08.01.02.c. Devise and implement strategies to apply reason, logic, and input from multiple perspectives to solve workplace and community problems.

Performance Indicator MN.FFA.08.02

Investigate, prioritize, and select solutions to solve problems in the workplace and community.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.08.02.01.a. Investigate and summarize potential tools and resources used to solve problems in the workplace and community.	FFA.08.02.01.b. Assimilate and prioritize potential solutions to solve problems in the workplace and community.	FFA.08.02.01.c. Devise and implement strategies to evaluate the effectiveness of solutions for resolving workplace and community problems.
FFA.08.02.02.a. Identify and summarize steps in the decision-making process to solve workplace and community problems.	FFA.08.02.02.b. Apply decision-making processes to generate possible solutions to solve workplace and community problems.	FFA.08.02.02.c. Evaluate and select solutions with greatest potential for success to solve workplace and community problems.

MN.FFA.08: Critical Thinking, Continued

Utilize critical thinking to make sense of problems and persevere in solving them.

Performance Indicator MN.FFA.08.03

Establish plans to solve workplace and community problems and execute them with resiliency.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.08.03.01.a. Identify different types of problem-solving models and summarize their applicability to workplace and community situations.	FFA.08.03.01.b. Analyze and determine the best problem-solving model to apply to workplace and community problems.	FFA.08.03.01.c. Evaluate the effectiveness of different problem-solving models for reaching a solution to workplace and community issues.
FFA.08.03.02.a. Identify and analyze the elements of a plan for solving workplace and community problems (e.g., budget, timeline).	FFA.08.03.02.b. Create plans to solve workplace and community problems.	FFA.08.03.02.c. Implement and evaluate plans to solve workplace and community problems.

MN.FFA.09: Integrity and Ethical Leadership

Model integrity, ethical leadership, and effective management. Career-ready individuals readily recognize problems in the workplace, understand the nature of the problem, and devise effective plans to solve the problem. They are aware of problems when they occur and take action quickly to address the problem. They thoughtfully investigate the root cause of the problem prior to introducing solutions. They carefully consider the options to solve the problem. Once a solution is agreed upon, they follow through to ensure the problem is solved, whether through their own actions or the actions of others.

Performance Indicator MN.FFA.09.01

Model characteristics of ethical and effective leaders in the workplace and community.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.09.01.01.a. Identify and summarize the characteristics of ethical and effective leaders in workplace and community settings.	FFA.09.01.01.b. Analyze workplace and community leaders and determine what ethical and effective leadership characteristics they demonstrate.	FFA.09.01.01.c. Evaluate ethical and effective leadership characteristics demonstrated by others.
FFA.09.01.02.a. Reflect upon and summarize situations where ethical and effective leadership characteristics were needed or personally demonstrated (e.g., motivation, empathy).	FFA.09.01.02.b. Conduct a self-assessment of personal ethical and effective leadership characteristics (e.g., relates to others, focused, integrity) and reflect upon the results to identify opportunities for improvement.	FFA.09.01.02.c. Model characteristics and actions of ethical and effective leaders in workplace and community situations (e.g., integrity, self-awareness).

Performance Indicator MN.FFA.09.02

Implement personal management skills to function effectively and efficiently in the workplace.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.09.02.01.a. Identify and summarize personal management skills necessary to function effectively in the workplace (e.g., time management, planning, prioritizing).	FFA.09.02.01.b. Analyze leaders' use of effective personal management skills and determine how they apply them in workplace and community situations.	FFA.09.02.01.c. Evaluate opportunities to apply personal management skills into daily tasks and responsibilities.
FFA.09.02.02.a. Examine and describe personal management skills (e.g., time management, prioritizing, setting goals) that are individually implemented and demonstrated in workplace and community situations.	FFA.09.02.02.b. Conduct a self-assessment of personal management skills used in daily workplace or community situations.	FFA.09.02.02.c. Model personal management skills and identify opportunities for continuous improvement.

MN.FFA.09: Integrity and Ethical Leadership, Continued

Model integrity, ethical leadership, and effective management.

Performance Indicator MN.FFA.09.03

Demonstrate behaviors that contribute to a positive morale and culture in the workplace and community (e.g., positively influencing others, effectively communicating).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.09.03.01.a. Identify and summarize respectful and purposeful behaviors that contribute to positive morale and culture in workplace and community settings (e.g., positively influencing others, effectively communicating).	FFA.09.03.01.b. Analyze the relationship between demonstrating respectful and purposeful behaviors (e.g., collaborative, clear expectations) and increased influence in the workplace and community.	FFA.09.03.01.c. Evaluate workplace and community cultures and determine specific behaviors and actions that contribute to building the morale and culture.
FFA.09.03.02.a. Examine personal levels of respectful and purposeful behaviors and summarize how they are demonstrated (e.g., treat others with respect, model professionalism).	FFA.09.03.02.b. Devise, implement and evaluate strategies for continuation and improvement of respectful and purposeful behaviors that contribute to positive morale and culture in workplace and community (e.g., recognize others' skills, promote collaboration).	FFA.09.03.02.c. Model respectful and purposeful behaviors that contribute to positive morale and culture in the workplace and community (e.g., effectively communicating, recognizing accomplishments of others).

MN.FFA.10: Career Planning

Plan education and career path aligned to personal goals. Career-ready individuals take personal ownership of their own educational and career goals, and they regularly act on a plan to attain these goals. They understand their own career interests, preferences, goals, and requirements. They have perspective regarding the pathways available to them and the time, effort, experience, and other requirements to pursue each, including a path of entrepreneurship. They recognize the value of each step in the educational and experiential process, and they recognize that nearly all career paths require ongoing education and experience. They seek counselors, mentors, and other experts to assist in the planning and execution of career and personal goals.

Performance Indicator MN.FFA.10.01

Identify career opportunities within a career cluster that match personal interests, talents, goals, and preferences.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.10.01.01.a. Determine personal interests, talents, goals, and preferences for potential careers.	FFA.10.01.01.b. Assess and select areas for growth and improvement based upon analysis of personal interests for potential careers.	FFA.10.01.01.c. Plan a career path based on personal interests, talents, goals, and preferences.
FFA.10.01.02.a. Examine career clusters and identify potential career opportunities based on personal interests, talents, goals, and preferences.	FFA.10.01.02.b. Analyze skills needed for potential careers and compare and contrast skills needed with personal interests, talents, goals, and preferences.	FFA.10.01.02.c. Match potential career opportunities in career clusters with personal interests, talents, goals, and preferences.

Performance Indicator MN.FFA.10.02

Examine career advancement requirements (e.g., education, certification, training) and create goals for continuous growth in a chosen career.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.10.02.01.a. Categorize career advancement requirements for potential careers (e.g., degrees, certification, training).	FFA.10.02.01.b. Analyze the steps to meet career advancement requirements for potential careers.	FFA.10.02.01.c. Devise and implement plans to complete the requirements for career advancement.
FFA.10.02.02.a. Identify methods for setting goals for personal improvement and continuous growth in a career area (e.g., SMART goals, training, professional development).	FFA.10.02.02.b. Create goals for personal improvement and continuous growth in a career area.	FFA.10.02.02.c. Evaluate actions taken and make appropriate modifications to continuous growth goals in career areas.

MN.FFA.10: Career Planning, Continued

Plan education and career path aligned to personal goals.

Performance Indicator MN.FFA.10.03

Develop relationships with and assimilate input and advice from experts (e.g., counselors, mentors) to plan career and personal goals in a chosen career area.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.10.03.01.a. Summarize ways that input and advice from career area experts could assist in planning personal career goals.	FFA.10.03.01.b. Assess career and personal goals and determine additional information career area experts could provide.	FFA.10.03.01.c. Devise strategies to gather answers and information from career area experts and use this information to plan and execute goals.
FFA.10.03.02.a. Identify trusted individuals to consult with on setting and achieving career and personal goals (e.g., counselors, teachers, mentors, coaches, community leaders).	FFA.10.03.02.b. Devise and implement strategies to gather input and advice for planning career and personal goals from trusted experts.	FFA.10.03.02.c. Assimilate input and advice from experts and formulate plans to implement into career and personal goals for chosen career areas.

Performance Indicator MN.FFA.10.04

Model active listening strategies when interacting with others in formal and informal settings.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.10.04.01.a. Identify and explain the purpose of fundamental tools used to pursue a career path (e.g., resume, cover letter, portfolio) as well as the common components of each (e.g., content in cover letter, categories in resume).	FFA.10.04.01.b. Organize personal information (e.g., goals, experiences, education, achievements, work examples) to prepare and continuously update a set of tools to aid in the pursuit of a career path.	FFA.10.04.01.c. Select and use appropriate tools to pursue career advancement opportunities and assimilate feedback from the process to identify improvements for the future.
FFA.10.04.02.a. Summarize common processes involved in pursuing a career (e.g., interviews, applications, networking) and the appropriate tools used for completing each.	FFA.10.04.02.b. Examine and practice the skills needed to complete common processes for pursuing a career (e.g., ability to communicate about past experiences, ability to articulate one's goals and career objectives).	FFA.10.04.02.c. Apply skills to complete common processes involved in pursuing a career and assimilate input and feedback from experts (e.g., mentors, teachers, businesspersons) to improve.

MN.FFA.11: Application of Technology

Use technology to enhance productivity. Career-ready individuals find and maximize the productive value of existing and new technology to accomplish workplace tasks and solve workplace problems. They are flexible and adaptive in acquiring and using new technology. They are proficient with ubiquitous technology applications. They understand the inherent risks—personal and organizational—of technology applications, and they take actions to prevent or mitigate these risks.

Performance Indicator MN.FFA.11.01

Research, select, and use new technologies, tools, and applications to maximize productivity in the workplace and community.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.11.01.01.a. Identify and summarize new technologies, tools, and applications to use in workplace and community situations.	FFA.11.01.01.b. Analyze advantages and disadvantages of new technologies, tools, and applications to maximize productivity in the workplace and community.	FFA.11.01.01.c. Construct effective communications to explain the features, benefits, and risks of new technologies, tools, and applications in the workplace and community.
FFA.11.01.02.a. Examine and categorize opportunities in workplace and community settings to use new technologies, tools, and applications to maximize productivity and efficiency.	FFA.11.01.02.b. Select, apply, and use new technologies, tools, and applications in workplace and community situations to maximize productivity.	FFA.11.01.02.c. Evaluate effectiveness and make recommendations for using new technologies, tools, and applications in the workplace and community.

Performance Indicator MN.FFA.11.02

Evaluate personal and organizational risks of technology use and take actions to prevent or minimize risks in the workplace and community.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.11.02.01.a. Identify and summarize potential personal and organizational risks of using technology in the workplace and community.	FFA.11.02.01.b. Assess the physical, financial, and professional risks associated with using technology in the workplace and community and use this information to determine appropriate uses of technology.	FFA.11.02.01.c. Construct and implement methods to evaluate personal and organizational risks of technology in workplace and community settings.
FFA.11.02.02.a. Synthesize tools and processes to prevent or minimize risks of technology use in community and work settings (e.g., risk management tools, benefit risks).	FFA.11.02.02.b. Analyze the effectiveness of methods for preventing or minimizing the risks of technology use.	FFA.11.02.02.c. Design and implement strategies to prevent or minimize the risks of technology use in the workplace and community.

MN.FFA.12: Teamwork and Cultural Competency

Work productively in teams while using cultural/global competence. Career-ready individuals positively contribute to every team, whether formal or informal. They apply an awareness of cultural differences to avoid barriers to productive and positive interaction. They find ways to increase the engagement and contribution of all team members. They plan and facilitate effective team meetings.

Performance Indicator MN.FFA.12.01

Speak using strategies that ensure clarity, logic, purpose, and professionalism in formal and informal settings.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.12.01.01.a. Differentiate the strengths and talents of all team members needed to complete projects in the workplace and community.	FFA.12.01.01.b. Formulate action plans to complete team-oriented projects in the workplace and community, including plans for personal contributions.	FFA.12.01.01.c. Evaluate the effectiveness of team-oriented projects at work and in the community and make recommendations for future improvements.
FFA.12.01.02.a. Identify and summarize techniques to build consensus in a team situation.	FFA.12.01.02.b. Apply consensus building techniques to accomplish results in team-oriented situations.	FFA.12.01.02.c. Devise and implement methods to obtain feedback from team members on their experiences after completing workplace and community projects.
FFA.12.01.03.a. Identify and categorize components of cultural and global competence (e.g., awareness, attitude, understanding cultural differences).	FFA.12.01.03.b. Assess the need and benefit for cultural and global competency and apply these competencies in team settings at work and in the community.	FFA.12.01.03.c. Evaluate personal level of cultural and global competence and implement plans for growth and improvement in workplace and community situations.

Performance Indicator MN.FFA.12.02

Create and implement strategies to engage team members to work toward team and organizational goals in a variety of workplace and community situations (e.g., meetings, presentations).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FFA.12.02.01.a. Identify and summarize effective strategies used to engage team members to accomplish goals.	FFA.12.02.01.b. Assess team dynamics and match strategies to increase team member engagement.	FFA.12.02.01.c. Create and implement novel strategies to engage team members based on the situation.
FFA.12.02.02.a. Examine and summarize workplace and community situations where it is important to engage team members to meet team and organizational goals (e.g., meetings, presentations).	FFA.12.02.02.b. Select strategies to engage team members and apply in a variety of situations.	FFA.12.02.02.c. Evaluate the effectiveness of strategies to engage team members in a variety of workplace and community situations.

Section 3 – Cluster-Wide: SAE and WBL Technical Skills

Introduction

Work-Based Learning and Supervised Agricultural Experiences (i.e., SAE). Supervised Agricultural Experience (SAE) is a student-led, instructor-supervised, Work-Based Learning (WBL) experience that results in measurable outcomes within a predefined, agreed upon set of AFNR Technical Standards and Career Ready Practices aligned to a Career Plan of study. SAE teaches technical skills and knowledge within the psychomotor domain of learning. SAE includes both experiential learning (i.e., pre-WBL) and WBL (federally defined as sustained interactions with industry or community professionals in real workplace settings, to the extent practicable, or simulated environments, at an educational institution that foster in-depth, firsthand engagement with the tasks required in a given career field, that are aligned to curriculum and instruction; Sec. 3 [20 U.S.C. 2302] 55). WBL/SAE is a required component of an AFNR program, first established in the Smith-Hughes Act (1917) and reinforced in each of the federal Perkins CTE Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires WBL (i.e., SAE) as a component of CTE Program Approval (Minn. R. 3505).

SAE and WBL Technical Skills—encompasses fundamental psychomotor skills and technical practices that all students should acquire to apply cognitive content and social-emotional skills in an industry setting, such as: (1) career planning, (2) securing employment, (3) health, safety, and human resource regulations in the workplace, (4) employability skills, (5) communication, (6) financial literacy, and (7) technical skills within a work-based learning experience. Schools must implement work-based learning standards into all AFNR pathways.

Section Contents

Note: The standards within this section mirror the Minnesota WBL Frameworks; they have been reorganized and may not follow the same numbering sequence when comparing individual benchmarks to the WBL Frameworks. The WBL Frameworks also align to services under the federal Workforce Innovation and Opportunity Act including job exploration counseling (JEC), work-based learning experiences (WBLE), postsecondary education counseling (PEC), workplace readiness training (WRT), and instruction in self-advocacy (ISA).

MN.SAE.01: Career Planning

Explore career interests while focusing on career planning.

Performance Indicator MN.SAE.01.01

Develop a sense of self as it relates to career planning.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.01.01.01.a. Identify personal interests, aptitudes, abilities, strengths, talents, and areas for growth (CSI 1.01, JEC 1).	SAE.01.01.01.b. Identify personal interests, aptitudes, abilities, strengths, talents, and areas for growth (CSII 1.01, JEC 1).	None
SAE.01.01.02.a. Complete an interest assessment (CSI 1.02, JEC 1).	SAE.01.01.02.b. Analyze personal interests, aptitudes, abilities, strengths, talents to determine how well they match with careers of interest (CSII 1.01, JEC 1).	None
SAE.01.01.03.a. Complete a personality assessment (CSI 1.01, JEC 1).	SAE.01.01.03.b. Complete a personality assessment (CSII 1.01, JEC 1).	None

MN.SAE.01: Career Planning, Continued

Explore career interests while focusing on career planning.

Performance Indicator MN.SAE.01.02

Research and identify career opportunities that align with personal interests and aptitudes.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.01.02.01.a. Identify skills and educational requirements for career opportunities of interest (CSI 1.02, PEC 2.4, JEC 2.3).	SAE.01.02.01.b. Compare and contrast education/training requirements for employment in careers of interest (CSII 1.02, PEC 2.4).	SAE.01.02.01.c. Identify required education, skills, and experience for a desired role (JEC 2.3, JEC 2.4, PEC 2.4, WE 1.03).
SAE.01.02.02.a. Compare and contrast the wide variety of postsecondary education options available for career interests, including technical, community and 4-year college options, apprenticeship, short-term options, military, etc. (CSI 1.02, PEC 2.1).	SAE.01.02.02.b. Compare and contrast the wide variety of postsecondary education options available for career interests, including technical, community and 4-year college options, apprenticeship, short-term options, military, etc. (CSII 1.02, PEC 2.1).	None
SAE.01.02.03.a. Review job outlook for career opportunities of interest (CSI 1.02, JEC 2.5).	SAE.01.02.03.b. Review job outlook for career opportunities of interest (CSII 1.02, JEC 2.5).	None
None	SAE.01.02.04.b. Assess the relative income and benefits of a possible career goal with respect to personal goals and lifestyle (CSII 1.02, JEC 2.7).	None
None	SAE.01.02.05.b. Investigate opportunities for career advancements (CSII 1.02, JEC 2.8).	SAE.01.02.05.c. Understand the roles of different positions within career paths of interest (JEC 2.1, WE 1.03).

MN.SAE.01: Career Planning, Continued

Explore career interests while focusing on career planning.

Performance Indicator MN.SAE.01.03

Explore entrepreneurial opportunities in a career field of interest.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
None	SAE.01.03.01.b. Describe the opportunities for entrepreneurship in a given industry (CSII 1.03, JEC 3.1).	None
None	SAE.01.03.02.b. Understands the knowledge and skills required of an entrepreneur (CSII 1.03, JEC 3.2).	None
None	SAE.01.03.03.b. Understands the opportunities, benefits, and risks of entrepreneurship versus employment in a career (CSII 1.03, JEC 3.3).	None

Performance Indicator MN.SAE.01.04

Develop a plan for meeting education and career goals.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.01.04.01.a. Create an academic plan based on careers of interest (CSI 1.03, WRT 1.1).	SAE.01.04.01.b. Create an academic plan based on careers of interest and identify employment trends and unknown factors that affect career plans (CSII 1.04, WRT 1.1).	SAE.01.04.01.c. List action steps toward achieving that goal (WE 1.03, WRT 1.1).
SAE.01.04.02.a. Participate in experiential learning such as job shadows, informational interviews, or industry tours related to careers of interest (CSI 1.03, WBLE 1).	SAE.01.04.02.b. Participate in experiential learning such as job shadows or informational interviews related to careers of interest (CSII 1.04, WBLE 1).	None
None	SAE.01.04.03.b. Identify and grow a personal network (CSII 1.04, WBLE 5).	None

MN.SAE.02: Securing Employment

Seek and successfully secure employment.

Performance Indicator MN.SAE.02.01

Identify sources for finding employment opportunities.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.02.01.01.a. Use multiple resources to locate job opportunities (CSI 2.01, WRT 2.5.1).	SAE.02.01.01.b. Identify online resources for locating job opportunities (CSII 2.01, WRT 2.5.3).	None
SAE.02.01.02.a. Compare personal strengths and weaknesses to job requirements (CSI 2.01, WRT 2.5.2).	SAE.02.01.02.b. Identify personal and professional networks that can assist in locating job opportunities (CSII 2.01, WRT 2.5.4).	None

Performance Indicator MN.SAE.02.02

Prepare relevant employment documents.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.02.02.01.a. Develop a resume, cover letter, and reference list (CSI 2.02, WRT 1.3.1, WRT 1.3.2).	SAE.02.02.01.b. Develop a resume, cover letter, and reference list (CSII 2.02, WRT 1.3.1, WRT 1.3.2).	SAE.02.02.01.c. Update cover letter and resume or LinkedIn Profile (WE 1.04, WRT 1.3.1, WRT 1.3.2, WRT 2.6).
SAE.02.02.02.a. Understand how to complete paper and online applications (CSI 2.02, WRT 2.2, WRT 1.3.3).	SAE.02.02.02.b. Understand how to complete paper and online applications (CSII 2.02, WRT 2.2, WRT 1.3.3).	SAE.02.02.02.c. Search for and apply for a job of interest (WBLE 7.1, WE 1.04).
SAE.02.02.03.a. Develop a career portfolio that demonstrates the mastery of career-related skills and knowledge and holds employment-related documents (CSI 2.02, WRT 1).	SAE.02.02.03.b. Uses professional digital media to create a personal brand and market self effectively to potential employers (e.g., LinkedIn Profile) (CSII 2.02, WRT 2.6).	None

MN.SAE.02: Securing Employment, Continued

Seek and successfully secure employment.

Performance Indicator MN.SAE.02.03

Identify and practice effective interview skills for employment.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.02.03.01.a. Identify and prepare relevant questions for the employer (CSI 2.03, WRT 2.1.2).	SAE.02.03.01.b. Identify and prepare relevant questions for the employer (CSII 2.03, WRT 2.1.2).	None
SAE.02.03.02.a. Practice multiple interview methods (CSI 2.03, WRT 2.1.1).	SAE.02.03.02.b. Practice multiple interview methods (CSII 2.03, WRT 2.1.1).	SAE.02.03.02.c. Demonstrate successful interviewing skills (WBLE 7.2, WE 1.02).
SAE.02.03.03.a. Prepare practice thank you notes and follow- up emails (CSI 2.03, WRT 2.1.3).	SAE.02.03.03.b. Prepare practice thank you notes and follow-up emails (CSII 2.03, WRT 2.1.3).	SAE.02.03.03.c. Send a thank you note and follow-up emails (WRT 2.1.3, WE 1.02).

Performance Indicator MN.SAE.02.04

Accept a job and for leave a job in a professional manner.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.02.04.01.a. Complete new hire paperwork, including a practice I-9 Form (CSI 2.04, WRT 3.1).	SAE.02.04.01.b. Complete new hire paperwork, including a I-9 Form (CSII 2.04, WRT 3.1).	SAE.02.04.01.c. Successfully accept a job offer (WBLE 7.3).
SAE.02.04.02.a. Write a resignation letter (CSI 2.04, WRT 3.2).	SAE.02.04.02.b. Write a resignation letter (CSII 2.04, WRT 3.2).	SAE.02.04.02.c. Successfully quit a job while maintaining professional relationships (WE 1.02, WBLE 7.3).
SAE.02.04.03.a. Request references (CSI 2.04, WRT 3.3).	SAE.02.04.03.b. Request references (CSII 2.04, WRT 3.3).	SAE.02.04.03.c. Request letters of recommendation (WE 1.04, WBLE 6).
SAE.02.04.04.a. Exhibit skills gained through an experiential learning experience through a product, portfolio, or demonstration (WBLE 9).	SAE.02.04.04.b. Exhibit skills gained through an experiential learning experience through a product, portfolio, or demonstration (WBLE 9).	SAE.02.04.04.c. Exhibit skills gained through work experience through a product, portfolio, or demonstration (WE 1.04, WBLE 9).

MN.SAE.03: Health, Safety, and Human Resource Regulations in the Workplace

Understand and internalize the importance of health, safety, and human resource regulations in the workplace.

Performance Indicator MN.SAE.03.01

Identify sources for finding employment opportunities.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.03.01.01.a. Review OSHA standards and PPE requirements for careers of interest (CSI 3.01, WRT 4.1).	SAE.03.01.01.b. Review OSHA standards and PPE requirements for careers of interest (CSII 3.01, WRT 4.1).	SAE.03.01.01.c. Identify related OSHA standards and other government regulations related to the workplace (WBLE 12.2, WE 3.01).
SAE.03.01.02.a. Identify common safety concerns within chosen careers of interest (CSI 3.01, WRT 4.2).	SAE.03.01.02.b. Identify common safety concerns within chosen careers of interest (CSII 3.01, WRT 4.2).	SAE.03.01.02.c. Identify safety hazards common to the workplace (WBLE 12.3, WE 3.01).
None	None	SAE.03.01.03.c. Review employer's safety policies (WBLE 12.1, WE 3.01).
None	None	SAE.03.01.04.c. Wear appropriate personal protective equipment (PPE) when needed (WBLE 13.1, WE 3.02).
None	None	SAE.03.01.05.c. Seek assistance proactively from supervisor when questions related to safety arise (WBLE 13.2, WE 3.02).

Performance Indicator MN.SAE.02.02

Examine federal, state, and local employment laws.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.03.02.01.a. Review the Fair Labor Standards Act and Minnesota child labor laws (CSI 3.02, ISA 2.1.1).	SAE.03.02.01.a. Review the Fair Labor Standards Act and Minnesota child labor laws (CSII 3.02, ISA 2.1.1).	None
SAE.03.02.02.a. Discuss the Americans with Disabilities Act (ADA), disability disclosure, and job accommodations (CSI 3.02, ISA 2.1.2).	SAE.03.02.02.b. Discuss the Americans with Disabilities Act (ADA), disability disclosure, and job accommodations (CSII 3.02, ISA 2.1.2).	None

MN.SAE.03: Health, Safety, and Human Resource Regulations, Continued

Understand and internalize the importance of health, safety, and human resource regulations in the workplace.

Performance Indicator MN.SAE.03.03

Compare and contrast employer and employee rights.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.03.03.01.a. Understand the requirements of the Equal Employment Opportunity Act (CSI 3.03, ISA 2.2.1).	SAE.03.03.01.b. Understand the requirements of the Equal Employment Opportunity Act (CSII 3.03, ISA 2.2.1).	None
SAE.03.03.02.a. Discuss labor unions and labor agreements (CSI 3.03, ISA 2.2.2).	SAE.03.03.02.b. Discuss labor unions and labor agreements (CSII 3.03, ISA 2.2.2).	None

MN.SAE.04: Employability Skills

Understand the employability skills needed to maintain employment.

Performance Indicator MN.SAE.04.01

Identify personal qualities needed to maintain employment.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.04.01.01.a. Identify what punctuality, time management, reliability, responsibility, and leadership looks like in careers of interest (CSI 4.01, WRT 6.4, ISA 6).	SAE.04.01.01.b. Identify what punctuality, time management, reliability, responsibility, and leadership looks like in careers of interest (CSII 4.01, WRT 6.4, ISA 6).	SAE.04.01.01.c. Demonstrate self-discipline, flexibility, integrity, initiative, and a willingness to learn (WBLE 6.1, WE 1.01).
SAE.04.01.02.a. Describe the importance of punctuality, time management, reliability, responsibility, and leadership in the workplace (CSI 4.01, WRT 6.4, ISA 6).	SAE.04.01.02.b. Discuss the importance of taking initiative and self-direction within the workplace (CSII 4.01, WRT 6.14).	SAE.04.01.02.c. Demonstrate initiative and self-direction when solving problems (WBLE 16.1, WE 4.03).

Performance Indicator MN.SAE.04.02

Identify workplace norms and professionalism standards for career of interest.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.04.02.01.a. Describe what ethical behavior looks like for careers of interest (e.g., logging hours, handling money; CSI 4.02, WRT 6.12).	SAE.04.02.01.b. Research the governing body or membership organization for career of interest and review the code of ethics for the organization (CSII 4.02).	SAE.04.02.01.c. Review and adhere to organizational policies, handbooks, and manuals (WBLE 14.3, WE 4.02).
SAE.04.02.02.a. Describe proper dress for the workplace for careers of interest (CSI 4.02, WRT 6.7).	SAE.04.02.02.b. Describe proper dress and workplace etiquette for careers of interest (CSII 4.02, WRT 6.7).	SAE.04.02.02.c. Demonstrate proper dress and etiquette in the workplace (WBLE 14.1, WBLE 14.2, WBLE 6.3, WE 4.02).
SAE.04.02.03.a. Demonstrate appropriate hygiene and personal grooming (WBLE 6.2).	SAE.04.02.03.b. Demonstrate appropriate hygiene and personal grooming (WBLE 6.2).	SAE.04.02.03.c. Demonstrate appropriate hygiene and personal grooming (WBLE 6.2, WE 1.01).
SAE.04.02.04.a. Identify the acceptable use of technology in the workplace for careers of interest (CSI 4.02, WRT 6.11).	SAE.04.02.04.b. Summarize the acceptable use of workplace technology in the workplace (CSII 4.02, WRT 6.11).	None
None	SAE.04.02.05.b. Research the requirements for continuing education and professional development for careers of interest (CSII 4.02).	None

MN.SAE.04: Employability Skills, Continued

Understand the employability skills needed to maintain employment.

Performance Indicator MN.SAE.04.03

Discuss and practice leadership and teamwork in a workplace setting.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.04.03.01.a. Practice working as a team to complete a project (CSI 4.03, WRT 6.6.2).	SAE.04.03.01.b. Compare and contrast being an individual contributor compared to a team contributor (CSI 4.03, WRT 6.6.1).	SAE.04.03.01.c. Collaborate as a member of a team or work independently as appropriate (WBLE 19.1, WE 5.01).
None	None	SAE.04.03.02.c. Work as a member of a team and contribute fairly to the task (WBLE 19.2, WE 5.01).
SAE.04.03.03.a. Discuss how to demonstrate respect for peers and superiors in the workplace (CSI 4.03, WRT 6.5).	SAE.04.03.03.b. Discuss how to demonstrate respect for peers and superiors in the workplace (CSII 4.03, WRT 6.5).	SAE.04.03.03.c. Listen to and consider all team members' ideas (WBLE 19.3, WE 5.01).
SAE.04.03.04.a. Discuss different cultures and how to work with a variety of co-workers (CSI 4.03, WRT 6.13).	SAE.04.03.04.b. Discuss different cultures and how to work with a variety of co-workers (CSII 4.03, WRT 6.13).	SAE.04.03.04.c. Work effectively with people from diverse social and cultural backgrounds (WBLE 20.1, WE 5.02).
SAE.04.03.05.a. Practice conflict resolution techniques (CSI 4.03, WRT 6.9).	SAE.04.03.05.b. Practice conflict resolution techniques (CSII 4.03, WRT 6.9).	SAE.04.03.05.c. Research and assess multiple strategies for resolving problems and resolve conflicts and work-place issues respectfully (WBLE 20.3, WBLE 16.2, WE 4.03).

MN.SAE.04: Employability Skills, Continued

Understand the employability skills needed to maintain employment.

Performance Indicator MN.SAE.04.04

Discuss self-advocacy skills in a workplace setting.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.04.04.01.a. Practice communicating requests for time off or schedule changes (CSI 4.04, WRT 6.2.4).	SAE.04.04.01.b. Practice communicating requests for time off or schedule changes (CSII 4.04, WRT 6.2.4).	SAE.04.04.01.c. Communicate requests for time off or schedule changes following company policies (WE 4.04).
SAE.04.04.02.a. Explore possible accommodations, services, supports, and assistive technology the workplace (CSI 4.04, ISA 3).	SAE.04.04.02.b. Explore possible accommodations, services, supports, and assistive technology for the workplace (CSI 4.04, ISA 3).	SAE.04.04.02.c. Communicate proactively about work product and work schedules with colleagues and employer (WBLE 17.2, WBLE 20.2, WE 5.02).
None	None	SAE.04.04.03.c. Identify who to contact if work issues arise (WBLE 17.1, WE 4.04).
None	None	SAE.04.04.04.c. Log hours worked correctly (WBLE 18.1, WE 4.05).
None	None	SAE.04.04.05.c. Ensure proper handling of tools, material, data, and money (WBLE 18.2, WE 4.05).

MN.SAE.05: Effective Communication

Practice effective communication in the workplace.

Performance Indicator MN.SAE.05.01

Identify and practice effective written communication in the work setting.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.05.01.01.a. Draft e-mails using proper etiquette and correct grammar (CSI 5.01, WRT 6.1.1).	SAE.05.01.01.b. Draft e-mails using proper etiquette and correct grammar (CSII 5.01, WRT 6.1.1).	SAE.05.01.01.c. Use correct grammar, spelling, punctuation, and capitalization when preparing written communications (WBLE 21.1, WE 6.01).
None	SAE.05.01.02.b. Compose written documents such as meeting agendas, meeting notes, or topic briefs. (CSII 5.01, WRT 6.1.4).	SAE.05.01.02.c. Organize, compose, and edit written communication, including email (WBLE 21.2, WE 6.01).
SAE.05.01.03.a. Identify when a professional writing style should be used in written communication (CSI 5.01, WRT 6.1.3).	SAE.05.01.03.b. Identify when a professional writing style should be used in written communication (CSII 5.01, WRT 6.1.3).	None

Performance Indicator MN.SAE.05.02

Identify and practice effective verbal communication in the work setting.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.05.02.01.a. Practice telephone etiquette (e.g., answering the phone, leaving voice mail messages, and recording voice mail greetings in a professional manner; CSI 5.02, WRT 6.2.1).	SAE.05.02.01.b. Practice telephone etiquette (e.g., answering the phone, leaving voice mail messages, and recording voice mail greetings in a professional manner; CII 5.02, WRT 6.2.1).	None
SAE.05.02.02.a. Role play speaking to customers in a professional manner (CSI 5.02, WRT 6.2.2).	SAE.05.02.02.b. Role play speaking to customers in a professional manner (CSII 5.02, WRT 6.2.2).	SAE.05.02.02.c. Adapt language for audience, purpose, situation (WBLE 22.1, WE 6.02).
None	SAE.05.02.03.b. Deliver an oral presentation on a workplace topic (CSII 5.02, WRT 6.2.3).	SAE.05.02.03.c. Develop and deliver messages in oral presentations (WBLE 22.2, WE 6.02).

MN.SAE.05: Effective Communication, Continued

Practice effective communication in the workplace.

Performance Indicator MN.SAE.05.03

Demonstrate effective listening skills.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.05.03.01.a. Demonstrate active listening and paraphrasing what has been heard (WRT 6.3.1).	SAE.05.03.01.b. Accurately paraphrase what has been heard (CSII 5.03, WRT 6.3.1).	SAE.05.03.01.c. Accurately paraphrasing what has been heard (WBLE 23.1, WE 6.03).
SAE.05.03.02.a. Observe and reproduce notetaking, questioning, and responding during a conversation (WRT 6.3.2).	SAE.05.03.02.b. Engage in notetaking, questioning, and responding during a conversation (CSII 5.03, WRT 6.3.2).	SAE.05.03.02.c. Engage in notetaking, questioning, and responding during a conversation (WBLE 23.2, WE 6.03).

MN.SAE.06: Financial Literacy

Demonstrate financial literacy as it relates to the workplace.

Performance Indicator MN.SAE.06.01

Identify and practice effective written communication in the work setting.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.06.01.01.a. Understand terms listed on paycheck (CSI 6.01, WRT 7.6.1).	SAE.06.01.01.b. Understand terms listed on paycheck (CSII 6.01, WRT 7.6.1).	None
SAE.06.01.02.a. Understand banking fees, service charges, and interest rates (CSI 6.01, WRT 7.6.2).	SAE.06.01.02.b. Understand banking fees, service charges, and interest rates (CSII 6.01, WRT 7.6.2).	None
None	SAE.06.01.03.b. Describe the impact of credit rating on certain careers (CSII 6.01, WRT 7.6.3).	None

Performance Indicator MN.SAE.06.02

Summarize the requirements for local state, and federal taxes.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.06.02.01.a. Review state and local tax forms and the timeline for filing taxes (CSI 6.02, WRT 7.7.1).	SAE.06.02.01.b. Review state and local tax forms and the timeline for filing taxes (CSII 6.02, WRT 7.7.1).	None
SAE.06.02.02.a. Identify how taxes are listed on a paycheck (CSI 6.02, WRT 7.7.2).	SAE.06.02.02.b. Identify how taxes are listed on a paycheck (CSII 6.02, WRT 7.7.2).	None

MN.SAE.06: Financial Literacy, Continued

Demonstrate financial literacy as it relates to the workplace.

Performance Indicator MN.SAE.06.03

Review insurance benefits and identify appropriate coverage.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
None	SAE.06.03.01.b. Understand the different benefits offered by employers (CSII 6.03, WRT 7.8.1).	None
None	SAE.06.03.02.b. Identify personal priorities for insurance coverage (CSII 6.03, WRT 7.8.2).	None
None	SAE.06.03.03.b. Understand how insurance needs change throughout a career (CSII 6.03, WRT 7.8.3).	None

MN.SAE.06: Technical Skills Within a Work-Based Learning Experience

Complete an experiential learning or work-based learning experience in a career field of interest.

Performance Indicator MN.SAE.07.01

Establish a training agreement and training plan for the duration of the work experience with the employer, and in consultation with the work-based learning coordinator.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.07.01.01.a. Summarize the conditions of the training agreement.	SAE.07.01.01.b. Summarize the conditions of the training agreement.	SAE.07.01.01.c. Summarize the conditions of the training agreement (WE 2.01).
SAE.07.01.02.a. Review and discuss the skills and evaluations identified in the training plan.	SAE.07.01.02.b. Review and discuss the skills and evaluations identified in the training plan.	SAE.07.01.02.c. Review and discuss the skills and evaluations identified in the training plan (WE 2.01).

Performance Indicator MN.SAE.07.02

Apply skills learned in technical courses to the work experience.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.07.02.01.a. Seek feedback from teacher or supervisor on technical skills practice during the experience learning opportunity (WBLE 10.1).	SAE.07.02.01.b. Seek feedback from teacher or supervisor on technical skills practice during the experience learning opportunity (WBLE 10.1).	SAE.07.02.01.c. Seek feedback from employer on technical skills practice during the work experience (WBLE 10.1, WE 2.02).
SAE.07.02.02.a. Refine technical skills based on teacher or supervisor feedback (WBLE 10.2).	SAE.07.02.02.b. Refine technical skills based on teacher or supervisor feedback (WBLE 10.2).	SAE.07.02.02.c. Refine technical skills based on employer feedback (WBLE 10.2, WE 2.02).

MN.SAE.07: Technical Skills Within a Work-Based Learning Experience, Continued

Complete an experiential learning or work-based learning experience in a career field of interest.

Performance Indicator MN.SAE.07.03

Perform daily work tasks consistent with the responsibilities and work culture of the workplace.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
SAE.07.03.01.a. Attend experiential learning opportunities as scheduled (WBLE 15.1).	SAE.07.03.01.b. Attend experiential learning opportunities as scheduled (WBLE 15.1).	SAE.07.03.01.c. Attend work or work-based learning opportunities as scheduled (WBLE 15.1, WE 4.02).
SAE.07.03.02.a. Complete planned learning objectives and tasks (WBLE 11.1).	SAE.07.03.02.b. Complete planned learning objectives and tasks (WBLE 11.1).	SAE.07.03.02.c. Complete tasks accurately and within in the agreed upon time frame (WBLE 11.1, WBLE 15.2, WE 2.03).
SAE.07.03.03.a. Demonstrate attention to detail and accuracy appropriate to the task (WBLE 11.2).	SAE.07.03.03.b. Demonstrate attention to detail and accuracy appropriate to the task (WBLE 11.2).	SAE.07.03.03.c. Demonstrate attention to detail and accuracy appropriate to the task (WBLE 11.2, WE 2.03).

Section 4 – Animal Systems (AS) Pathway Frameworks

Introduction

The Animal Systems (AS) Career Pathway encompasses the study of AS, including content areas such as life processes, health, nutrition, genetics, management, and processing, as applied to small animals, aquaculture, exotic animals, livestock, dairy, horses, and poultry. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application, and management of AS in AFNR settings.

Section Contents

Recommended AS Courses and Pathway Sequence

Students concentrating on the AS pathway should complete a sequence of at least two courses within the following course offerings based their career goals and interests.

Introductory Courses	Intermediate Courses	Advanced Courses
01 Principles of Agriculture, Food, and Natural Resources	19 Equine Science	13 Agricultural Education, Research, and Development
02 Advanced Principles of Agriculture, Food, and Natural Resources	20 Livestock and Poultry Production	29 Specialty and Emerging Animal Systems Topics
03 Principles of AFNR Biology (Science-Elective Credit)	21 Livestock, Poultry, and Equine Operations (Simulated WBL: School Farm)	75 Food Science
04 Advanced Principles of AFNR Biology (Science-Elective Credit)	22 Aquaculture Operations (Simulated WBL: School Farm)	76 Advanced Food Science
15 Animal Science and Small Animal Care	23 Aquacultural Chemistry (Science Credit; Simulated WBL: School Farm)	77 Food Chemistry (Science Credit)
16 Advanced Animal Science and Large Animal Care	24 Veterinary Science	78 Advanced Food Chemistry (Science Credit)
17 Animal Biology (Science-Elective Credit)	25 Advanced Veterinary Science	85 Animal and Plant Biotechnology
18 Advanced Animal Biology (Science-Elective Credit)	26 Veterinary Biology (Science-Elective Credit)	86 Advanced Animal and Plant Biotechnology
	27 Adv. Veterinary Biology (Science-Elective Credit)	87 Agricultural Biotechnology and Biology (Science-Elective Credit)
	28 Small Animal Care Operations (Simulated WBL: School Business)	88 Advanced Agricultural Biotechnology and Biology (Science-Elective Credit)
		93 Extended/Summer AFNR Work-Based Learning (SAE) and Leadership (FFA)
		94 Agricultural Leadership Development
		95 Agricultural Career Seminar
		96 Advanced Agricultural Career Seminar
		97 AFNR Work Experience: Immersion SAE (Advanced Internship/Placement, Entrepreneurship, Research)

Recommended Work-Based Learning (WBL) and SAEs within AS

A Supervised Agricultural Experience (SAE) is a student-led, instructor-supervised, Work-Based Learning (WBL) experience that results in measurable outcomes within a predefined, agreed upon set of AFNR Technical Standards and Career Ready Practices aligned to a Career Plan of study. SAE teaches technical skills and knowledge within the psychomotor domain of learning. SAE includes both experiential learning (i.e., pre-WBL) and WBL (federally defined as sustained interactions with industry or community professionals in real workplace settings, to the extent practicable, or simulated environments, at an educational institution that foster in-depth, firsthand engagement with the tasks required in a given career field, that are aligned to curriculum and instruction; Sec. 3 [20 U.S.C. 2302] 55).

SAE/WBL is a required component of an AFNR program, first established in the Smith-Hughes Act (1917) and reinforced in each of the federal Perkins Career and Technical Education (CTE) Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires WBL/SAE as a component of CTE Program Approval (Minn. R. 3505). Table 1 has example SAE opportunities within this pathway, as defined by the National Council for AFNR Education, Perkins V legislation, and the Minnesota Department of Education.

Table 1. Examples of WBL/SAE Curricula and Programs within AS

SAE Program Area	Examples, Non-Exhaustive
Experiential Learning (Foundational SAE; Pre-WBL)	● Career exploration ● Showing or judging livestock ● Job shadowing in the animal industry ● Field trip to local animal shelter ● Train an animal to perform basic commands
Internship (Placement SAE; Immersion WBL)	● Working at a Veterinary Clinic/Humane Society/Groomer ● Working for a livestock producer ● Working in a livestock feed processing/testing facility
Apprenticeship (Placement SAE; Immersion WBL)	● More than 450 hours in an internship, combined with coursework ● Contact the Minnesota Department of Education (MDE) for support
Entrepreneurship (Entrepreneurship SAE; Immersion WBL)	● Breeding/raising animal herd for market animals ● Animal care business (i.e., pet sitting, dog grooming, etc.) ● Livestock fitting and trimming business
Research (Research SAE; Immersion WBL)	● Consumer research perceptions of grass-fed beef ● Animal weight gain research ● Animal health or reproduction research
School-Based Enterprise (School-Based SAE; Simulated WBL)	● Aquaculture Operations SBE WBL ● Animal Production/School Farm Operations SBE WBL ● Honey Production/Operations SBE WBL
FFA Work-Based Learning and SAE Proficiency Award Areas	● Agriscience Research - Animal Systems ● Dairy Production ● Veterinary Science ● Wildlife Production and Management

Recommended Social-Emotional Learning (SEL) and FFA Opportunities within AS

The National FFA Organization (FFA) is a student-led, instructor-supervised, Career and Technical Student Organization (CTSO) that results in measurable outcomes within a predefined, agreed upon set of AFNR Social-Emotional Standards and Career Ready Practices aligned to a Career Plan of study. FFA teaches social-emotional and leadership skills and knowledge within the affective domain of learning. FFA includes programs that provide essential employability skills such as critical thinking, consensus building, communication, teamwork, and leadership. FFA was founded in 1928 and is federally defined as intracurricular (i.e., within the curriculum; cf. extracurricular: external, co-curricular: alongside) and an integral part (i.e., necessary to form the whole) of School-Based AFNR Education (Public Law No. 116-7).

Leadership/FFA is a required component of an AFNR program, formalized in the FFA Federal Charter in 1950 (Public Law No. 116-7) and reinforced in federal Perkins CTE Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires leadership/FFA as a component of CTE Program Approval (Minn. R. 3505). Table 2 has example FFA opportunities with this pathway, as defined by the National Council for AFNR Education, Perkins V legislation, Department of Education, and the Minnesota FFA Association.

Table 2. Examples of SEL/FFA Curricula and Programs within AS

FFA Program Area	Examples, Non-Exhaustive
Student Development Programs (Growing Leaders)	● Agriscience fair or SAE open house ● Animal facility tours ● Career day/guest speakers
Community Development/ Service (Building Communities)	● Host a pet supply drive for local animal shelter ● Raising an animal to donate to food shelf ● Raising/training a service animal
Literacy, Advocacy, and Safety (Strengthening Agriculture)	● CHS Miracle of Birth Barnyard attendant ● Animal welfare project ● Safe animal handling education ● County fair animal exhibit
Conferences, Conventions, and Banquets	● #FFANextGen Animal Science conference ● InTENse ● Horizon conference ● Livestock industry events (e.g., Cattlemen's Association, Pork Producers, Turkey Growers)
Career Development Events (CDE)	● Horse Evaluation ● Livestock Evaluation ● Meats Evaluation and Technology ● Milk Quality and Products ● Poultry Evaluation ● Small Animal Veterinary Science
Leadership Development Events (LDE)	● Agricultural Issues Forum ● Marketing Plan ● Prepared Public Speaking ● Extemporaneous Speaking

MN.AS.01: History and Trends within Animal Systems

Analyze historic and current trends impacting the animal systems industry.

Performance Indicator MN.AS.01.01

Evaluate the development and implications of animal origin, domestication, and distribution on production practices and the environment.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.01.01.01.a. Identify and summarize the origin, significance, distribution, and domestication of different animal species.	AS.01.01.01.b. Describe the historical and scientific developments of different animal industries and summarize the products, services and careers associated with each.	AS.01.01.01.c. Evaluate the implications of animal adaptations on production practices and the environment.
AS.01.01.02.a. Research and summarizes the major component areas in different animal systems.	AS.01.01.02.b. Describe several characteristics of animals and evaluate reasoning that led to their domestication.	AS.01.01.02.c. Predict possible trends and their implications within different animal industry and the impact on society and the environment.

MN.AS.01: History and Trends within Animal Systems, Continued

Analyze historic and current trends impacting the animal systems industry.

Performance Indicator MN.AS.01.02

Assess and select animal production methods for use in animal systems based upon their effectiveness and impacts.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.01.02.01.a. Identify and categorize terms and methods related to animal production (e.g., sustainable, conventional, humanely raised, natural, organic).	AS.01.02.01.b. Compare and contrast the impact of methods of animal production on the quality of the final product.	AS.01.02.01.c. Evaluate the effectiveness of different production methods and defend the use of selected methods using data and evidence.
AS.01.02.02.a. Research and examine marketing methods for animal products and services (e.g., conventional, niche markets, locally grown).	AS.01.02.02.b. Calculate the value of different marketing methods as compared to variable income returns (e.g., direct markets, terminal markets, futures markets).	AS.01.02.02.c. Devise and evaluate marketing plans for an animal agriculture product or service.
AS.01.02.03.a. Summarize the types, purposes, and characteristics of effective record keeping and documentation practices for animal systems enterprises (e.g., managing records for animal identification, feeding, breeding, treatment, income/expense).	AS.01.02.03.b. Analyze and evaluate the accuracy and effectiveness of records used in an animal system business.	AS.01.02.02.c. Select and defend the use of a specific record management system based upon its effectiveness for a business related to animal systems.

MN.AS.01: History and Trends within Animal Systems, Continued

Analyze historic and current trends impacting the animal systems industry.

Performance Indicator MN.AS.01.03

Analyze and apply laws and sustainable practices to animal agriculture from a global perspective.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.01.03.01.a. Investigate local, national, and global laws pertaining to different animal production systems.	AS.01.03.01.b. Analyze the structure of laws governing animal industries, international trade, and animal production policies.	AS.01.03.01.c. Assess the compliance of production practices with established regulations and evaluate the impact of those laws pertaining to different animal agriculture.
AS.01.03.02.a. Summarize the value of sustainability in animals systems.	AS.01.03.02.b. Analyze the local and global impact of sustainable animal agriculture practices on human and environmental systems.	AS.01.03.02.c. Select, evaluate, and defend the use of sustainable practices in animal agriculture.

MN.AS.02: Animal Behavior and Welfare

Utilize best-practice protocols based upon animal behaviors for animal husbandry and welfare.

Performance Indicator MN.AS.02.01

Demonstrate management techniques that ensure animal welfare.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.02.01.01.a. Discuss possible implications of different animal welfare and animal rights-based animal systems.	AS.02.01.01.b. Design programs that assure the welfare of animals and prevent abuse or mistreatment.	AS.02.01.01.c. Describe the implementation and evaluation of quality-assurance programs and procedures for animal production.
AS.02.01.02.a. Research different management practices to reduce the challenges faced in working with animals.	AS.02.01.02.b. Analyze and document animal welfare procedures used to ensure safety and maintain low stress when handling and working with animals	AS.02.01.02.c. Devise and evaluate safety procedures and plans for working with animals by species using information based on animal behavior and responses.
AS.02.01.03.a. Distinguish between animal husbandry practices that promote animal welfare and those that do not.	AS.02.01.03.b. Analyze and document animal husbandry practices and their impact on animal welfare.	AS.02.01.03.c. Design recommendations to increase the welfare of animals while maintaining economic viability.
AS.02.01.04.a. Research animal training practices that promote and ensure animal welfare.	AS.02.01.04.b. Analyze and document animal training practices and their impact on animal welfare.	AS.02.01.04.c. Design an animal training program with recommendations to increase the welfare of animals.

MN.AS.01: Animal Behavior and Welfare, Continued

Utilize best-practice protocols based upon animal behaviors for animal husbandry and welfare.

Performance Indicator MN.AS.02.02

Analyze procedures to ensure that animal products are safe for consumption (e.g., use in food system).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.02.02.01.a. Identify tools, practices, technology, and equipment used in animal systems to help provide an abundant and safe food supply.	AS.02.02.01.b. Utilize tools, practices, technology, and equipment to perform animal husbandry procedures while maintaining welfare standards.	AS.02.02.01.c. Select, evaluate, and defend the use of specific tools, practices, technology, and equipment used to perform animal husbandry and welfare tasks.
AS.02.02.02.a. Research and summarize animal production practices that may pose health risks.	AS.02.02.02.b. Compare and discuss current consumer concerns with animal production practices relative to human health.	AS.02.02.02.c. Research and evaluate programs currently used to assure the safety of animal products for consumption.
AS.02.02.03.a. Identify and describe current animal tracking systems used in animal systems.	AS.02.02.03.b. Evaluate the different possible impacts of animal trace-back capabilities on producers and consumers.	AS.02.02.03.c. Evaluate the effectiveness of animal and premise identification programs for a given species.

MN.AS.03: Animal Nutrition

Design and provide proper animal nutrition to achieve desired outcomes for performance, development, reproduction, and economic production.

Performance Indicator MN.AS.03.01

Analyze the nutritional needs and available feed rations in an attempt to meet the animal's nutritional requirements.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.03.01.01.a. Identify and summarize essential nutrients required for animal health and analyze each nutrient's role in growth and performance.	AS.03.01.01.b. Differentiate between nutritional needs of animals in different growth/production stages and systems (e.g., maintenance, gestation, natural, organic).	AS.03.01.01.c. Assess nutritional needs for an individual animal based on its growth stage and production system.
AS.03.01.02.a. Differentiate between nutritional needs of animal species.	AS.03.01.02.b. Correlate a species' nutritional needs to possible and available feedstuffs to meet those needs.	AS.03.01.02.c. Design and defend a nutritional program by demonstrating the relationship between the nutrient requirements and the feedstuffs provided.

Performance Indicator MN.AS.03.02

Analyze feed rations and assess if they meet the nutritional needs of animals.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.03.02.01.a. Compare and contrast common types of feedstuffs and the roles they play in the diets of animals.	AS.03.02.01.b. Analyze and calculate the relative nutritional value of feedstuffs by evaluating their general quality and condition.	AS.03.02.01.c. Select appropriate feedstuffs for animals based on a variety of factors (e.g., economics, digestive system, nutritional needs).
AS.03.02.02.a. Discuss the importance of a balanced ration for animals based on the animal's growth stage (e.g., maintenance, newborn, gestation, lactation).	AS.03.02.02.b. Appraise the adequacy of feed rations using data from the analysis of feedstuffs compared to animal requirements and performance.	AS.03.02.02.c. Select and utilize animal feeds based on nutritional requirements, using rations for maximum nutrition, and optimal economic production.
AS.03.02.03.a. Summarize the purpose, impact, and mode of action of different feed additives and growth promotants in animal production.	AS.03.02.03.b. Compare and contrast methods that utilize feed additives and growth promotants with production practices that do not (e.g., organic versus conventional production methods).	AS.03.02.03.c. Make and defend decisions regarding whether to use feed additives and growth promotants based on scientific evidence, production system needs and goals, and input from industry standards.

MN.AS.03: Animal Nutrition, Continued

Design and provide proper animal nutrition to achieve desired outcomes for performance, development, reproduction, and economic production.

Performance Indicator MN.AS.03.03

Utilize industry tools to make animal nutrition decisions.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.03.03.01.a. Identify and categorize tools and equipment used to meet animal nutrition needs and ensure an abundant and safe food supply.	AS.03.03.01.b. Utilize tools and equipment to perform animal nutrition tasks.	AS.03.03.01.c. Select, evaluate, and defend the use of specific tools or equipment used to perform animal nutrition tasks.
AS.03.03.02.a. Examine and summarize the meaning of various components of feed labels and feeding directions.	AS.03.03.02.b. Analyze and apply information from a feed label and feeding directions to feed animals.	AS.03.03.02.c. Evaluate and summarize the potential impacts, positive and negative, of compliance and noncompliance with a feed label and feeding directions.
AS.03.03.03.a. Examine the use of technology to provide animal nutrition.	AS.03.03.03.b. Analyze technologies used to provide animal nutrition and summarize their potential benefits and consequences.	AS.03.03.03.c. Research and recommend technology improvements to provide proper nutrition to animals.

MN.AS.04: Animal Reproduction

Apply principles of animal reproduction to achieve desired outcomes for performance, development, and economic production.

Performance Indicator MN.AS.04.01

Evaluate animals for breeding readiness and soundness.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.04.01.01.a. Identify and categorize the male and female reproductive organs of the major animal species.	AS.04.01.01.b. Analyze the functions of major organs in the male and female reproductive systems.	AS.04.01.01.c. Select breeding animals based on characteristics of the reproductive organs.
AS.04.01.02.a. Compare and contrast how age, size, life cycle, maturity level, and health status affect the reproductive efficiency of male and female animals.	AS.04.01.02.b. Assess and describe factors that lead to reproductive maturity.	AS.04.01.02.c. Evaluate and select animals for reproductive readiness.
AS.04.01.03.a. Summarize the importance of efficient and economic reproduction in animals.	AS.04.01.03.b. Evaluate reproductive problems that occur in animals.	AS.04.01.03.c. Treat or cull animals with reproductive problems.

Performance Indicator MN.AS.04.02

Apply scientific principles for the selection of breeding animals.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.04.02.01.a. Summarize genetic inheritance in animals.	AS.04.02.01.b. Compare and contrast the use of genetically superior animals in the production of animals and animal products.	AS.04.02.01.c. Select and evaluate a breeding system based on the principles of genetics.
AS.04.02.02.a. Identify and summarize inheritance and terms related to inheritance in animal breeding (e.g., dominate, co-dominate, recessive, homozygous, heterozygous).	AS.04.02.02.b. Demonstrate how to determine probability trait inheritance in animals.	AS.04.02.02.c. Select and evaluate breeding animals and determine the probability of a given trait in their offspring.
AS.04.02.03.a. Identify and summarize genetic defects that affect animal performance.	AS.04.02.03.b. Analyze how DNA analysis can detect genetic defects in breeding stock.	AS.04.02.03.c. Perform a DNA analysis and use the data to make and defend breeding decisions.
AS.04.02.04.a. Identify and summarize different needs of breeding animals based on their growth stages (e.g., newborn, parturition, gestation, gestation lengths).	AS.04.02.04.b. Analyze the care needs for breeding stock in each stage of growth.	AS.04.02.04.c. Create a plan to differentiate care of a species of breeding animals throughout their growth stages.

MN.AS.04: Animal Reproduction, Continued

Apply principles of animal reproduction to achieve desired outcomes for performance, development, and economic production.

Performance Indicator MN.AS.04.03

Apply scientific principles to breed animals.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.04.03.01.a. Identify and categorize natural and artificial breeding methods (e.g., natural breeding, artificial insemination, estrous synchronization, flushing, cloning).	AS.04.03.01.b. Calculate the potential economic benefits of natural versus artificial breeding methods.	AS.04.03.01.c. Select animal breeding methods based on reproductive and economic efficiency.
AS.04.03.02.a. Analyze the materials, methods, and processes of artificial insemination.	AS.04.03.02.b. Demonstrate artificial insemination techniques.	AS.04.03.02.c. Evaluate the implementation and effectiveness of artificial insemination techniques.
AS.04.03.03.a. Identify and summarize the advantages and disadvantages of major reproductive management practices, including estrous synchronization, superovulation, flushing and embryo transfer (e.g., cost, labor, equipment).	AS.04.03.03.b. Analyze the processes of major reproductive management practices, including estrous synchronization, superovulation, flushing and embryo transfer.	AS.04.03.03.c. Create and evaluate plans and procedures for estrous synchronization, superovulation, flushing, embryo transfer, and other reproductive management practices.
AS.04.03.04.a. Examine the use of quantitative breeding values (e.g., EPDs, performance records, pedigrees) in the selection of genetically superior breeding stock.	AS.04.03.04.b. Compare and contrast quantitative breeding value differences between genetically superior animals and animals of average genetic value.	AS.04.03.04.c. Select and assess animal performance based on quantitative breeding values for specific characteristics.

MN.AS.05: Environmental Factors, Animal Housing, and Safety

Evaluate environmental factors affecting animal performance and implement procedures for enhancing performance and animal health.

Performance Indicator MN.AS.05.01

Design animal housing, equipment, and handling facilities for the major systems of animal production.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.05.01.01.a. Differentiate between the types of facilities needed to house and produce animal species safely and efficiently.	AS.05.01.01.b. Critique designs for an animal facility and prescribe alternative layouts and adjustments for the safe, sustainable, and efficient use of the facility.	AS.05.01.01.c. Design an animal facility focusing on animal requirements, economic efficiency, sustainability, safety, and ease of handling.
AS.05.01.02.a. Identify and summarize equipment, technology and handling facility procedures used in modern animal production (e.g., climate control devices, sensors, automation).	AS.05.01.02.b. Analyze the use of modern equipment, technology and handling facility procedures and determine if they enhance the safe, economic, and sustainable production of animals.	AS.05.01.02.c. Select, use, and evaluate equipment, technology, and handling procedures to enhance sustainability and production efficiency.

Performance Indicator MN.AS.05.02

Comply with government regulations and safety standards for facilities used in animal production.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.05.02.01.a. Identify and summarize the general standards that must be met in facilities for animal production (e.g., environmental, zoning, construction).	AS.05.02.01.b. Analyze animal facilities to determine if standards have been met.	AS.05.02.01.c. Evaluate facility designs and make recommendations to ensure that it meets standards for the legal, safe, ethical, economic, and efficient production of animals.
AS.05.02.02.a. Distinguish between the types of laws and regulations pertaining to animal systems.	AS.05.02.02.b. Analyze the structure of laws pertaining to animal systems.	AS.05.02.02.c. Evaluate the impact of laws pertaining to animal systems.

MN.AS.06: Animal Anatomy and Physiology

Classify, evaluate, and select animals based on anatomical and physiological characteristics.

Performance Indicator MN.AS.06.01

Classify animals according to taxonomic classification systems and use (e.g., agricultural, companion).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.06.01.01.a. Explain the importance of the binomial nomenclature system for classifying animals.	AS.06.01.01.b. Explain how animals are classified using a taxonomic classification system.	AS.06.01.01.c. Assess taxonomic characteristics and classify animals according to the taxonomic classification system.
AS.06.01.02.a. Compare and contrast major uses of different animal species (e.g., agricultural, companion).	AS.06.01.02.b. Appraise and evaluate the economic value of animals for various applications in the agriculture industry.	AS.06.01.02.c. Recommend different uses for an animal species based upon an analysis of local market needs.
AS.06.01.03.a. Identify and summarize common classification terms utilized in animal systems (e.g., external and internal body parts, maturity, mature male, immature female, animal products, breeds).	AS.06.01.03.b. Analyze the visual characteristics of an animal or animal product and select correct classification terminology when referring to companion and production animals.	AS.06.01.03.c. Apply knowledge of classification terms to communicate with others about animal systems in an effective and accurate manner.

Performance Indicator MN.AS.06.02

Apply principles of comparative anatomy and physiology to uses within various animal systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.06.02.01.a. Research and summarize characteristics of a typical animal cell and identify the organelles.	AS.06.02.01.b. Analyze the functions of each animal cell structure.	AS.06.02.01.c. Correlate the functions of animal cell structures to animal growth, development, health, and reproduction.
AS.06.02.02.a. Examine the basic functions of animal cells in animal growth and reproduction.	AS.06.02.02.b. Analyze the processes of meiosis and mitosis in animal growth, development, health, and reproduction.	AS.06.02.02.c. Apply the processes of meiosis and mitosis to solve animal growth, development, health, and reproductive problems.
AS.06.02.03.a. Identify and summarize the properties, locations, functions and types of animal cells, tissues, organs, and body systems.	AS.06.02.03.b. Compare and contrast animal cells, tissues, organs, body systems types, and functions among animal species.	AS.06.02.03.c. Apply knowledge of anatomical and physiological characteristics of animals to make production and management decisions.

MN.AS.06: Animal Anatomy and Physiology, Continued

Classify, evaluate, and select animals based on anatomical and physiological characteristics.

Performance Indicator MN.AS.06.03

Select and train animals for specific purposes and maximum performance based on anatomy and physiology.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.06.03.01.a. Identify and summarize how an animal's health can be affected by anatomical and physiological disorders.	AS.06.03.01.b. Compare and contrast desirable anatomical and physiological characteristics of animals within and between species.	AS.06.03.01.c. Evaluate and select animals to maximize performance based on anatomical and physiological characteristics that affect health, growth, and reproduction.
AS.06.03.02.a. Evaluate an animal against its optimal anatomical and physiological characteristics.	AS.06.03.02.b. Compare and contrast procedures to sustainably and efficiently develop an animal to reach its highest performance potential with respect to its anatomical and physiological characteristics.	AS.06.03.02.c. Choose, implement, and evaluate sustainable and efficient procedures (e.g., selection, housing, nutrition, management) to produce consistently high-quality animals that are well suited for their intended purposes.
AS.06.03.03.a. Research and summarize the use of products and by-products derived from animals.	AS.06.03.03.b. Evaluate and select products from animals based on industry standards.	AS.06.03.03.c. Evaluate and select animals to produce superior animal products based on industry standards.

MN.AS.07: Animal Care and Health

Apply principles of effective animal health care.

Performance Indicator MN.AS.07.01

Design programs for identification, prevention, and treatment of animal diseases, parasites, and other disorders and ensure animal welfare.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.07.01.01.a. Identify and summarize specific tools and technology used in animal health management.	AS.07.01.01.b. Describe and demonstrate the proper use and function of specific tools and technology related to animal health management.	AS.07.01.01.c. Select and use tools and technology to meet specific animal health management goals.
AS.07.01.02.a. Explain methods of determining animal health and disorders.	AS.07.01.02.b. Perform simple health-check evaluations on animals and practice basic emergency response procedures related to animals.	AS.07.01.02.c. Determine when an animal health concern needs to be referred to an animal health professional.
AS.07.01.03.a. List and summarize the characteristics of wounds, common diseases, parasites, and physiological disorders that affect animals.	AS.07.01.03.b. Identify and describe common illnesses and disorders of animals based on symptoms and problems caused by wounds, diseases, parasites, and physiological disorders.	AS.07.01.03.c. Treat common diseases, parasites, and physiological disorders of animals according to directions prescribed by an animal health professional.
AS.07.01.04.a. Identify and summarize characteristics of causal agents and vectors of diseases and disorders in animals.	AS.07.01.04.b. Research and analyze data to evaluate preventive measures for controlling and limiting the spread of diseases, parasites, and disorders among animals.	AS.07.01.04.c. Design and implement health maintenance and a disease and disorder prevention plan for animals in their natural and confined environments.
AS.07.01.05.a. Explain the clinical significance of common veterinary methods and treatment (e.g., aseptic techniques, antibiotic use, wound management).	AS.07.01.05.b. Assess the safety and effectiveness of facilities and equipment used for surgical and nonsurgical veterinary treatments and procedures.	AS.07.01.05.c. Identify and describe surgical and nonsurgical veterinary treatments and procedures to meet specific animal health care objectives.

MN.AS.07: Animal Anatomy and Physiology, Continued

Classify, evaluate, and select animals based on anatomical and physiological characteristics.

Performance Indicator MN.AS.07.02

Analyze biosecurity measures utilized to protect the welfare of animals on a local, state, national, and global level.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.07.02.01.a. Summarize the importance of biosecurity to the animal industry at multiple levels (e.g., local, state, national, global).	AS.07.02.01.b. Analyze procedures at the local, state, and national levels to ensure biosecurity of the animal industry.	AS.07.02.01.c. Design and evaluate a biosecurity plan for an animal production operation.
AS.07.02.02.a. Identify and describe zoonotic diseases including their historical significance and potential future implications.	AS.07.02.02.b. Analyze the health risk of different zoonotic diseases to humans and identify prevention methods.	AS.07.02.02.c. Research and evaluate the effectiveness of zoonotic disease prevention methods and procedures to identify those that are best suited to ensure public safety and animal welfare.

Performance Indicator MN.AS.07.03

Demonstrate technical skills through clinical, hospital, and other laboratory procedures (e.g., restraints, injections, bandaging, physical exams).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.07.03.01.a. Summarize the importance of technical skills and clinical procedures in the veterinary industry.	AS.07.03.01.b. Analyze when the procedures would be utilized in the clinic setting and describe how they would be performed.	AS.07.03.01.c. Demonstrate the clinical procedures performed in the veterinary medicine industry.

MN.AS.08: Environmental Conservation within Animal Systems

Analyze environmental factors associated with animal production.

Performance Indicator MN.AS.08.01

Design and implement methods to reduce the effects of animal production on the environment.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
AS.08.01.01.a. Identify and summarize the effects of animal agriculture on the environment (e.g., waste disposal, carbon footprint, air quality, environmental efficiencies).	AS.08.01.01.b. Assess the effectiveness of methods of reducing the effects of animal agriculture on the environment.	AS.08.01.01.c. Devise a plan that includes measures to reduce the impact of animal agriculture on the environment.
AS.08.01.02.a. Research and summarize environmental conditions that impact animals (e.g., weather, sources of water, food resources).	AS.08.01.02.b. Critique the reliability and validity of evidence presented to support claims regarding the effects of environmental conditions on animal populations and performance (e.g., population changes, emerging species, extinction).	AS.08.01.02.c. Apply valid and reliable research evidence to predict the potential effects of different environmental conditions for an animal population.
AS.08.01.03.a. Identify and summarize methods for ensuring optimal environmental conditions for animals.	AS.08.01.03.b. Implement and evaluate the effectiveness of methods to ensure optimal environmental conditions for animals.	AS.08.01.03.c. Devise and improve plans to establish favorable environmental conditions for animal growth and performance based on a variety of factors (e.g., economic feasibility, environmental sustainability, impact on animals).

Secondary/Multidisciplinary AFNR Pathways that Align with AS

A secondary or multidisciplinary AFNR pathway, often integrating standards or cumulating from coursework from the AFNR animal, plant, natural resources, and power systems pathways—encompassing the study of agribusinesses and their management including, but not limited to, record keeping, budget management (cash and credit), business planning, and sales and marketing. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the planning, development, application, and management of agribusiness systems in AFNR settings.

A secondary or multidisciplinary AFNR pathway—often integrating standards or cumulating from coursework from the AFNR animal and plant systems pathways—encompassing the study of food safety and sanitation; nutrition, biology, microbiology, chemistry, and human behavior in local and global food systems; food selection and processing for storage, distribution, and consumption; and the historical and current development of the food industry. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application, and management of food products and processing systems in AFNR settings.

A secondary or multidisciplinary AFNR pathway—often integrating standards or cumulating from coursework from the AFNR animal, plant, and natural resources pathways—encompassing the study of using data and scientific techniques to solve problems concerning living organisms with an emphasis on applications to agriculture, food, and natural resource systems. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application, and management of biotechnology systems in AFNR settings.

Section 5 – Plant Systems (AS) Pathway Frameworks

Introduction

The Plant Systems (PS) pathway encompasses the study of plant life cycles, classifications, functions, structures, reproduction, media, and nutrients, as well as growth and cultural practices through the study of crops, turf grass, trees, shrubs, and ornamental plants. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application, and management of plant systems in AFNR settings.

Section Contents

Recommended PS Courses and Pathway Sequence

Students concentrating on the PS pathway should complete a sequence of at least two courses within the following course offerings based their career goals and interests.

Introductory Courses	Intermediate Courses	Advanced Courses
01 Principles of Ag., Food, and Natural Resources	34 Soil Chemistry (Chemistry Credit)	13 Agricultural Education, Research, and Development
02 Advanced Principles of Ag., Food, and Natural Resources	35 Crop Production and Agronomy	44 Specialty and Emerging Plant Systems Topics
03 Principles of AFNR Biology (Science-Elective Credit)	36 Garden and Crop Operations (Simulated WBL: School Farm)	75 Food Science
04 Advanced Principles of AFNR Biology (Science-Elective Credit)	37 Pest Management, Entomology, and Plant Pathology	76 Advanced Food Science
30 Plant Science and Horticulture	38 Floriculture and Ornamental Horticulture	77 Food Chemistry (Science Credit)
31 Advanced Plant Science and Horticulture	39 Floral Design (Art Credit)	78 Advanced Food Chemistry (Science Credit)
32 Plant Biology (Science-Elective Credit)	40 Greenhouse and Nursery Operations (Simulated WBL: School Farm)	85 Animal and Plant Biotechnology
33 Advanced Plant Biology (Science-Elective Credit)	41 Turf, Landscape, and Parks Management	86 Advanced Animal and Plant Biotechnology
	42 Landscape Design (Art Credit)	87 Agricultural Biotechnology and Biology (Science-Elective Credit)
	43 Floral and Landscaping Operations (Simulated WBL: School Business)	88 Advanced Agricultural Biotechnology and Biology (Science-Elective Credit)
		93 Extended/ Summer AFNR Work-Based Learning (SAE) and Leadership (FFA)
		94 Agricultural Leadership Development
		95 Agricultural Career Seminar
		96 Advanced Agricultural Career Seminar
		97 AFNR Work Experience: Immersion SAE (Adv. Internship/Placement, Entrepreneurship, Research)

Recommended Work-Based Learning (WBL) and SAEs within PS

A Supervised Agricultural Experience (SAE) is a student-led, instructor-supervised, Work-Based Learning (WBL) experience that results in measurable outcomes within a predefined, agreed upon set of AFNR Technical Standards and Career Ready Practices aligned to a Career Plan of study. SAE teaches technical skills and knowledge within the psychomotor domain of learning. SAE includes both experiential learning (i.e., pre-WBL) and WBL (federally defined as sustained interactions with industry or community professionals in real workplace settings, to the extent practicable, or simulated environments, at an educational institution that foster in-depth, firsthand engagement with the tasks required in a given career field, that are aligned to curriculum and instruction; Sec. 3 [20 U.S.C. 2302] 55).

SAE/WBL is a required component of an AFNR program, first established in the Smith-Hughes Act (1917) and reinforced in each of the federal Perkins Career and Technical Education (CTE) Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires WBL/SAE as a component of CTE Program Approval (Minn. R. 3505). Table 1 has example SAE opportunities within this pathway, as defined by the National Council for AFNR Education, Perkins V legislation, and the Minnesota Department of Education.

Table 1. Examples of WBL/SAE Curricula and Programs within PS

SAE Program Area	Examples, Non-Exhaustive
Experiential Learning (Foundational SAE; Pre-WBL)	● Career exploration ● Job shadowing a local crop farmer ● Assist with school/community garden project ● Plant identification and management experience ● Field trip to a local greenhouse
Internship (Placement SAE; Immersion WBL)	● Working for a crop services business ● Working at a flower arrangement shop ● Working for hay production business ● Working for a seed company
Apprenticeship (Placement SAE; Immersion WBL)	● More than 450 hours in an internship, combined with coursework ● Contact the Minnesota Department of Education (MDE) for support
Entrepreneurship (Entrepreneurship SAE; Immersion WBL)	● Farming grain crops ● Owning a flower arrangement business ● Crop services business ● Fertilizer or chemical sales business
Research (Research SAE; Immersion WBL)	● Research flowering techniques by varying temperature ● Vegetable production on varying light exposure ● Plant pest control research
School-Based Enterprise (School-Based SAE; Simulated WBL)	● Greenhouse Management/Operations SBE WBL ● Community Supported Ag/School Farm Operations SBE WBL ● School or Crop Research Plot SBE WBL
FFA Work-Based Learning and SAE Proficiency Award Areas	● Agriscience Research - Plant Systems ● Grain Production ● Turf Grass Management

Recommended Social-Emotional Learning (SEL) and FFA Opportunities within PS

The National FFA Organization (FFA) is a student-led, instructor-supervised, Career and Technical Student Organization (CTSO) that results in measurable outcomes within a predefined, agreed upon set of AFNR Social-Emotional Standards and Career Ready Practices aligned to a Career Plan of study. FFA teaches social-emotional and leadership skills and knowledge within the affective domain of learning. FFA includes programs that provide essential employability skills such as critical thinking, consensus building, communication, teamwork, and leadership. FFA was founded in 1928 and is federally defined as intracurricular (i.e., within the curriculum; cf. extracurricular: external, co-curricular: alongside) and an integral part (i.e., necessary to form the whole) of School-Based AFNR Education (Public Law No. 116-7).

Leadership/FFA is a required component of an AFNR program, formalized in the FFA Federal Charter in 1950 (Public Law No. 116-7) and reinforced in federal Perkins CTE Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires leadership/FFA as a component of CTE Program Approval (Minn. R. 3505). Table 2 has example FFA opportunities with this pathway, as defined by the National Council for AFNR Education, Perkins V legislation, Department of Education, and the Minnesota FFA Association.

Table 2. Examples of SEL/FFA Curricula and Programs within PS

FFA Program Area	Examples, Non-Exhaustive
Student Development Programs (Growing Leaders)	● Agriscience fair or SAE open house ● Crop test plot ● Career day/guest speakers
Community Development/ Service (Building Communities)	● Community beautification projects-planting flowers/shrubs/etc. ● Community education (e.g., wreath design, memorial planters) ● Donate food from school garden to local food shelf ● Agritourism (e.g., pumpkin patch, apple orchard)
Literacy, Advocacy, and Safety (Strengthening Agriculture)	● Crop plot research/harvest day ● Agriculture in the Classroom ● Activities with Master Gardeners
Conferences, Conventions, and Banquets	● InTENse ● Horizon conference ● Horticulture industry events (e.g., Horticultural Society, Nursery and Landscape Association)
Career Development Events (CDE)	● Horse Evaluation ● Agronomy ● Floriculture ● Forestry ● Nursery Landscape ● Soils
Leadership Development Events (LDE)	● Agricultural Issues Forum ● Marketing Plan ● Prepared Public Speaking ● Extemporaneous Speaking

MN.PS.01: Plant Nutrition, Environmental Factors, and Reproduction

Develop and implement a plant management plan for a given production goal based on current industry standards.

Performance Indicator MN.PS.01.01

Determine the influence of environmental factors on plant growth.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PS.01.01.01.a. Identify and summarize the three measurements of light (i.e., color, intensity, and duration) that affect plant growth.	PS.01.01.01.b. Analyze and describe plant responses to light color, intensity, and duration.	PS.01.01.01.c. Analyze plant responses to varied light color, intensity and duration and recommend modifications to light for desired plant growth.
PS.01.01.02.a. Identify and summarize the effects of air and temperature on plant metabolism and growth.	PS.01.01.02.b. Determine the optimal air and temperature conditions for plant growth.	PS.01.01.02.c. Design, implement, and evaluate a plan to maintain optimal air and temperature conditions for plant growth.
PS.01.01.03.a. Identify and summarize the effects of water quality on plant growth, (e.g., pH, dissolved solids).	PS.01.01.03.b. Analyze and describe plant responses to water conditions.	PS.01.01.03.c. Analyze plant responses to water conditions and recommend modifications to water for desired plant growth.

Performance Indicator MN.PS.01.02

Prepare and manage growing media for use in plant systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PS.01.02.01.a. Identify the major components of growing media and describe how growing media support plant growth.	PS.01.02.01.b. Describe the physical and chemical characteristics of growing media and explain the influence they have on plant growth.	PS.01.02.01.c. Formulate and prepare growing media for specific plants or crops.
PS.01.02.02.a. Identify the categories of soil water.	PS.01.02.02.b. Discuss how soil drainage and water-holding capacity can be improved.	PS.01.02.02.c. Determine the hydraulic conductivity for soil and how the results influence irrigation practices.
PS.01.02.03.a. List and summarize the reasons for preparing growing media before planting.	PS.01.02.03.b. Prepare soil and growing media for planting with the addition of amendments.	PS.01.02.03.c. Analyze how mechanical planting equipment performs soil preparation and seed placement.

MN.PS.01: Plant Nutrition, Environmental Factors, and Reproduction, Continued

Develop and implement a plant management plan for a given production goal based on current industry standards.

Performance Indicator MN.PS.01.03

Develop and implement a fertilization plan for specific plants or crops.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PS.01.03.01.a. Summarize the impact of environmental factors on nutrient availability (e.g., moisture, temperature, pH).	PS.01.03.01.b. Assess and describe the impact environmental factors have on a crop.	PS.01.03.01.c. Devise a plan to meet plant nutrient needs based on environmental factors present.
PS.01.03.02.a. Discuss the influence of pH and cation exchange capacity on the avail-ability of nutrients.	PS.01.03.02.b. Contrast pH and cation ex-change capacity between mineral soil and soilless growing media.	PS.01.03.02.c. Adjust the pH of growing media for specific plants or crops.
PS.01.03.03.a. Collect soil and plant tissue samples using generally accepted procedures and explain how incorrect sample collection will affect the results of a laboratory analysis.	PS.01.03.03.b. Interpret laboratory analyses of soil and tissue samples.	PS.01.03.03.c. Prescribe fertilizer applications based on the results of a laboratory analysis of soil and plant tissue samples.
PS.01.03.04.a. Identify fertilizer sources of essential plant nutrients; explain fertilizer formulations, including organic and inorganic; and describe different methods of fertilizer application.	PS.01.03.04.b. Calculate the amount of fertilizer to be applied based on nutrient recommendation and fertilizer analysis.	PS.01.03.04.c. Calibrate application equipment to meet plant nutrient needs.
PS.01.03.05.a. Research and summarize production methods focused on soil management (e.g., crop rotation, companion planting, cover crops, etc.).	PS.01.03.05.b. Assess and describe the short- and long-term effects production methods have on soil.	PS.01.03.05.c. Devise a plan for soil management for a selected production method.
PS.01.03.06.a. Summarize the impact of environmental factors on nutrient availability (e.g., moisture, temperature, pH, etc.).	PS.01.03.06.b. Assess and describe the impact environmental factors have on a crop.	PS.01.03.06.c. Devise a plan to meet plant nutrient needs based on environmental factors present.

MN.PS.02: Plant Anatomy and Physiology

Apply principles of classification, plant anatomy, and plant physiology to plant production and management.

Performance Indicator MN.PS.02.01

Classify plants according to taxonomic systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PS.02.01.01.a. Identify and summarize systems used to classify plants based on specific characteristics.	PS.02.01.01.b. Compare and contrast the hierarchical classification of agricultural and ornamental plants.	PS.02.01.01.c. Classify agricultural and ornamental plants according to the hierarchical classification system.
PS.02.01.02.a. Describe the morphological characteristics used to identify agricultural and herbaceous plants (e.g., life cycles, growth habit, plant use, and as monocotyledons or di-cotyledons, woody, herbaceous).	PS.02.01.02.b. Identify and describe important plants to agricultural and ornamental plant systems by common names.	PS.02.01.02.c. Identify and describe important plants to agricultural and ornamental plant systems by scientific names.

MN.PS.02: Plant Anatomy and Physiology, Continued

Apply principles of classification, plant anatomy, and plant physiology to plant production and management.

Performance Indicator MN.PS.02.02

Apply knowledge of plant anatomy and the functions of plant structures to activities associated with plant systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PS.02.02.01.a. Identify structures in a typical plant cell and summarize the function of plant cell organelles.	PS.02.02.01.b. Compare and contrast mitosis and meiosis.	PS.02.02.01.c. Apply the knowledge of cell differentiation and the functions of the major types of cells to plant systems.
PS.02.02.02.a. Identify and summarize the components, the types, and the functions of plant roots.	PS.02.02.02.b. Analyze root tissues and explain the pathway of water and nutrients into and through root tissues.	PS.02.02.02.c. Correlate the active and passive transport of minerals into and through the root system to plant nutrition.
PS.02.02.03.a. Identify and summarize the components and the functions of plant stems.	PS.02.02.03.b. Analyze and describe the difference in arrangement of vascular tissue between monocot and dicot plant stems.	PS.02.02.03.c. Evaluate the function of the xylem, phloem and cambium tissues and the impact on plant systems.
PS.02.02.04.a. Research and summarize leaf morphology and the functions of leaves.	PS.02.02.04.b. Analyze how leaves capture light energy and summarize the exchange of gases.	PS.02.02.04.c. Devise a plan for plant management practices that takes into account leaf structure and functions.
PS.02.02.05.a. Identify and summarize the components of a flower, the functions of a flower and the functions of flower components.	PS.02.02.05.b. Apply knowledge of flower structure to differentiate between the types of flowers and flower inflorescence (e.g., complete, incomplete, perfect, imperfect).	PS.02.02.05.c. Evaluate flower structures and analyze the impact of plant structure on plant breeding, production, and use.
PS.02.02.06.a. Identify and summarize the functions and components of seeds and fruit.	PS.02.02.06.b. Analyze and categorize the major types of seeds and fruit.	PS.02.02.06.c. Evaluate the impact of different seed and fruit structures to plant culture and use.

MN.PS.02: Plant Anatomy and Physiology, Continued

Apply principles of classification, plant anatomy, and plant physiology to plant production and management.

Performance Indicator MN.PS.02.03

Apply knowledge of plant physiology and energy conversion to plant systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PS.02.03.01.a. Summarize the importance of photosynthesis to plant life on earth and the process of photosynthesis, including the types (c3, c4, Cam), its stages (e.g., light-dependent, and light independent reactions), and its products and byproducts.	PS.02.03.01.b. Apply knowledge of photosynthesis to analyze how various environmental factors will affect the rate of photosynthesis.	PS.02.03.01.c. Evaluate the impact of photosynthesis and the factors that affect it (e.g., plant management, culture, and production problems).
PS.02.03.02.a. Summarize the stages of cellular respiration including their products and byproducts.	PS.02.03.02.b. Analyze the factors that affect cellular respiration processes and rate in a crop production setting.	PS.02.03.02.c. Evaluate the impact of plant respiration on plant growth, crop management, and post-harvest handling decisions.
PS.02.03.03.a. Summarize primary growth and the role of the apical meristem.	PS.02.03.03.b. Analyze plant growth and assess the process of secondary plant growth.	PS.02.03.03.c. Use the principals of primary and secondary plant growth to achieve desired characteristics of plant products.
PS.02.03.04.a. Identify and categorize the five groups of naturally occurring plant hormones and synthetic plant growth regulators.	PS.02.03.04.b. Analyze and identify the plant responses to plant growth regulators and different forms of tropism.	PS.02.03.04.c. Select and defend the use of specific plant growth regulators to produce desired responses from plants.
PS.02.03.05.a. Compare and contrast the effects of transpiration, translocation, and assimilation on plants.	PS.02.03.05.b. Identify and analyze the factors affecting transpiration, translocation, and assimilation rate and products.	PS.02.03.05.c. Devise plans for plant management that applies knowledge of transpiration, translocation, and assimilation on plant growth.
PS.02.03.06.a. Compare and contrast the different types of grafting and their purpose	PS.02.03.06.b. Describe the correct procedure for grafting plant parts.	PS.02.03.06.c. Demonstrate how to perform different types of grafts and use them as a part of a plant production plan.

MN.PS.03: Plant Health and Environmental Conservation within PS

Develop and implement a plant management plan for a given production goal based on current industry standards.

Performance Indicator MN.PS.03.01

Demonstrate plant propagation techniques in plant system activities.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PS.03.01.01.a. Identify examples of and summarize pollination, cross-pollination, and self-pollination of flowering plants.	PS.03.01.01.b. Examine and apply the process of plant pollination and fertilization.	PS.03.01.01.c. Select and defend the use of pollination methods and practices used to maximize crop pollination.
PS.03.01.02.a. Demonstrate sowing techniques for providing favorable conditions to meet the factors of seed germination.	PS.03.01.02.b. Prepare seed in order to overcome seed dormancy mechanisms and to maintain seed viability and vigor.	PS.03.01.02.c. Conduct tests associated with seed germination rates, viability, and vigor.
PS.03.01.03.a. Summarize optimal conditions for asexual propagation and demonstrate techniques used to propagate plants by cuttings, division, separation, layering, budding, and grafting.	PS.03.01.03.b. Manage the plant environment to support asexual reproduction.	PS.03.01.03.c. Evaluate asexual propagation practices based on productivity and efficiency.
PS.03.01.04.a. Define micropropagation and discuss advantages and disadvantages associated with the practice.	PS.03.01.04.b. Summarize the main stages of the micropropagation process.	PS.03.01.04.c. Demonstrate aseptic micropropagation techniques.
PS.03.01.05.a Define Genetically Modified Organisms (GMO) and discuss advantages and disadvantages associated with the practice.	PS.03.01.05.b. Summarize the steps used to modify the genetic code for a plant and the applications of the various processes.	PS.03.01.05.c. Evaluate the applications of GMO technology in AFNR.

MN.PS.03: Plant Health and Environmental Conservation with PS, Continued

Develop and implement a plant management plan for a given production goal based on current industry standards.

Performance Indicator MN.PS.03.02

Develop and implement a management plan for plant production.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PS.03.02.01.a. Determine seeding rate need for specified plant population or desired quantity of finished plants.	PS.03.02.01.b. Apply pre-plant treatments required of seeds and plants and evaluate the results.	PS.03.02.01.c. Adjust and calibrate mechanized seeding and/or planting equipment for desired seed application rate.
PS.03.02.02.a. Observe and record environmental conditions during the germination, growth, and development of a crop.	PS.03.02.02.b. Monitor the progress of plantings and determine the need to adjust environmental conditions.	PS.03.02.02.c. Prepare and implement a plant production schedule based on predicted environmental conditions and desired market target (e.g., having plants ready to market on a specific day such as Mother's Day, organic production, low maintenance landscape plants).
PS.03.02.03.a. Summarize the stages of plant growth and the reasons for controlling plant growth.	PS.03.02.03.b. Demonstrate proper techniques to control and manage plant growth through mechanical, cultural, or chemical means.	PS.03.02.03.c. Prepare plant production schedules utilizing plant growth knowledge to get plants to their optimal growth stage at a given time.
PS.03.02.04.a. Identify and categorize structures and technologies used for controlled atmosphere production of plants.	PS.03.02.04.b. Compare and contrast the types of technologies used for controlled atmosphere production.	PS.03.02.04.c. Research, select, and utilize technology for use in controlled atmosphere production.
PS.03.02.05.a. Summarize the use of hydroponic and aquaponic systems for plant production.	PS.03.02.05.b. Compare and contrast the types of systems used in hydroponic and aquaponic plant production.	PS.03.02.05.c. Research, select, and create and manage a hydroponic or aquaponic plant system.
PS.03.02.06.a. Identify and categorize structures and technologies used for controlled atmosphere production of plants.	PS.03.02.06.b. Compare and contrast the types of technologies used for controlled atmosphere production.	PS.03.02.06.c. Research, select and defend technology for use in controlled atmosphere production.
PS.03.02.07.a. Summarize the use of hydroponic and aquaponic systems for plant production.	PS.03.02.07.b. Compare and contrast the types of systems used in hydroponic and aquaponic plant production.	PS.03.02.07.c. Research, select and defend the use of a hydroponic or aquaponic plant system.

MN.PS.03: Plant Health and Environmental Conservation with PS, Continued

Develop and implement a plant management plan for a given production goal based on current industry standards.

Performance Indicator MN.PS.03.03

Develop and implement a plan for integrated pest management for plant production.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PS.03.03.01.a. Identify and categorize plant pests, diseases, and disorders.	PS.03.03.01.b. Identify and analyze major local weeds, insect pests and infectious and noninfectious plant diseases.	PS.03.03.01.c. Devise solutions for plant pests, diseases, and disorders.
PS.03.03.02.a. Diagram the life cycle of major plant pests and diseases.	PS.03.03.02.b. Predict pest and disease problems based on environmental conditions and life cycles.	PS.03.03.02.c. Design and implement a crop scouting program.
PS.03.03.03.a. Identify and summarize pest control strategies associated with integrated pest management and the importance of determining economic threshold.	PS.03.03.03.b. Demonstrate pesticide formulations including organic and synthetic active ingredients and selection of pesticide to control specific pest.	PS.03.03.03.c. Employ pest management strategies to manage pest populations, assess the effectiveness of the plan, and adjust the plan as needed.
PS.03.03.04.a. Distinguish between risks and benefits associated with the materials and methods used in plant pest management.	PS.03.03.04.b. Evaluate environmental and consumer concerns regarding pest management strategies.	PS.03.03.04.c. Examine and apply procedures for the safe handling, use and storage of pesticides including personal protective equipment, and reentry interval.

MN.PS.03: Plant Health and Environmental Conservation with PS, Continued

Develop and implement a plant management plan for a given production goal based on current industry standards.

Performance Indicator MN.PS.03.04

Apply principles and practices of sustainable agriculture to plant production.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PS.03.04.01.a. Research and summarize production methods focused on soil management (e.g., crop rotation, companion planting, cover crops).	PS.03.04.01.b. Assess and describe the short and long-term effects production methods have on soil.	PS.03.04.01.c. Devise a plan for soil management for a selected production method.
PS.03.04.02.a. Compare, and contrast, the alignment of different production systems (conventional and organic) with USDA sustainable practices criteria.	PS.03.04.02.b. Analyze the alignment of modern technologies used in production systems (e.g., precision agriculture, GE crops) with USDA sustainable practices criteria.	PS.03.04.02.c. Research, prepare, and defend plans for a plant systems enterprise that aligns with USDA sustainable practices criteria.
PS.03.04.03.a. Compare, and contrast, organic and conventional production practices.	PS.03.04.03.b. Describe how organic and conventional practices impact global food security.	PS.03.04.03.c. Compare, and contrast, a U.S. and a foreign production system and their impact on global food security and the environment.
PS.03.04.04.a. Evaluate the water needs of different plants.	PS.03.04.04.b. Describe production practices used to minimize water inputs.	PS.03.04.04.c. Analyze a production system and develop a plan to decrease its water input.

MN.PS.03: Plant Health and Environmental Conservation with PS, Continued

Develop and implement a plant management plan for a given production goal based on current industry standards.

Performance Indicator MN.PS.03.05

Harvest, handle, and store crops according to current industry standards.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PS.03.05.01.a. Identify and summarize harvesting methods and equipment.	PS.03.05.01.b. Analyze the processes used by mechanical harvesting equipment.	PS.03.05.01.c. Assess the stage of growth to determine crop maturity or marketability and demonstrate proper harvesting techniques.
PS.03.05.02.a. Research and summarize reasons for calculating crop loss and or damage.	PS.03.05.02.b. Evaluate crop yield and loss data.	PS.03.05.02.c. Make recommendations to reduce crop loss.
PS.03.05.03.a. Research and summarize how safety is ensured at each stage of the following processes: harvesting, processing, and storing.	PS.03.05.03.b. Research and analyze practices used to maintain a safe product through harvest, processing, storage, and shipment (e.g., Food Safety Modernization Act, Good Agricultural Practices).	PS.03.05.03.c. Research laws and apply regulations to ensure the production of plants and plant products that are safe for distribution and use
PS.03.05.04.a. Identify and categorize plant preparation methods for storing and shipping plants and plant products.	PS.03.05.04.b. Analyze the proper conditions required to maintain the quality of plants and plant products held in storage and during shipping.	PS.03.05.04.c. Monitor and evaluate environmental conditions in storage facilities for plants and plant products.
PS.03.05.05.a. Summarize the reasons for preparing plants and plant products for distribution.	PS.03.05.05.b. Demonstrate techniques for grading, handling, and packaging plants and plant products for distribution.	PS.03.05.05.c. Evaluate techniques for grading, handling, and packaging plants and plant products.

MN.PS.04: Plant Design and Art

Apply principles of design in plant systems to enhance an environment (e.g., floral, forest, landscape, farm).

Performance Indicator MN.PS.04.01

Evaluating, identifying, and preparing plants to enhance an environment.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PS.04.01.01.a. Identify and categorize plants by their purpose (e.g., floral plants, landscape plants, house plants).	PS.04.01.01.b. Demonstrate proper use of plants in their environment (e.g., focal and filler plants in floriculture, heat tolerant and shade plants in a landscape design).	PS.04.01.01.c. Prepare and install plant materials according to a design plan that uses the proper plants based on the situation and environment.
PS.04.01.02.a. Summarize the applications of design in agriculture and ornamental plant systems.	PS.04.01.02.b. Create a design utilizing plants in their proper environments.	PS.04.01.02.c. Evaluate a design and provide feedback and suggestions for improvement (e.g., a floral arrangement, a landscape, or a landscape plan).
PS.04.01.03.a. List and describe industry standard plant preparation techniques.	PS.04.01.03.b. Create a series of plant care steps from purchase to final installation.	PS.04.01.03.c. Prepare plant materials following industry standard techniques.

Performance Indicator MN.PS.04.02

Create designs using plants.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PS.04.02.01.a. Research and summarize the principles and elements of design for use in plant systems.	PS.04.02.01.b. Apply principles and elements of design that form the basis of artistic impression.	PS.04.02.01.c. Analyze designs to identify use of design principles and elements.
PS.04.02.02.a. Identify and categorize tools used for design (e.g., computer landscape software, drawing tools, florist tools).	PS.04.02.02.b. Demonstrate the use of tools used for creating designs.	PS.04.02.02.c. Choose and properly use appropriate tools to create a desired design.
PS.04.02.03.a. Identify characteristics of a landscape that are analyzed during a site evaluation.	PS.04.02.03.b. Analyze a landscape site using proper site evaluation methods.	PS.04.02.03.c. Make recommendations based on a site evaluation.

Secondary/Multidisciplinary AFNR Pathways that Align with PS

A secondary or multidisciplinary AFNR pathway, often integrating standards or cumulating from coursework from the AFNR animal, plant, natural resources, and power systems pathways—encompassing the study of agribusinesses and their management including, but not limited to, record keeping, budget management (cash and credit), business planning, and sales and marketing. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the planning, development, application, and management of agribusiness systems in AFNR settings.

A secondary or multidisciplinary AFNR pathway—often integrating standards or cumulating from coursework from the AFNR animal and plant systems pathways—encompassing the study of food safety and sanitation; nutrition, biology, microbiology, chemistry, and human behavior in local and global food systems; food selection and processing for storage, distribution, and consumption; and the historical and current development of the food industry. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application, and management of food products and processing systems in AFNR settings.

A secondary or multidisciplinary AFNR pathway—often integrating standards or cumulating from coursework from the AFNR animal, plant, and natural resources pathways—encompassing the study of using data and scientific techniques to solve problems concerning living organisms with an emphasis on applications to agriculture, food, and natural resource systems. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application, and management of biotechnology systems in AFNR settings.

Section 6 – Natural Resources & Environmental Service Systems (NRES) Pathway Frameworks

Introduction

The Minnesota Natural Resource and Environmental Service Systems (NRES) Career Pathway is a combination of two overlapping national AFNR pathways. The Natural Resource Systems (NRS) national AFNR pathway encompasses the study of the management, protection, enhancement and improvement of soil, water, wildlife, forests, and air as natural resources. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application, and management of natural resource systems in AFNR settings. The Environmental Service Systems (ESS) national AFNR pathway encompasses the study of systems, instruments and technology used to monitor and minimize the impact of human activity on environmental systems. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application, and management of environmental service systems in AFNR settings.

Section Contents

Recommended NRES Courses and Pathway Sequence

Students concentrating on the NRES pathway should complete a sequence of at least two courses within the following course offerings based their career goals and interests.

Introductory Courses	Intermediate Courses	Advanced Courses
01 Principles of Ag., Food, and Natural Resources	49 Wildlife, Fisheries, and Ecology Management	13 Agricultural Education, Research, and Development
02 Advanced Principles of Ag., Food, and Natural Resources	50 Advanced Wildlife, Fisheries, and Ecology Management	59 Specialty and Emerging Natural Resource Systems Topics
03 Principles of AFNR Biology (Science-Elective Credit)	51 Water Treatment and Environmental Services	93 Extended/ Summer AFNR Work-Based Learning (SAE) and Leadership (FFA)
04 Advanced Principles of AFNR Biology (Science-Elective Credit)	52 Forestry Science and Management	94 Agricultural Leadership Development
45 Energy and Natural Resources Science	53 Forestry Operations (Simulated WBL: School Farm)	95 Agricultural Career Seminar
46 Advanced Energy and Natural Resources Science	54 Biofuels, Renewable Resources, and Alternative Energy	96 Advanced Agricultural Career Seminar
47 Energy and Natural Resources Ecology (Science-Elective Credit)	55 Minerals, Mining, and Fuels	97 AFNR Work Experience: Immersion SAE (Adv. Internship/Placement, Entrepreneurship, Research)
48 Advanced Energy and Natural Resources Ecology (Science-Elective Credit)	56 Energy and Environmental Engineering	
	57 Outdoor Education and Recreation Management	
	58 Environmental Science Issues and Policy	

Recommended Work-Based Learning (WBL) and SAEs within NRES

A Supervised Agricultural Experience (SAE) is a student-led, instructor-supervised, Work-Based Learning (WBL) experience that results in measurable outcomes within a predefined, agreed upon set of AFNR Technical Standards and Career Ready Practices aligned to a Career Plan of study. SAE teaches technical skills and knowledge within the psychomotor domain of learning. SAE includes both experiential learning (i.e., pre-WBL) and WBL (federally defined as sustained interactions with industry or community professionals in real workplace settings, to the extent practicable, or simulated environments, at an educational institution that foster in-depth, firsthand engagement with the tasks required in a given career field, that are aligned to curriculum and instruction; Sec. 3 [20 U.S.C. 2302] 55).

SAE/WBL is a required component of an AFNR program, first established in the Smith-Hughes Act (1917) and reinforced in each of the federal Perkins Career and Technical Education (CTE) Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires WBL/SAE as a component of CTE Program Approval (Minn. R. 3505). Table 1 has example SAE opportunities within this pathway, as defined by the National Council for AFNR Education, Perkins V legislation, and the Minnesota Department of Education.

Table 1. Examples of WBL/SAE Curricula and Programs within NRES

SAE Program Area	Examples, Non-Exhaustive
Experiential Learning (Foundational SAE; Pre-WBL)	● Career exploration ● Review of the hunting industry in your area ● Job shadowing at a local game farm ● Ag issues in the outdoor recreational industry ● State parks and recreational tourism business workshops
Internship (Placement SAE; Immersion WBL)	● Working at a recreational wildlife farm ● Working for the state department of natural resources ● Working for a wildlife management specialist in habitats ● Working for MN DNR in Wildlife/Tree Planting/Smoke Chaser
Apprenticeship (Placement SAE; Immersion WBL)	● More than 450 hours in an internship, combined with coursework ● Contact the Minnesota Department of Education (MDE) for support
Entrepreneurship (Entrepreneurship SAE; Immersion WBL)	● Starting a wildlife management consulting firm ● Forest management consulting ● Food plot and trail installation/consultation ● Creating and selling fishing lures and decoys
Research (Research SAE; Immersion WBL)	● Economic value in rural communities from hunting ● Trail cam/camera trap population surveys and research ● Wildlife disease and population studies
School-Based Enterprise (School-Based SAE; Simulated WBL)	● Community Supported Ag/School Farm Operations SBE WBL ● Aquaculture Operations SBE WBL ● Forest/Natural Resources Operations SBE WBL
FFA Work-Based Learning and SAE Proficiency Award Areas	● Environmental Science and Natural Resources Management ● Forest Management and Products ● Outdoor Recreation

Recommended Social-Emotional Learning (SEL) and FFA Opportunities within NRES

The National FFA Organization (FFA) is a student-led, instructor-supervised, Career and Technical Student Organization (CTSO) that results in measurable outcomes within a predefined, agreed upon set of AFNR Social-Emotional Standards and Career Ready Practices aligned to a Career Plan of study. FFA teaches social-emotional and leadership skills and knowledge within the affective domain of learning. FFA includes programs that provide essential employability skills such as critical thinking, consensus building, communication, teamwork, and leadership. FFA was founded in 1928 and is federally defined as intracurricular (i.e., within the curriculum; cf. extracurricular: external, co-curricular: alongside) and an integral part (i.e., necessary to form the whole) of School-Based AFNR Education (Public Law No. 116-7).

Leadership/FFA is a required component of an AFNR program, formalized in the FFA Federal Charter in 1950 (Public Law No. 116-7) and reinforced in federal Perkins CTE Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires leadership/FFA as a component of CTE Program Approval (Minn. R. 3505). Table 2 has example FFA opportunities with this pathway, as defined by the National Council for AFNR Education, Perkins V legislation, Department of Education, and the Minnesota FFA Association.

Table 2. Examples of SEL/FFA Curricula and Programs within NRES

FFA Program Area	Examples, Non-Exhaustive
Student Development Programs (Growing Leaders)	● Agriscience fair or SAE open house ● Outdoor recreation activities
Community Development/ Service (Building Communities)	● Veteran hunting/fishing program ● Roadside/trail/streambank clean-up ● Recycling/composting program ● Water quality monitoring program
Literacy, Advocacy, and Safety (Strengthening Agriculture)	● Firearms safety ● ATV/snowmobile safety ● Wildland firefighting S130/S190 ● Alternative energy education ● Camping and fishing trips ● Trapper education program
Conferences, Conventions, and Banquets	● InTENse ● Wildlife conservation organization events (e.g., Ducks Unlimited, Pheasants Forever, Wild Turkey Federation, Deer Hunters) ● Environmental organization events (e.g., Audobon Chapters, Land Stewardship Project, Nature Conservancy)
Career Development Events (CDE)	● Environmental and Natural Resources ● Fish and Wildlife Management ● Forestry ● Soils
Leadership Development Events (LDE)	● Agricultural Issues Forum ● Marketing Plan ● Prepared Public Speaking ● Extemporaneous Speaking

MN.NRES.01: Ecology and Resource Management

Plan and conduct natural resource management activities that apply logical, reasoned, and scientifically based solutions to natural resource issues and goals.

Performance Indicator MN.NRES.01.01

Classify different types of natural resources in order to enable protection, conservation, enhancement, and management in a particular geographical region.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.01.01.01.a. Research and examine the characteristics used to identify trees and woody plants.	NRES.01.01.01.b. Apply identification techniques to determine the species of a tree or woody plant.	NRES.01.01.01.c. Evaluate the species of trees present to assess the health of an ecosystem (e.g., presence of native versus invasive species, biodiversity).
NRES.01.01.02.a. Research and examine the characteristics used to identify herbaceous plants.	NRES.01.01.02.b. Apply identification techniques to determine the species of an herbaceous plant.	NRES.01.01.02.c. Evaluate the species of herbaceous plants present to assess the health of an ecosystem (e.g., presence of native versus invasive plants, biodiversity).
NRES.01.01.03.a. Research and examine the characteristics used to identify wildlife and insects.	NRES.01.01.03.b. Apply identification techniques to determine the species of wildlife or insect.	NRES.01.01.03.c. Evaluate the species of wildlife and insects present to assess the health of an ecosystem.
NRES.01.01.04.a. Research and examine the characteristics used to identify aquatic species.	NRES.01.01.04.b. Apply identification techniques to determine the species of an aquatic organism.	NRES.01.01.04.c. E valuate the aquatic species present to assess the health of an ecosystem.
NRES.01.01.05.a. Research and examine the characteristics used to identify non-living resources (e.g., soil types, climate, geography).	NRES.01.01.05.b. Apply identification techniques to determine the types of non-living resources in an area.	NRES.01.01.05.c. Evaluate the non-living resources present in an area to determine the best practices for improving, enhancing, and protecting an ecosystem.
NRES.01.01.06.a. Research the purpose and value of resource inventories and population studies.	NRES.01.01.06.b. Apply procedures for conducting resource inventories and population studies.	NRES.01.01.06.c. Conduct an assessment of the resource inventories or population in a given area.

MN.NRES.01: Ecology and Resource Management, Continued

Plan and conduct natural resource management activities that apply logical, reasoned, and scientifically based solutions to natural resource issues and goals.

Performance Indicator MN.NRES.01.02

Apply ecological concepts and principles to atmospheric natural resource systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.01.02.01.a. Classify different kinds of biogeochemical cycles and the role they play in natural resources systems.	NRES.01.02.01.b. Assess the role that the atmosphere plays in the regulation of biogeochemical cycles.	NRES.01.02.01.c. Evaluate and make recommendations to lessen the impact of human activity on the ability of the atmosphere to regulate biogeochemical cycles.
NRES.01.02.02.a. Research and summarize how climate factors influence natural resource systems.	NRES.01.02.02.b. Analyze the impact that climate has on natural resources and debate how this impact has changed due to human activity.	NRES.01.02.02.c. Assess the primary causes of climate change and design strategies to lessen its impact on natural resource systems.

Performance Indicator MN.NRES.01.03

Apply ecological concepts and principles to aquatic natural resource systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.01.03.01.a. Summarize the roles and properties of watersheds.	NRES.01.03.01.b. Assess the function of watersheds and their effect on natural resources.	NRES.01.03.01.c. Evaluate and defend the importance of watersheds to ecosystem function.
NRES.01.03.02.a. Examine and describe the importance of groundwater and surface water to natural resources.	NRES.01.03.02.b. Analyze how different classifications of ground and surface water affect ecosystem function.	NRES.01.03.02.c. Devise and apply strategies to manage, protect, enhance, or improve sources of groundwater or surface water based on its properties.
NRES.01.03.03.a. Compare and contrast riparian zones and riparian buffers based on their function.	NRES.01.03.03.b. Assess techniques used in the creation, enhancement, and management of riparian zones and riparian buffers.	NRES.01.03.03.c. Devise and apply strategies for the creation, enhancement, and management of riparian zones and riparian buffers.

MN.NRES.01: Ecology and Resource Management, Continued

Plan and conduct natural resource management activities that apply logical, reasoned, and scientifically based solutions to natural resource issues and goals.

Performance Indicator MN.NRES.01.04

Apply ecological concepts and principles to terrestrial natural resource systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.01.04.01.a. Research and describe the stages of ecological succession.	NRES.01.04.01.b. Analyze and summarize examples of stages of succession.	NRES.01.04.01.c. Evaluate the stages of succession present in an ecosystem and predict which species will become more prevalent through future stages of succession.
NRES.01.04.02.a. Compare, and contrast, the impact of habitat disturbances and habitat resilience.	NRES.01.04.02.b. Analyze and summarize examples of habitat disturbances and habitat resilience.	NRES.01.04.02.c. Interpret signs of habitat disturbances and resilience in an ecosystem and use these signs to assess the health of an ecosystem.
NRES.01.04.03.a. Compare, and contrast, techniques associated with sustainable forestry (e.g., timber stand improvement, diversity improvement, reforestation).	NRES.01.04.03.b. Analyze a forest in order to determine which forestry techniques would improve that habitat.	NRES.01.04.03.c. Devise a forest management plan that improves the habitat while sustainably maximizing the amount of timber that can be harvested.
NRES.01.04.04.a. Compare, and contrast, techniques associated with soil management (e.g., soil survey and interpretation, erosion control).	NRES.01.04.04.b. Analyze a plot of land in order to determine which soil management techniques would be most applicable.	NRES.01.04.04.c. Devise a soil management plan to minimize erosion and maximize biodiversity, plant productivity, and the formation of topsoil.

MN.NRES.01: Ecology and Resource Management, Continued

Plan and conduct natural resource management activities that apply logical, reasoned, and scientifically based solutions to natural resource issues and goals.

Performance Indicator MN.NRES.01.05

Apply ecological concepts and principles to living organisms in natural resource systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.01.05.01.a. Differentiate between population ecology, population density, and population dispersion and describe the importance of these concepts to natural resource systems.	NRES.01.05.01.b. Analyze the factors that influence population density and population dispersion in natural resource systems.	NRES.01.05.01.c. Create a management plan for a population of a species in an ecosystem given its population ecology, population density, and population dispersion in natural resource systems.
NRES.01.05.02.a. Research and summarize examples of invasive species.	NRES.01.05.02.b. Analyze factors that influence the establishment and spread of invasive species and determine the appropriate steps to prevent or minimize the impact of invasive species.	NRES.01.05.02.c. Evaluate the presence and impact of invasive species on natural resources in a given area and devise a plan to prevent, control, or eliminate invasive species from that habitat.

MN.NRES.02: Human Impact on the Environment and Conservation

Analyze the interrelationships between natural resources and humans.

Performance Indicator MN.NRES.02.01

Examine and interpret the purpose, enforcement, impact and effectiveness of laws and agencies related to natural resource management, protection, enhancement, and improvement (e.g., water regulations, game laws, historic preservation laws, environmental policy).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.02.01.01.a. Distinguish between the types of laws associated with natural resources systems.	NRES.02.01.01.b. Analyze the structure of laws associated with natural resources systems.	NRES.02.01.01.c. Evaluate the impact of laws associated with natural resources systems (e.g., mitigation, water regulations, carbon emissions, game limits, invasive species).
NRES.02.01.02.a. Distinguish between the types of agencies associated with natural resources systems.	NRES.02.01.02.b. Analyze the specific purpose of agencies associated with natural resources systems.	NRES.02.01.02.c. Evaluate the impact and effectiveness of agencies associated with natural resources systems (e.g., regulation of consumption, prevention of damage to natural resources systems, management of ecological interactions).

MN.NRES.02: Human Impact on the Environment and Conservation, Continued

Analyze the interrelationships between natural resources and humans.

Performance Indicator MN.NRES.02.02

Assess the impact of human activities on the availability of natural resources and or environmental service systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.02.02.01.a. Summarize the relationship between natural resources, ecosystems, and human activity.	NRES.02.02.01.b. Assess and explain how different kinds of human activity affect the use and availability of natural resources (e.g., agriculture, industry, transportation).	NRES.02.02.01.c. Evaluate how the availability of natural resources can be improved through changes to human activity.
NRES.02.02.02.a. Categorize the primary causes of extinction of living species due to human activity (e.g., overharvesting, habitat loss, invasive species, pollution).	NRES.02.02.02.b. Assess causes of extinction and describe how those causes related to loss of biodiversity.	NRES.02.02.02.c. Devise a strategy for preventing the loss of species and biodiversity that takes into account the primary causes of species extinction from human activity.
NRES.02.02.03.a. Examine and describe the manner in which modern lifestyles are related to the depletion of natural resources.	NRES.02.02.03.b. Identify solutions to improve the sustainability of modern lifestyles.	NRES.02.02.03.c. Evaluate how modern lifestyles affect resource consumption and energy use and devise a strategy to prevent the complete loss of a natural resource.

MN.NRES.02: Human Impact on the Environment and Conservation, Continued

Analyze the interrelationships between natural resources and humans.

Performance Indicator MN.NRES.02.03

Analyze how modern perceptions of environmental service systems and or natural resource management, protection, enhancement, and improvement change and develop over time.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.02.03.01.a. Summarize and categorize the different social considerations in regard to the use of natural resources (e.g., public versus private, laws and regulations, economics, green technology).	NRES.02.03.01.b. Analyze how social considerations can affect the use and sustainability of natural resources.	NRES.02.03.01.c. Develop predictions for how the management, protection, enhancement, and improvement of natural resources will evolve through social considerations (e.g., establishment of national parks, public opinion, fishing, reduction of waste and energy consumption).
NRES.02.03.02.a. Research and assess how historical figures played a prominent role in shaping how natural resources are viewed and used today (e.g., Aldo Leopold, Teddy Roosevelt, John Muir, Rachel Carson, Gaylord Nelson).	NRES.02.03.02.b. Examine and describe the relationship between current trends in natural resource systems and historical figures that played a prominent role in shaping how natural resources are viewed and used today.	NRES.02.03.02.c. Anticipate and predict how society's views and use of natural resources will continue to change as a result of historical figures and trends in modern society.
NRES.02.03.03.a. Research how technology has affected the use and views of natural resources.	NRSE.02.03.03.b. Analyze and document how some technological advancements changed how natural resources were used and viewed (e.g., Industrial Revolution, fossil fuels, green technology).	NRES.02.03.03.c. Anticipate and predict how future technological advancements may affect the use and views of natural resources.

MN.NRES.02: Human Impact on the Environment and Conservation, Continued

Analyze the interrelationships between natural resources and humans.

Performance Indicator MN.NRES.02.04

Examine and explain how economics affects the use of natural resources and or environmental service systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.02.04.01.a. Compare and contrast how the economic value of a natural resource affects its availability.	NRES.02.04.01.b. Assess whether economic value increases or decreases the conservation, protection, improvement, and enhancement of natural resources.	NRES.02.04.01.c. Devise a plan to improve the conservation, protection, improvement, and enhancement of natural resources based on economic value and practices.
NRES.02.04.02.a. Research the impact of the use of natural resources on local, state, and national economies (e.g., outdoor recreation, energy production, preservation).	NRES.02.04.02.b. Assess the importance of the use of natural resources on local, state, and national economies.	NRES.02.04.02.c. Anticipate and predict how changes to the availability of natural resources because of human activity may impact a local, state, and national economy.
NRES.02.04.03.a. Compare and contrast the economic impact of green technology and alternative energy.	NRES.02.04.03.b. Analyze and document how the adoption of green technology or alternative energy affected a local, state, or national economy.	NRES.02.04.03.c. Anticipate and predict the economic impact green technology and alternative energy.

MN.NRES.02: Human Impact on the Environment and Conservation, Continued

Analyze the interrelationships between natural resources and humans.

Performance Indicator MN.NRES.02.05

Communicate information to the public regarding topics related to the management, protection, enhancement, and improvement of natural resources.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.02.05.01.a. Examine and describe ways in which a message regarding natural resources may be communicated to the public through standard media sources (e.g., press, radio, TV, public appearances).	NRES.02.05.01.b. Assess the effectiveness of different methods for communicating natural resource messages.	NRES.02.05.01.c. Devise and implement a strategy for communicating a natural resources message through media.
NRES.02.05.02.a. Research and summarize how social media and the Internet have changed how people perceive and utilize natural resources (e.g., greater awareness of conservation issues, calls to action).	NRES.02.05.02.b. Assess how to communicate a message most effectively about the conservation, management, enhancement, and improvement of natural resources via social media and the internet.	NRES.02.05.02.c. Anticipate and predict how messages about the conservation, management, enhancement, and improvement of natural resources will change because of social media and the internet.
NRES.02.05.03.a. Examine and describe how communication can be used to influence behavior, call people to action, and instill a sense of civic behavior related to the conservation, management, enhancement, and improvement of natural resources.	NRES.02.05.03.b. Analyze and summarize examples of how communication can be used to influence behavior, call people to action, and instill a sense of civic behavior related to the conservation, management, enhancement, and improvement of natural resources.	NRES.02.05.03.c. Create a communication plan to influence the behavior of people, call people to action and instill a sense of civic behavior related to the conservation, management, enhancement, and improvement of natural resources.

MN.NRES.03: Natural Resources Production and Processing

Develop plans to ensure sustainable production and processing of natural resources.

Performance Indicator MN.NRES.03.01

Sustainably produce, harvest, process and use natural resource products (e.g., forest products, wildlife, minerals, fossil fuels, shale oil, alternative energy, recreation, aquatic species).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.03.01.01.a. Summarize forest harvesting methods.	NRES.03.01.01.b. Assess harvesting methods in regard to their economic value, environmental impact, and other factors.	NRES.03.01.01.c. Develop a forest harvesting plan that ensures economic, environmental, and social sustainability.
NRES.03.01.02.a. Research and describe methods by which wildlife can be sustainably harvested (e.g., controlled harvests, hunting licenses, regulations).	NRES.03.01.02.b. Assess and apply techniques used to harvest wildlife in regard to sustainability, practicality, and other factors.	NRES.03.01.02.c. Develop a method for the sustainable harvest of wildlife species.
NRES.03.01.03.a. Compare and contrast the costs and benefits (e.g., impacts on environment, economic, wildlife) of mineral extraction to a local, state, and national economy.	NRES.03.01.03.b. Assess the economic impact of mineral extraction in regard to the costs and benefits to a local, state, and national economy.	NRES.03.01.03.c. Evaluate methods used to extract and process minerals for economic, environmental, and social sustainability.
NRES.03.01.04.a. Compare and contrast the costs and benefits (e.g., impacts on environment, economic, wildlife) of fossil fuels to a local, state, and national economy.	NRES.03.01.04.b. Assess the economic impact of fossil fuel extraction in regard to the costs and benefits to a local, state, and national economy.	NRES.03.01.04.c. Evaluate methods used to extract and process fossil fuels for economic, environmental, and social sustainability.
NRES.03.01.05.a. Compare and contrast the costs and benefits (e.g., environmental impacts) of shale oil from fracking to a local, state, and national economy.	NRES.03.01.05.b. Assess the economic impact of shale oil extraction (i.e., fracking) in regard to the costs and benefits to a local, state, and national economy.	NRES.03.01.05.c. Evaluate methods used to extract and process shale oil for economic, environmental, and social sustainability.
NRES.03.01.06.a. Compare and contrast the costs and benefits (e.g., environmental impacts) of alternative sources of energy (e.g., hydroelectric, solar, wind, biofuels, geothermal).	NRES.03.01.06.b. Assess and evaluate factors that affect the economic, environmental, and social sustainability in regard to the use of alternative sources of energy.	NRES.03.01.06.c. Assess trends in energy production and consumption in order to predict how the impact of alternative energy will change in the future.

MN.NRES.03: Natural Resources Production and Processing, Continued

Develop plans to ensure sustainable production and processing of natural resources.

Performance Indicator MN.NRES.03.01, Continued

Sustainably produce, harvest, process and use natural resource products (e.g., forest products, wildlife, minerals, fossil fuels, shale oil, alternative energy, recreation, aquatic species).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.03.01.07.a. Research and summarize how recreational uses of natural resources can be changed to improve sustainability.	NRES.03.01.07.b. Assess different options for improving the sustainability of outdoor recreation based on its impact on natural resources and likelihood of acceptance.	NRES.03.01.07.c. Evaluate an example of outdoor recreation and develop suggestions for how that activity can be made more sustainable in a manner that is acceptable to those who take part in that activity.
NRES.03.01.08.a. Categorize aquatic species used for commercial and recreational purposes.	NRES.03.01.08.b. Analyze and apply techniques used to acquire aquatic species for their environmental, economic, and social sustainability.	NRES.03.01.08.c. Develop recommendations for the sustainable harvest of aquatic species.

Performance Indicator MN.NRES.03.02

Demonstrate mapping skills, tools, and technologies to aid in developing, implementing, and evaluating natural resource management plans.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.03.02.01.a. Summarize how to use maps and technologies to identify directions and land features, calculate actual distance and determine the elevations of points.	NRES.03.02.01.b. Apply cartographic skills and tools and technologies (e.g., land surveys, geographic coordinate systems) to locate natural resources.	NRES.03.02.01.c. Evaluate the availability of and threats to natural resources using cartographic skills, tools, and technologies (e.g., spread of invasive species, movement of wildlife populations, changes to biodiversity of edge of habitat versus interior).
NRES.03.02.02.a. Summarize how GIS can be used to manage, conserve, improve, and enhance the natural resources of an area.	NRES.03.02.02.b. Analyze an area's resources using GIS technologies.	NRES.03.02.02.c. Use GIS data for a given area to devise a management plan for the management, conservation, improvement, and enhancement of its natural resources.

MN.NRES.04: Natural Resources Safety, Health, and Ethics

Demonstrate responsible management procedures and techniques to protect, maintain, enhance, and improve natural resources.

Performance Indicator MN.NRES.04.01

Demonstrate natural resource protection, maintenance, enhancement, and improvement techniques.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.04.01.01.a. Identify and categorize different kinds of streams.	NRES.04.01.01.b. Assess and explain indicators of the biological health of a stream.	NRES.04.01.01.c. Create an enhancement plan for a stream.
NRES.04.01.02.a. Identify and categorize characteristics of a healthy forest.	NRES.04.01.02.b. Assess and apply the methods used to improve a forest stand.	NRES.04.01.02.c. Create a timber stand improvement plan for a forest.
NRES.04.01.03.a. Identify and categorize characteristics of a healthy wildlife habitat.	NRES.04.01.03.b. Assess and apply methods of wildlife habitat improvement.	NRES.04.01.03.c. Devise a comprehensive improvement plan for a wildlife habitat.
NRES.04.01.04.a. Identify and categorize characteristics of healthy rangeland.	NRES.04.01.04.b. Assess and apply methods of rangeland improvement.	NRES.04.01.04.c. Evaluate and revise a rangeland management plan.
NRES.04.01.05.a. Identify and categorize characteristics of natural resources that make them desirable for recreational purposes.	NRES.04.01.05.b. Assess and apply management techniques for improving outdoor recreation opportunities.	NRES.04.01.05.c. Evaluate the impact of recreational activities on natural resources and create an improvement plan.
NRES.04.01.06.a. Identify and categorize characteristics of healthy marine and coastal natural resources.	NRES.04.01.06.b. Assess and apply methods to improve marine and coastal natural resources.	NRES.04.01.06.c. Create an improvement plan for marine or coastal natural resources.

MN.NRES.02: Natural Resources Safety, Health, and Ethics, Continued

Demonstrate responsible management procedures and techniques to protect, maintain, enhance, and improve natural resources.

Performance Indicator MN.NRES.04.02

Diagnose plant and wildlife diseases and follow protocols to prevent their spread.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.04.02.01.a. Classify causes of diseases in plants and the correct authorities to whom some diseases should be reported.	NRES.04.02.01.b. Analyze a plant disease based on its symptoms, identify if the disease needs to be reported to authorities and determine which authorities it should be reported to.	NRES.04.02.01.c. Create a management plan to reduce infection and the spread of plant diseases in natural resource systems.
NRS.04.02.02.a. Classify causes of diseases in wildlife and aquatic species and determine the correct authorities to whom some diseases should be reported.	NRS.04.02.02.b. Analyze a wildlife or aquatic species disease based on its symptoms, identify if the disease needs to be reported to authorities and determine which authorities it should be reported to.	NRS.04.02.02.c. Create a management plan to reduce infection and spread of wildlife or aquatic species diseases in natural resource systems.

Performance Indicator MN.NRES.04.03

Prevent or manage introduction of ecologically harmful species in a particular region.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.04.03.01.a. Categorize harmful and beneficial insects, as well as signs of insect damage to natural resources.	NRES.04.03.01.b. Analyze signs of insect infestation, identify if it needs to be reported to authorities and determine which authorities it should be reported to.	NRES.04.03.01.c. Create a management plan to reduce spread of harmful insects in natural resource systems.
NRES.04.03.02.a. Identify and classify invasive species common to a particular region.	NRES.04.03.02.b. Analyze signs of the spread of invasive species, identify if it needs to be reported to authorities and determine which authorities it should be reported to.	NRES.04.03.02.c. Create a management plan to reduce spread of harmful invasive species in natural resource systems.
NRES.04.03.03.a. Research and summarize strategies and benefits of preventing the introduction of harmful species to a particular region.	NRES.04.03.03.b. Assess and implement a plan for preventing the spread of harmful species for its effectiveness.	NRES.04.03.03.c. Identify potentially invasive species and devise strategies to prevent ecological damage that would result from the introduction of that species.

MN.NRES.02: Natural Resources Safety, Health, and Ethics, Continued

Demonstrate responsible management procedures and techniques to protect, maintain, enhance, and improve natural resources.

Performance Indicator MN.NRES.04.04

Manage fires in natural resource systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.04.04.01.a. Differentiate between desirable and undesirable fires and research the role fire plays in a healthy ecosystem.	NRES.04.04.01.b. Assess and apply techniques used to fight wildfires, manage prescribed fires, and ensure human safety.	NRES.04.04.01.c. Develop a prevention plan for harmful fires for a particular region.
NRES.04.04.02.a. Research and summarize how fire management techniques have evolved.	NRES.04.04.02.b. Assess the effectiveness of techniques previously and currently used to prevent harmful fires.	NRES.04.04.02.c. Anticipate and predict how fire management techniques will evolve in the future.

MN.NRES.05: Environmental Research

Use analytical procedures and instruments to manage environmental service systems.

Performance Indicator MN.NRES.05.01

Demonstrate natural resource protection, maintenance, enhancement, and improvement techniques.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.05.01.01.a. Identify sample types and sampling techniques used to collect laboratory and field data.	NRES.05.01.01.b. Determine the appropriate sampling techniques needed to generate data.	NRES.05.01.01.c. Collect and prepare sample measurements using appropriate data collection techniques.
NRES.05.01.02.a. Identify methods of statistical analysis commonly used in research (e.g., mean, standard deviation, standard error, error bars).	NRES.05.01.02.b. Summarize the purpose of statistical analysis methods commonly used in environmental service systems research and explain examples of their use in practice.	NRES.05.01.02.c. Utilize data analysis to identify trends in a data sample and assess the confidence that can be drawn from those conclusions.

Performance Indicator MN.NRES.05.02

Properly utilize scientific instruments in environmental monitoring situations (e.g., laboratory equipment, environmental monitoring instruments).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.05.02.01.a. Identify basic laboratory equipment and explain their uses.	NRES.05.02.01.b. Demonstrate the proper use and maintenance of basic laboratory equipment.	NRES.05.02.01.c. Calibrate and use laboratory equipment according to standard operating procedures.
NRES.05.02.02.a. Identify basic environmental monitoring instruments and explain their uses.	NRES.05.02.02.b. Demonstrate the proper use and maintenance of environmental monitoring instruments.	NRES.05.02.02.c. Calibrate and use environmental monitoring instruments according to standard operating procedures.

MN.NRES.06: Environmental Policy

Evaluate the impact of public policies and regulations on environmental service system operations.

Performance Indicator MN.NRES.06.01

Interpret and evaluate the impact of laws, agencies, policies, and practices affecting environmental service systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.06.01.01.a. Distinguish between the types of laws associated with environmental service systems.	NRES.06.01.01.b. Analyze the structure of laws associated with environmental service systems.	NRES.06.01.01.c. Evaluate the impact of laws associated with environmental service systems for their impact on wildlife, people, the environment, and the economy.
NRES.06.01.02.a. Distinguish between the types of government agencies (i.e., local, state, and federal) associated with environmental service systems.	NRES.06.01.02.b. Analyze the specific purpose of government agencies associated with environmental service systems.	NRES.06.01.02.c. Evaluate the impact and effectiveness of government agencies (i.e., local, state, and federal) associated with environmental service systems (e.g., regulation of consumption, prevention of damage to natural resources systems, management of ecological interactions).
NRES.06.01.03.a. Research policies, practices, and initiatives common in business and advocacy groups associated with environmental service systems (e.g., zero-waste, LEED-certified, locally grown).	NRES.06.01.03.b. Assess the intent, feasibility and effectiveness of policies, practices, and initiatives common in business and advocacy groups associated with environmental service systems.	NRES.06.01.03.c. Evaluate the impact of policies, practices, and initiatives common in business and advocacy groups associated with environmental service systems on wildlife, people, the environment, and the economy.

MN.NRES.06: Environmental Policy, Continued

Evaluate the impact of public policies and regulations on environmental service system operations.

Performance Indicator MN.NRES.06.02

Compare and contrast the impact of current trends on regulation of environmental service systems (e.g., climate change, population growth, international trade).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.06.02.01.a. Research and categorize the purpose, implementation, and impact of greenhouse gas emission policies (e.g., cap and-trade, emission offsetting, zero-emissions, carbon-neutrality, carbon sequestration).	NRES.06.02.01.b. Assess the effectiveness and impact of greenhouse gas emissions policies.	NRES.06.02.01.c. Devise new policies for controlling greenhouse gas emissions that reduce atmospheric carbon levels while generating additional economic activity.
NRES.06.02.02.a. Research the impact of environmental service systems regulations on international trade.	NRES.06.02.02.b. Analyze how environmental service systems regulations can both negatively and positively affect international trade.	NRES.06.02.02.c. Interpret and evaluate the impact of specific environmental service regulation policies (e.g., Clean Air Act, EISA, Clean Water Act, Superfund) on international trade.
NRES.06.02.03.a. Examine and summarize the impact that population growth has on environmental service systems.	NRES.06.02.03.b. Analyze the correlation between increased population size and the need for regulation of environmental service systems.	NRES.06.02.03.c. Predict the impact of future population growth on the regulation of environmental service systems and evaluate how changes made today will impact future regulations.
NRES.06.02.04.a. Research current policies related to fracking and shale oil gas.	NRES.06.02.04.b. Assess whether current policies related to fracking and shale oil gas sufficiently address the needs of environmental service systems.	NRES.06.02.04.c. Evaluate current fracking policies and create suggestions for modification of these policies to more thoroughly address the needs related to environmental, economic, and social sustainability.

MN.NRES.06: Environmental Policy, Continued

Evaluate the impact of public policies and regulations on environmental service system operations.

Performance Indicator MN.NRES.06.03

Diagnose plant and wildlife diseases and follow protocols to prevent their spread.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.06.03.01.a. Research and summarize how the perception and regulation of environmental service systems has changed over time.	NRES.06.03.01.b. Analyze and summarize specific changes to perceptions and regulations of environmental service systems and their impact on reducing the ecological, economical, and sociological impact.	NRES.06.03.01.c. Evaluate the impact of specific historical figures, or organizations, on the perception and regulation of environmental service systems.
NRES.06.03.02.a. Examine how social views and movements (e.g., zero-waste philosophy, carbon footprints, recycling) have affected the implementation and need for regulation of environmental service systems.	NRES.06.03.02.b. Assess the effectiveness of specific social movements related to regulation of environmental service systems.	NRES.06.03.02.c. Research current issues related to modern or future environmental service systems and devise strategies for engaging the public to address these issues through social movements.

MN.NRES.07: Scientific Applications within NRES

Develop proposed solutions to environmental issues, problems and applications using scientific principles of meteorology, soil science, hydrology, microbiology, chemistry, and ecology.

Performance Indicator MN.NRES.07.01

Apply soil science and hydrology principles to environmental service systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.07.01.01.a. Differentiate and distinguish land uses, capability factors and land capability classes.	NRES.07.01.01.b. Use a soil survey to determine the land capability classes for different parcels of land in an area.	NRES.07.01.01.c. Design a master land-use management plan for a given area that utilizes land capability classes in order to minimize erosion and flooding, maximize development, and preservation of topsoil, etc.
NRES.07.01.02.a. Research and describe the process of soil formation through weathering.	NRES.07.01.02.b. Differentiate rock types and relate the chemical composition of mineral matter in soils to the parent material.	NRES.07.01.02.c. Examine and explain how the physical qualities of the soil influence the infiltration and percolation of water.
NRES.07.01.03.a. Examine and explain how the physical qualities of the soil influence the infiltration and percolation of water.	NRES.07.01.03.b. Assess the physical qualities of the soil that determine its potential for filtration of groundwater supplies and likelihood for flooding.	NRES.07.01.03.c. Conduct tests of soil to determine its potential for filtration of groundwater supplies and likelihood for flooding.
NRES.07.01.04.a. Summarize environmental hazards associated with groundwater supplies	NRES.07.01.04.b. Assess the effectiveness of precautions taken to prevent or reduce contamination of groundwater supplies.	NRES.07.01.04.c. Evaluate the methods used in a given example to protect groundwater supplies.
NRES.07.01.05.a. Research and summarize hydrogeology and differentiate between groundwater and surface water.	NRES.07.01.05.b. Analyze how interactions between groundwater and surface water affect flow and availability of water.	NRES.07.01.05.c. Construct explanations and solutions to situations involving the declining availability of water that incorporate groundwater flow equations as well as human activity.
NRES.07.01.06.a. Research and describe how groundwater and surface water interactions affect the existence of wetlands.	NRES.07.01.06.b. Analyze the importance of the roles played by wetlands in regard to water availability, prevention of flooding and other factors.	NRES.07.01.06.c Evaluate and select strategies for wetlands preservation and restoration that maximize services provided by wetlands while taking human concerns into consideration.

MN.NRES.07: Scientific Applications within NRES, Continued

Develop proposed solutions to environmental issues, problems and applications using scientific principles of meteorology, soil science, hydrology, microbiology, chemistry, and ecology.

Performance Indicator MN.NRES.07.02

Apply chemistry principles to environmental service systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.07.02.01.a. Examine and summarize how chemistry affects soil structure and function (e.g., pH, cation-exchange capacity, filtration capability, flooding likelihood).	NRES.07.02.01.b. Analyze the soil chemistry of a sample.	NRES.07.02.01.c. Evaluate a sample's soil chemistry and assess how the results may impact considerations in environmental service systems.
NRES.07.02.02.a. Examine and summarize how chemistry affects water quality and function (e.g., oxygen saturation, pH, biomagnification).	NRES.07.02.02.b. Analyze the water chemistry of a sample.	NRES.07.02.02.c. Evaluate a sample's water chemistry and assess how the results may impact considerations in environmental service systems.
NRES.07.02.03.a. Examine and summarize how chemistry affects air quality and function (e.g., heat retention, formation of smog and acid rain).	NRES.07.02.03.b. Analyze how components of atmospheric chemistry (e.g., air chemical components, heat, moisture) affect air quality.	NRES.07.02.03.c. Assess the impact of atmospheric chemistry on operational decisions in environmental service systems.
NRES.07.02.04.a. Examine and summarize the relationship between water and soil chemistry and the formation of different kinds of wetlands (e.g., fens, peat bogs, potholes).	NRES.07.02.04.b. Assess how different kinds of wetlands are formed based on the different kinds of soil and water chemistry present in each case.	NRES.07.02.04.c. Evaluate the services provided by types of wetlands and predict how different types of wetlands respond to pressures due to human activity.

MN.NRES.07: Scientific Applications within NRES, Continued

Develop proposed solutions to environmental issues, problems and applications using scientific principles of meteorology, soil science, hydrology, microbiology, chemistry, and ecology.

Performance Indicator MN.NRES.07.03

Apply microbiology principles to environmental service systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.07.03.01.a. Describe the microbial biodiversity found in soil and summarize the contribution of microbial biodiversity to the physical and chemical characteristics of soil.	NRES.07.03.01.b. Assess how the activities of microorganisms in soil affect environmental service systems and ecosystem biodiversity.	NRES.07.03.01.c. Evaluate how soil microorganisms in environmental service systems can be used to minimize waste, maximize nutrient cycling, and increase ecosystem biodiversity.
NRES.07.03.02.a. Research and describe how microbial populations in an ecosystem affect carbon cycling.	NRES.07.03.02.b. Analyze the microbial populations present in an area and assess how carbon cycling is affected.	NRES.07.03.02.c. Develop strategies for negating air pollutants based on soil microbial populations (e.g., carbon sequestration and rates of decomposition).
NRES.07.03.03.a. Examine and explain the role that microbes play in wastewater treatment.	NRES.07.03.03.b. Assess the impact of wastewater treatment on environmental service systems.	NRES.07.03.03.c. Evaluate modern uses of microbial wastewater treatment and devise strategies to further reduce the environmental, economic, and social impact of wastewater treatment.
NRES.07.03.04.a. Research the purposes of bioassay tests and describe potential applications for environmental service systems.	NRES.07.03.04.b. Analyze procedures for a bioassay test.	NRES.07.03.04.c. Conduct bioassay tests related to environmental service systems and interpret results.

MN.NRES.07: Scientific Applications within NRES, Continued

Develop proposed solutions to environmental issues, problems and applications using scientific principles of meteorology, soil science, hydrology, microbiology, chemistry, and ecology.

Performance Indicator MN.NRES.07.04

Apply ecology principles to environmental service systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.07.04.01.a. Research the role that biodiversity plays in environmental service systems and how biodiversity can be measured.	NRES.07.04.01.b. Calculate the amount of biodiversity in a given area using an appropriate method (e.g., quadrat assessment, transect measurements).	NRES.07.04.01.c. Evaluate the biodiversity of an area and predict the impact of changing the levels of biodiversity on environmental service systems.
NRES.07.04.02.a. Examine and explain the role played by habitats on environmental service systems.	NRES.07.04.02.b. Assess the impact of the current rate of habitat loss on environmental service systems.	NRES.07.04.02.c. Evaluate the importance of habitat to environmental service systems and devise strategies to minimize the future loss of habitats.
NRES.07.04.03.a. Research and explain how carrying capacities relate to environmental service systems (e.g., waste processing, rate or production of pollution, disease).	NRES.07.04.03.b. Assess and describe the impact of a population exceeding its carrying capacity on environmental service systems.	NRES.07.04.03.c. Devise a strategy for monitoring and supporting environmental service systems through management of a species' carrying capacity.
NRES.07.04.04.a. Examine and describe how ecological interactions can be used to assess environmental service systems (i.e., macroinvertebrates or amphibians as bioindicators).	NRES.07.04.04.b. Evaluate the benefits and drawbacks of using bioindicator species in environmental service systems.	NRES.07.04.04.c. Utilize evidence from bioindicator species to detect pollutants in a given area.

MN.NRES.08: Environmental Service Operations

Demonstrate the operation of environmental service systems (e.g., pollution control, water treatment, wastewater treatment, solid waste management, energy conservation).

Performance Indicator MN.NRES.08.01

Use pollution control measures to maintain a safe facility and environment.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.08.01.01.a. Identify and distinguish types of pollution and distinguish between point source and nonpoint source pollution.	NRES.08.01.01.b. Assess how industrial and nonindustrial pollution has damaged the environment.	NRES.08.01.01.c. Evaluate evidence for a given area for industrial and nonindustrial pollution.
NRES.08.01.02.a. Research ways in which pollution can be managed and prevented and propose solutions to meet the needs of local systems.	NRES.08.01.02.b. Conduct tests to determine the presence and extent of pollution.	NRES.08.01.02.c. Create a plan for pollution remediation, management, or prevention for a given area.
NRES.08.01.03.a. Interpret the conditions necessary for waste to be labeled as hazardous.	NRES.08.01.03.b. Classify examples of pollution as hazardous or nonhazardous.	NRES.08.01.03.c. Construct a plan for handling hazardous waste in given situations.

Performance Indicator MN.NRES.08.02

Manage safe disposal of all categories of solid waste in environmental service systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.08.02.01.a. Compare and contrast different types of solid waste and options for treating solid waste.	NRES.08.02.01.b. Analyze environmental hazards created by different types of solid waste, solid waste accumulation, and solid waste disposal.	NRES.08.02.01.c. Develop a plan for solid waste disposal for a given situation that considers the environmental hazards, economic realities, and social concerns associated with this task.
NRES.08.02.02.a. Examine and describe the components of disposing waste in sanitary landfills.	NRES.08.02.02.b. Analyze and document basic sanitary landfill operating procedures and design.	NRES.08.02.02.c. Evaluate sanitary landfill procedures for environmental, economic, and social sustainability.
NRES.08.02.03.a. Research and summarize the benefits and processes of composting.	NRES.08.02.03.b. Apply scientific principles to explain the benefits and processes of composting.	NRES.08.02.03.c. Evaluate the appropriateness of composting methods in different situations.
NRES.08.02.04.a. Examine and describe the importance and potential impact of recycling.	NRES.08.02.04.b. Analyze and document different recycling methods and classify materials that can be recycled.	NRES.08.02.04.c. Survey and evaluate recycling programs and procedures.

MN.NRES.08: Environmental Service Operations, Continued

Demonstrate the operation of environmental service systems (e.g., pollution control, water treatment, wastewater treatment, solid waste management, energy conservation).

Performance Indicator MN.NRES.08.03

Apply techniques to ensure a safe supply of drinking water and adequate treatment of wastewater according to applicable rules and regulations.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.08.03.01.a. Categorize chemical and physical properties of drinking water.	NRES.08.03.01.b. Analyze and document all steps in the public drinking water treatment process according to applicable standards.	NRES.08.03.01.c. Evaluate samples of water and the processes necessary to verify that the samples are safe for consumption according to applicable standards.
NRES.08.03.02.a. Research methods commonly used to treat wastewater and septic waste.	NRES.08.03.02.b. Analyze and document the steps necessary to ensure that wastewater and septic waste can be safely released into the environment.	NRES.08.03.02.c. Evaluate examples of wastewater or septic waste for its potential to cause environmental, economic, and social problems.

MN.NRES.08: Environmental Service Operations, Continued

Demonstrate the operation of environmental service systems (e.g., pollution control, water treatment, wastewater treatment, solid waste management, energy conservation).

Performance Indicator MN.NRES.08.04

Compare and contrast the impact of conventional and alternative energy sources on the environment and operation of environmental service systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.08.04.01.a. Research conventional energy sources and list conservation measures to reduce the impact on environmental service systems	NRES.08.04.01.b. Assess the advantages and disadvantages of conventional energy sources in regard to environmental service systems.	NRES.08.04.01.c. Evaluate the impact burning of fossil fuels has on environmental service systems.
NRES.08.04.02.a. Research alternative energy sources and describe the motivations for seeking alternatives to conventional energy sources as they relate to environmental monitoring.	NRES.08.04.02.b. Identify advantages and disadvantages of alternative energy sources as they pertain to environmental service systems.	NRES.08.04.02.c. Evaluate the impact alternative energy sources have on environmental conditions.
NRES.08.04.03.a. Examine the factors that affect energy consumption and describe how these factors are related to environmental monitoring.	NRES.08.04.03.b. Analyze and document the main categories of energy consumption.	NRES.08.04.03.c. Evaluate strategies for reducing energy consumption to determine the most effective course of action based on the needs of environmental service systems.
NRES.08.04.04.a. Research the impact on environmental service systems that occur because of energy consumption.	NRES.08.04.04.b. Analyze and document the most significant impacts that energy consumption has on environmental monitoring.	NRES.08.04.04.c. Devise a strategy for improving future energy consumption in a manner consistent with the intents of environmental service systems.
NRES.08.04.05.a. Examine and explain how energy consumption and the carbon cycle relate to environmental monitoring.	NRES.08.04.05.b. Calculate the impact of the carbon cycle imbalance (due to energy consumption) and assess how this imbalance affects environmental service systems.	NRES.08.04.05.c. Use data from environmental monitoring to evaluate methods for reducing the imbalance in the carbon cycle through changes to energy consumption.
NRES.08.04.06.a. Research and describe the purpose and applications of life cycle assessments to environmental service systems.	NRES.08.04.06.b. Interpret a life cycle assessment and explain how it can be utilized in environmental service systems to assess the potential ecological impact of an energy source.	NRES.08.04.06.c. Conduct a life cycle assessment for a given source of energy and use this assessment to determine the best option for energy in regard to environmental service systems.

MN.NRES.09: NRES Tools and Technology

Use tools, equipment, machinery, and technology common to tasks in environmental service systems.

Performance Indicator MN.NRES.09.01

Use technological and mathematical tools to map land, facilities, and infrastructure for environmental service systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
NRES.09.01.01.a. Examine the importance and describe applications of surveying and mapping for environmental service systems.	NRES.09.01.01.b. Apply surveying and mapping principles to a situation involving environmental service systems and identify and explain the use of equipment for surveying and mapping.	NRES.09.01.01.c. Demonstrate surveying and cartographic skills to make site measurements in order to address concerns and needs within an environmental service systems situation.
NRES.09.01.02.a. Research the methods in which GIS can be used in environmental service systems (e.g., tracing of point pollution, control of the spread of invasive species).	NRES.09.01.02.b. Apply GIS skills to a situation specific to environmental service systems.	NRES.09.01.02.c. Interpret and evaluate GIS data to come to a conclusion about a scenario specific to environmental service systems.
NRES.09.01.03.a. Research how advancements in technology (e.g., unmanned aerial vehicles and drones, genetic modification, fracking, alternative energy) have changed environmental service systems.	NRES.09.01.03.b. Analyze and document examples of utilization of breaking technology in environmental service systems.	NRES.09.01.03.c. Evaluate trends in technology and develop predictions about how these advancements will change environmental service systems.

Secondary/Multidisciplinary AFNR Pathways that Align with NRES

A secondary or multidisciplinary AFNR pathway, often integrating standards or cumulating from coursework from the AFNR animal, plant, natural resources, and power systems pathways—encompassing the study of agribusinesses and their management including, but not limited to, record keeping, budget management (cash and credit), business planning, and sales and marketing. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the planning, development, application, and management of agribusiness systems in AFNR settings.

A secondary or multidisciplinary AFNR pathway—often integrating standards or cumulating from coursework from the AFNR animal, plant, and natural resources pathways—encompassing the study of using data and scientific techniques to solve problems concerning living organisms with an emphasis on applications to agriculture, food, and natural resource systems. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application, and management of biotechnology systems in AFNR settings.

Section 7 – Power, Structural, and Technical Systems (PST) Pathway Frameworks

Introduction

The Power, Structural, and Technical Systems (PST) pathway encompasses the study of agricultural equipment, power systems, alternative fuel sources, precision technology, as well as woodworking, metalworking, welding, and project planning for agricultural structures. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application, and management of power, structural, and technical systems in AFNR settings.

Section Contents

Recommended PST Courses and Pathway Sequence

Students concentrating on the PST pathway should complete a sequence of at least two courses within the following course offerings based their career goals and interests.

Introductory Courses	Intermediate Courses	Advanced Courses
01 Principles of Ag., Food, and Natural Resources	61 Agricultural Physics (Physics or Math Credit)	13 Agricultural Education, Research, and Development
02 Advanced Principles of Ag., Food, and Natural Resources	62 Agricultural Manufacturing	72 Creative Power Systems Design (Art Credit)
03 Principles of AFNR Biology (Science-Elective Credit)	63 Advanced Agricultural Manufacturing	73 Ag. Fabrication and Repair Operations (Simulated WBL: School Business)
04 Advanced Principles of AFNR Biology (Science-Elective Credit)	64 Agricultural Construction	74 Specialty and Emerging Power Systems Topics
60 Agricultural Power Systems Technology	65 Advanced Agricultural Construction	93 Extended/ Summer AFNR Work-Based Learning (SAE) and Leadership (FFA)
	66 Agricultural Electricity and Plumbing	94 Agricultural Leadership Development
	67 Agricultural Transportation and Operations	95 Agricultural Career Seminar
	68 Advanced Agricultural Transportation and Operations	96 Advanced Agricultural Career Seminar
	69 Agricultural Small Engines	97 AFNR Work Experience: Immersion SAE (Adv. Internship/Placement, Entrepreneurship, Research)
	70 Agricultural Engineering	
	71 Agricultural Engineering and Physics (Physics or Math Credit)	

Recommended Work-Based Learning (WBL) and SAEs within PST

A Supervised Agricultural Experience (SAE) is a student-led, instructor-supervised, Work-Based Learning (WBL) experience that results in measurable outcomes within a predefined, agreed upon set of AFNR Technical Standards and Career Ready Practices aligned to a Career Plan of study. SAE teaches technical skills and knowledge within the psychomotor domain of learning. SAE includes both experiential learning (i.e., pre-WBL) and WBL (federally defined as sustained interactions with industry or community professionals in real workplace settings, to the extent practicable, or simulated environments, at an educational institution that foster in-depth, firsthand engagement with the tasks required in a given career field, that are aligned to curriculum and instruction; Sec. 3 [20 U.S.C. 2302] 55).

SAE/WBL is a required component of an AFNR program, first established in the Smith-Hughes Act (1917) and reinforced in each of the federal Perkins Career and Technical Education (CTE) Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires WBL/SAE as a component of CTE Program Approval (Minn. R. 3505). Table 1 has example SAE opportunities within this pathway, as defined by the National Council for AFNR Education, Perkins V legislation, and the Minnesota Department of Education.

Table 1. Examples of WBL/SAE Curricula and Programs within PST

SAE Program Area	Examples, Non-Exhaustive
Experiential Learning (Foundational SAE; Pre-WBL)	● Career exploration ● Job shadowing in the fabrication industry ● Ag issues in the alternative fuels industry ● Field trip to a local equipment dealer ● Community learning experiences
Internship (Placement SAE; Immersion WBL)	● Working at a custom fabrication business ● Working for a renewable energy company ● Placement with a local agricultural construction company
Apprenticeship (Placement SAE; Immersion WBL)	● More than 450 hours in an internship, combined with coursework ● Contact the Minnesota Department of Education (MDE) for support
Entrepreneurship (Entrepreneurship SAE; Immersion WBL)	● Custom trailer fabrication ● Equipment repair business ● Wind energy business
Research (Research SAE; Immersion WBL)	● Hydraulic pressure of varies lubricants ● Emission control effects of diesel engines ● Ethanol fuel impacts on small engines ● Structural integrity of various materials used in construction
School-Based Enterprise (School-Based SAE; Simulated WBL)	● Power Systems SBE WBL ● Metal Fabrication SBE WBL ● Animal Production/School Farm Operations SBE WBL
FFA Work-Based Learning and SAE Proficiency Award Areas	● Agricultural Mechanics Design and Fabrication ● Agricultural Mechanics Repair and Maintenance ● Agricultural Services

Recommended Social-Emotional Learning (SEL) and FFA Opportunities within PST

The National FFA Organization (FFA) is a student-led, instructor-supervised, Career and Technical Student Organization (CTSO) that results in measurable outcomes within a predefined, agreed upon set of AFNR Social-Emotional Standards and Career Ready Practices aligned to a Career Plan of study. FFA teaches social-emotional and leadership skills and knowledge within the affective domain of learning. FFA includes programs that provide essential employability skills such as critical thinking, consensus building, communication, teamwork, and leadership. FFA was founded in 1928 and is federally defined as intracurricular (i.e., within the curriculum; cf. extracurricular: external, co-curricular: alongside) and an integral part (i.e., necessary to form the whole) of School-Based AFNR Education (Public Law No. 116-7).

Leadership/FFA is a required component of an AFNR program, formalized in the FFA Federal Charter in 1950 (Public Law No. 116-7) and reinforced in federal Perkins CTE Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires leadership/FFA as a component of CTE Program Approval (Minn. R. 3505). Table 2 has example FFA opportunities with this pathway, as defined by the National Council for AFNR Education, Perkins V legislation, Department of Education, and the Minnesota FFA Association.

Table 2. Examples of SEL/FFA Curricula and Programs within PST

FFA Program Area	Examples, Non-Exhaustive
Student Development Programs (Growing Leaders)	● Agriscience fair or SAE open house ● Career Day/guest speakers ● Facility tours
Community Development/ Service (Building Communities)	● Build benches/planters for community spaces ● Servicing lawn mowers/generators for the community ● Build community recreation options (e.g., disc golf course) ● Build little community libraries ● Building garages and storage building for community
Literacy, Advocacy, and Safety (Strengthening Agriculture)	● Lawn mower safety demonstrations ● Farm/ATV/Electrical Safety Demonstrations ● Alternative Energy Education
Conferences, Conventions, and Banquets	● InTENse ● Horizon conference
Career Development Events (CDE)	● Ag Mechanical and Technical Systems
Leadership Development Events (LDE)	● Agricultural Issues Forum ● Marketing Plan ● Prepared Public Speaking ● Extemporaneous Speaking

MN.PST.01: Physics and Engineering Principles within PST; PST Fabrication and Metals

Apply physical science principles and engineering applications to solve problems and improve performance in AFNR power, structural, and technical systems.

Performance Indicator MN.PST.01.01

Apply physical science and engineering principles to design, implement, and improve safe and efficient mechanical systems in AFNR situations.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PST.01.01.01.a. Compare, and contrast, applications of simple machines in AFNR related mechanical systems.	PST.01.01.01.b. Perform mathematical calculations to determine the mechanical advantage of simple machines in AFNR related mechanical systems.	PST.01.01.01.c. Apply the scientific method to devise strategies to improve the efficiency of operation of AFNR related mechanical systems.
PST.01.01.02.a. Identify the tools, machines, and equipment needed to construct and fabricate a project in AFNR.	PST.01.01.02.b. Calculate the maintenance and purchase cost of tools, machines, and equipment used in AFNR.	PST.01.01.02.c. Devise and document processes to safely implement and evaluate the safe use of AFNR related tools, machinery, and equipment.
PST.01.01.03.a. Examine manuals to classify the types of safety hazards associated with different mechanical systems used in AFNR (e.g., caution, warning, danger).	PST.01.01.03.b. Select, maintain, and demonstrate the proper use of tools, machines, and equipment used in different AFNR related mechanical systems.	PST.01.01.03.c. Conduct a safety inspection of tools, machines, and equipment used in different AFNR related mechanical systems.

Performance Indicator MN.PST.01.02

Apply physical science principles to metal fabrication using a variety of welding and cutting processes (e.g., SMAW, GMAW, GTAW, fuel-oxygen, plasma arc torch).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PST.01.02.01.a. Compare, and, contrast the principles and procedures of different welding and cutting processes (e.g., SMAW, GMAW, GTAW, fuel-oxygen, plasma arc torch, CNC plasma cutting).	PST.01.02.01.b. Analyze the situation and determine the best welding and cutting process to be used in AFNR metal fabrication.	PST.01.02.01.c. Evaluate the quality of AFNR metal fabrication procedures (e.g., SMAW, GMAW, GTAW, fuel-oxygen, plasma arc torch).
PST.01.02.02.a. Compare, and contrast, the properties of different metals used in AFNR power, structural, and technical systems (e.g., malleability, conductivity, optical properties, chemical composition).	PST.01.02.02.b. Assess and select the proper electrode for use in various shielded metal arc welding situations.	PST.01.02.02.c. Construct or repair metal structures and equipment using metal fabrication procedures.

MN.PST.02: AFNR Tool Operations and Maintenance

Operate, maintain, and repair AFNR mechanical equipment and power systems.

Performance Indicator MN.PST.02.01

Use hand and power (portable and stationary) tools commonly required in power, structural, and technical systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PST.02.01.01.a. Identify common tools used in AFNR settings.	PST.02.01.01.b. Demonstrate proper use of common tools used in AFNR settings.	PST.02.01.01.c. Effectively use common tools in AFNR settings to complete an assigned task.
PST.02.01.02.a. Utilize Metric and Standard (i.e., SAE) units of measurement.	PST.02.01.02.b. Demonstrate proficiency in the use of precision measurement tools.	PST.02.01.02.c. Utilize precision measuring equipment to perform common AFNR problem solving calculations (e.g., engine displacement, land area, CFMs moved).

Performance Indicator MN.PST.02.02

Perform preventative maintenance and scheduled service to maintain equipment, machinery, and power units used in AFNR settings.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PST.02.02.01.a. Maintain the cleanliness and appearance of equipment, machinery and power units used in AFNR power, structural, and technical systems to assure proper functionality.	PST.02.02.01.b. Develop a preventative maintenance schedule for equipment, machinery and power units used in AFNR power, structural, and technical systems.	PST.02.02.01.c. Devise a strategy to communicate to different audiences, preventative maintenance and service schedule for equipment, machinery and power units used in AFNR power, structural, and technical systems.
PST.02.02.02.a. Examine operator's manuals to determine recommendations for servicing filtration systems and maintaining fluid levels on equipment, machinery and power units used in AFNR power, structural, and technical systems.	PST.02.02.02.b. Service filtration systems and maintain fluid levels on equipment, machinery, and power units in accordance with operator's manuals.	PST.02.02.02.c. Assess and adjust equipment (e.g., belts and drives, chains, sprockets) and maintain fluid conveyance components (e.g., hoses, lines, nozzles) to ensure proper functioning.

MN.PST.02: AFNR Tool Operations and Maintenance, Continued

Operate, maintain, and repair AFNR mechanical equipment and power systems.

Performance Indicator MN.PST.02.03

Apply ecological concepts and principles to atmospheric natural resource systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PST.02.03.01.a. Research and summarize the use of equipment, machinery, and power units for AFNR power, structural, and technical systems.	PST.02.03.01.b. Analyze and calculate the cost of using equipment, machinery, and power units for AFNR power, structural, and technical systems.	PST.02.03.01.c. Perform pre-operation inspections, start-up and shut-down procedures on equipment, machinery, and power units as specified in owner's manuals.
PST.02.03.02.a. Examine and identify safety hazards associated with equipment, machinery, and power units used in AFNR power, structural, and technical systems (e.g., caution, warning, danger).	PST.02.03.02.b. Apply safety principles and applicable regulations to operate equipment, machinery, and power units used in AFNR power, structural, and technical systems.	PST.02.03.02.c. Adjust equipment, machinery, and power units for safe and efficient operation in AFNR power, structural, and technical systems.

MN.PST.03: AFNR Transportation, Engines, and Electricity

Service and repair AFNR mechanical equipment and power systems.

Performance Indicator MN.PST.03.01

Troubleshoot, service, and repair components of internal combustion engines using manufacturers' guidelines.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PST.03.01.01.a. Identify and classify components of internal combustion engines used in AFNR power, structural, and technical systems.	PST.03.01.01.b. Analyze and explain how the components of internal combustion engines interrelate during operation.	PST.03.01.01.c. Evaluate service and repair needs for internal combustion engines using a variety of performance tests (e.g., manuals, computer-based diagnostics).
PST.03.01.02.a. Distinguish the characteristics of spark-and-compression internal combustion engines used in AFNR power, structural, and technical systems.	PST.03.01.02.b. Utilize technical manuals and diagnostic tools to determine service and repair needs of spark-and-compression internal combustion engines used in AFNR power, structural, and technical systems.	PST.03.01.02.c. Inspect, analyze, and repair spark-and-compression internal combustion engines used in AFNR power, structural, and technical systems.

Performance Indicator MN.PST.03.02

Service electrical systems and components of mechanical equipment and power systems using a variety of troubleshooting and diagnostic methods.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PST.03.02.01.a. Compare, and contrast, basic units of electricity (i.e., volts, amps, watts, ohms) and the principles that describe their relationship (i.e., Ohm's Law, Power Law).	PST.03.02.01.b. Assess the tools used to measure the basic units of electrical circuits in AFNR power, structural, and technical systems, and perform the measurements.	PST.03.02.01.c. Analyze and design electrical circuits for AFNR power, structural, and technical systems using knowledge of the basic units of electricity.
PST.03.02.02.a. Compare, and contrast, the characteristics of electronic components used in AFNR power, structural, and technical systems (e.g., battery, resistor, diode, transistor, capacitor).	PST.03.02.02.b. Analyze and interpret electrical system symbols and diagrams.	PST.03.02.02.c. Conduct testing procedures to evaluate and repair malfunctioning electrical components and systems used in AFNR power, structural, and technical systems.
PST.03.02.03.a. Classify the uses of electrical sensors and controls in AFNR power, structural, and technical systems.	PST.03.02.03.b. Distinguish and select materials and tools used in electrical control circuit installation.	PST.03.02.03.c. Plan and install electrical control circuits and circuit boards to assure proper operation within AFNR power, structural, and technical systems.

MN.PST.03: AFNR Transportation, Engines, and Electricity, Continued

Service and repair AFNR mechanical equipment and power systems.

Performance Indicator MN.PST.02.03

Utilize manufacturers' guidelines to diagnose and troubleshoot malfunctions in machinery, equipment, and power source systems (e.g., hydraulic, pneumatic, transmission, steering, suspension).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PST.03.03.01.a. Research and summarize the applications of common types of hydraulic and pneumatic systems used in AFNR power, structural, and technical systems.	PST.03.03.01.b. Analyze and interpret hydraulic and pneumatic system symbols and diagrams used in AFNR power, structural, and technical systems.	PST.03.03.01.c. Inspect, analyze, and repair hydraulic and pneumatic system components used in AFNR power, structural, and technical systems.
PST.03.03.02.a. Compare, and contrast, operation principles and features of mechanical transmission systems used in AFNR power, structural, and technical systems (e.g., belts, chains, gears, bearings, seals, universals, drive shafts).	PST.03.03.02.b. Utilize speed, torque, and power measurements to calculate efficiency in power transmission systems used in AFNR power, structural, and technical systems.	PST.03.03.02.c. Inspect, analyze, and repair the components of power transmission systems used in AFNR power, structural, and technical systems.
PST.03.03.03.a. Identify and examine the components of suspension and steering systems used in AFNR power, structural, and technical systems.	PST.03.03.03.b. Assess and analyze vehicle and machinery performance related to suspension and steering systems used in AFNR power, structural, and technical systems.	PST.03.03.03.c. Inspect, analyze, and repair vehicle suspension and steering systems used in AFNR power, structural, and technical systems.

MN.PST.04: AFNR Construction and Woods

Plan, build, and maintain AFNR structures or manufactured products.

Performance Indicator MN.PST.04.01

Create sketches and plans for AFNR structures or manufactured products.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PST.04.01.01.a. Interpret and explain the meaning of symbols used in sketches of agricultural structures or manufactured products.	PST.04.01.01.b. Apply scale measurement and dimension to develop sketches of agricultural structures or manufactured products.	PST.04.01.01.c. Create sketches of an agricultural structure or manufactured products by applying principles of design (e.g., drafting software, computer-aided design).
PST.04.01.02.a. Read and interpret the parts and views of plans for agricultural structures or manufactured products.	PST.04.04.02.b. Construct plans for agricultural structures or manufactured products using current technology (e.g., drafting software, computer-aided design).	PST.04.01.02.c. Evaluate, plan, and design functional and efficient facilities or products for use in AFNR power, structural, and technical systems.

Performance Indicator MN.PST.04.02

Determine requirements, specifications, and estimate costs for AFNR structures or manufactured products.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PST.04.02.01.a. Summarize and categorize the information needed to complete a bill of materials and cost estimate for an AFNR structure or manufactured products.	PST.04.02.01.b. Analyze a project plan to prepare a bill of materials and an estimate of material costs.	PST.04.02.01.c. Create a project cost estimate, including materials, labor, and management for an AFNR structure or manufactured products.
PST.04.02.02.a. Research and summarize sources of industry construction and materials standards and their importance [e.g., American National Standards Institute (ANSI); Underwriters' Laboratories (UL)].	PST.04.02.02.b. Assess and analyze local building code requirements for agriculture structures or manufactured products.	PST.04.02.02.c. Design and conduct a functionality and safety assessment on an agricultural structure or manufactured products using knowledge of industry standards and local code requirements.

MN.PST.04: AFNR Construction and Woods, Continued

Plan, build, and maintain AFNR structures or manufactured products.

Performance Indicator MN.PST.04.03

Follow architectural, engineering, and mechanical plans/schematics to construct, maintain, or repair AFNR structures or products (e.g., material selection, site preparation/layout, plumbing, masonry, electrical).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PST.04.03.01.a. Examine the criteria in selecting materials for constructing, maintaining, and repairing AFNR structures or manufactured products.	PST.04.03.01.b. Analyze and assess samples of materials or products for quality and efficiency of workmanship.	PST.04.03.01.c. Select materials for a project based upon an analysis of the project and the quality of the materials.
PST.04.03.02.a. Summarize the characteristics needed for an ideal building site.	PST.04.03.02.b. Complete a building site analysis checklist to select an ideal building site.	PST.04.03.02.c. Assess site characteristics, identify adjustments, and demonstrate procedures for preparing a building site.
PST.04.03.03.a. Compare, and contrast, the characteristics of wood or metal products used in AFNR structures or manufactured products.	PST.04.03.03.b. Calculate costs associated with the repair and replacement of wood or metal components an AFNR structure or manufactured products.	PST.04.03.03.c. Construct AFNR structures using wood or metal materials.
PST.04.03.04.a. Compare, and contrast, the characteristics of materials used in plumbing and water systems (e.g., copper, PVC, PEX).	PST.04.03.04.b. Calculate costs associated with the repair and replacement of wood or metal components an AFNR structure.	PST.04.03.04.c. Install or repair pipes and plumbing equipment and fixtures in AFNR structures.
PST.04.03.05.a. Summarize the characteristics of the components found in concrete.	PST.04.03.05.b. Calculate volume for concrete projects.	PST.04.03.05.c. Construct, maintain, and repair AFNR structures with concrete, brick, stone, or masonry.
PST.04.03.06.a. Compare, and contrast, direct and alternating current.	PST.04.03.06.b. Assess and analyze the electrical requirements of an AFNR structure or manufactured products.	PST.04.03.06.c. Install or repair fixtures following appropriate codes and standards.
PST.04.03.07.a. Distinguish electrical circuits and the components of each.	PST.04.03.07.b. Calculate the cost of operating an electrical motor.	PST.04.03.07.c. Plan and wire electrical circuits (i.e., single pole switch, three-way switch, duplex outlet).

MN.PST.05: AFNR Technology

Use control, monitoring, geospatial, and other technologies in AFNR power, structural, and technical systems.

Performance Indicator MN.PST.05.01

Apply computer and other technologies (e.g., robotics, CNC, UAS) to solve problems and increase the efficiency of AFNR systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PST.05.01.01.a. Research and categorize computer technologies used to solve problems and increase efficiency in AFNR systems.	PST.05.01.01.b. Analyze data using computer programs and other current technologies used in AFNR systems.	PST.05.01.01.c. Solve problems and calculate changes in efficiency using computer technologies for AFNR systems.
PST.05.01.02.a. Examine and summarize the specific intent of technologies used to solve problems and increase the efficiency of AFNR systems [e.g., robotics; unmanned aircraft systems (UAS); computer numerical control machine (CNC)].	PST.05.01.02.b. Calculate the change in efficiency after using technologies in AFNR systems.	PST.05.01.02.c. Solve problems and evaluate changes in efficiency and create recommendations for the use of technologies in AFNR systems [e.g., robotics; unmanned aircraft systems (UAS); computer numerical control machine (CNC)].

Performance Indicator MN.PST.05.02

Prepare and use electrical drawings to design, install, and troubleshoot electronic control systems in AFNR settings.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PST.05.02.01.a. Examine and categorize electrical control system components used in AFNR systems (e.g., transistors, relays, HVAC, logic controllers).	PST.05.02.01.b. Analyze schematic drawings for electrical control systems used in AFNR systems.	PST.05.02.01.c. Design schematic drawings for electrical control systems used in AFNR systems.
PST.05.02.02.a. Differentiate between the purpose of electrical sensors and controls used in AFNR power, structural, and technical systems.	PST.05.02.02.b. Interpret maintenance schedules for electrical control systems used in AFNR power, structural, and technical systems.	PST.05.02.02.c. Troubleshoot electrical control system performance problems found in AFNR power, structural, and technical systems.
PST.05.02.03.a. Research and summarize the importance of AFNR power, structural, and technical control systems using programmable logic controllers (PLC) or other computer-based systems.	PST.05.02.03.b. Assess the functions of AFNR power, structural, and technical control systems using programmable logic controllers (PLC) in agricultural production and manufacturing.	PST.05.02.03.c. Develop and implement AFNR power, structural, and technical control systems using programmable logic controllers (PLC) or, sensor-based technologies, other computer-based systems.

MN.PST.05: AFNR Technology, Continued

Use control, monitoring, geospatial, and other technologies in AFNR power, structural, and technical systems.

Performance Indicator MN.PST.05.03

Apply geospatial technologies to solve problems and increase the efficiency of AFNR systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PST.05.03.01.a. Research and summarize the impact of utilizing geospatial technologies [i.e., global positioning system (GPS); geographic information system (GIS); remote sensing; telematics] in AFNR systems.	PST.05.03.01.b. Analyze and interpret trends in data collected utilizing geospatial technologies.	PST.05.03.01.c. Collect data and create maps utilizing geospatial technologies.
PST.05.03.02.a. Examine the components of precision technologies used in AFNR systems.	PST.05.03.02.b. Analyze and calculate the economic impact of utilizing precision technologies (e.g., GPS/GIS) in AFNR systems.	PST.05.03.02.c. Install, maintain, and service instrumentation and equipment used for precision technologies (i.e., GPS receivers, yield monitors, remote sensors) used in AFNR systems.

MN.PST.06: AFNR Biotechnology and Energy

Use control, monitoring, geospatial, and other technologies in AFNR power, structural, and technical systems.

Performance Indicator MN.PST.06.01

Apply biotechnology principles, techniques, and processes to produce biofuels renewable energy sources (e.g., fermentation, transesterification, methanogenesis, wind energy, solar power, geothermal).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
PST.06.01.01.a. Examine and synthesize the need for biofuels (e.g., cellulosic bioenergy).	PST.06.01.01.b. Analyze the impact of the production and use of biofuels on the environment.	PST.06.01.01.c. Evaluate and support how biofuels could solve a global issue (e.g., environmental, agricultural).
PST.06.01.02.a. Differentiate between biomass and sources of biomass.	PST.06.01.02.b. Assess the characteristics of biomass that make it useful for biofuels production.	PST.06.01.02.c. Conduct a review of the technologies used to create biofuels from biomass and weigh the pros and cons of each method.
PST.06.01.03.a. Research and explain the process of fermentation and its potential applications.	PST.06.01.03.b. Correlate the relationship between the process used to produce alcohol from biomass and fermentation.	PST.06.01.03.c. Produce alcohol and co-products from biomass.
PST.06.01.04.a. Define and summarize the process of transesterification and its potential applications.	PST.06.01.04.b. Analyze and document the process used to produce biodiesel from biomass.	PST.06.01.04.c. Produce biodiesel and co-products from biomass.
PST.06.01.05.a. Examine the process of methanogenesis and its potential applications.	PST.06.01.05.b. Analyze and describe the process used to produce methane from biomass.	PST.06.01.05.c. Produce methane and co-products from biomass.
PST.06.01.06.a. Research and identify renewable and nonrenewable energy sources used in AFNR.	PST.06.01.06.b. Assess the environmental impacts of renewable and nonrenewable energy sources used in AFNR.	PST.06.01.06.c. Design and implement methods to evaluate the efficiency of renewable and nonrenewable energy sources.
PST.06.01.07.a. Compare, and contrast, the pathways of delivery for renewable and nonrenewable energy sources in an AFNR enterprise or business.	PST.06.01.07.b. Calculate the costs of using renewable and nonrenewable energy sources in an AFNR enterprise or business.	PST.06.01.07.c. Devise a strategy to incorporate the use of selected energy sources in an ANFR enterprise or business.
PST.06.01.08.a. Summarize methods and compare, and contrast, units used to benchmark energy use of AFNR structures (e.g., EUIs, BTUs).	PST.06.01.08.b. Convert energy utilized in an AFNR structure to an energy utilization index (e.g., convert CCF, KWH to Btu consumption per square foot).	PST.06.01.08.c. Apply energy benchmarking data to examine and select methods to conserve energy in AFNR structures.
PST.06.01.09.a. Identify the basic mechanical components of a photovoltaic, wind turbine, or geothermal system.	PST.06.01.09.b. Measure and test energy output generated from solar power and wind energy systems.	PST.06.01.09.c. Design solar and wind energy systems to meet stand alone and off grid energy use applications.

Secondary/Multidisciplinary AFNR Pathways that Align with PST

A secondary or multidisciplinary AFNR pathway, often integrating standards or cumulating from coursework from the AFNR animal, plant, natural resources, and power systems pathways—encompassing the study of agribusinesses and their management including, but not limited to, record keeping, budget management (cash and credit), business planning, and sales and marketing. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the planning, development, application, and management of agribusiness systems in AFNR settings.

A secondary or multidisciplinary AFNR pathway—often integrating standards or cumulating from coursework from the AFNR animal, plant, and natural resources pathways—encompassing the study of using data and scientific techniques to solve problems concerning living organisms with an emphasis on applications to agriculture, food, and natural resource systems. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application, and management of biotechnology systems in AFNR settings.

Section 8 – Agribusiness Systems (ABS) Pathway Frameworks

Introduction

The Agribusiness Systems (ABS) Career Pathway encompasses the study of agribusinesses and their management including, but not limited to, record keeping, budget management (cash and credit), business planning, and sales and marketing. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the planning, development, application, and management of agribusiness systems in AFNR settings.

Section Contents

Recommended ABS Courses and Pathway Sequence

Students concentrating on the ABS pathway should complete a sequence of at least two courses within the following course offerings based their career goals and interests.

Introductory Courses	Intermediate Courses	Advanced Courses
01 Principles of Ag., Food, and Natural Resources	06 Advanced Agribusiness and Farm Business Management	13 Agricultural Education, Research, and Development
02 Advanced Principles of Ag., Food, and Natural Resources	07 Agricultural Economics	14 Specialty and Emerging Agribusiness Systems Topics
03 Principles of AFNR Biology (Science-Elective Credit)	08 Agricultural and Applied Economics (Economics Credit)	93 Extended/ Summer AFNR Work-Based Learning (SAE) and Leadership (FFA)
04 Advanced Principles of AFNR Biology (Science-Elective Credit)	09 Agribusiness Finance and Accounting	94 Agricultural Leadership Development
05 Agribusiness and Farm Business Management	10 Agribusiness Sales	95 Agricultural Career Seminar
	11 Agribusiness Marketing	96 Advanced Agricultural Career Seminar
	12 Agricultural Communications and Journalism	97 AFNR Work Experience: Immersion SAE (Adv. Internship/Placement, Entrepreneurship, Research)

Recommended Work-Based Learning (WBL) and SAEs within ABS

A Supervised Agricultural Experience (SAE) is a student-led, instructor-supervised, Work-Based Learning (WBL) experience that results in measurable outcomes within a predefined, agreed upon set of AFNR Technical Standards and Career Ready Practices aligned to a Career Plan of study. SAE teaches technical skills and knowledge within the psychomotor domain of learning. SAE includes both experiential learning (i.e., pre-WBL) and WBL (federally defined as sustained interactions with industry or community professionals in real workplace settings, to the extent practicable, or simulated environments, at an educational institution that foster in-depth, firsthand engagement with the tasks required in a given career field, that are aligned to curriculum and instruction; Sec. 3 [20 U.S.C. 2302] 55).

SAE/WBL is a required component of an AFNR program, first established in the Smith-Hughes Act (1917) and reinforced in each of the federal Perkins Career and Technical Education (CTE) Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires WBL/SAE as a component of CTE Program Approval (Minn. R. 3505). Table 1 has example SAE opportunities within this pathway, as defined by the National Council for AFNR Education, Perkins V legislation, and the Minnesota Department of Education.

Table 1. Examples of WBL/SAE Curricula and Programs within ABS

SAE Program Area	Examples, Non-Exhaustive
Experiential Learning (Foundational SAE; Pre-WBL)	● Career exploration ● Farm management training at a local bank ● Job shadowing a farm crop business consultant ● Volunteer for a CSA or local Farmer's Market ● Field trip to audit and tax company that specializes in AFNR
Internship (Placement SAE; Immersion WBL)	● Working for an agricultural marketing/advertising firm ● Working at a bank in agricultural lending ● Working for a commodity processor ● Working for a leadership development consulting firm
Apprenticeship (Placement SAE; Immersion WBL)	● More than 450 hours in an internship, combined with coursework ● Contact the Minnesota Department of Education (MDE) for support
Entrepreneurship (Entrepreneurship SAE; Immersion WBL)	● Starting a natural resource consulting firm ● Creating your own agricultural communications company ● Starting a local farmers market ● Custom commodity processing
Research (Research SAE; Immersion WBL)	● Consumer research perceptions of grass-fed beef ● Corn yield research/fertilizer ● Student perception of courses in agricultural business
School-Based Enterprise (School-Based SAE; Simulated WBL)	● Greenhouse Management/Operations SBE WBL ● Community Supported Ag/School Farm Operations SBE WBL ● Animal Production/School Farm Operations SBE WBL
FFA Work-Based Learning and SAE Proficiency Award Areas	● Agricultural Communications ● Agricultural Sales ● Agricultural Services

Recommended Social-Emotional Learning (SEL) and FFA Opportunities within ABS

The National FFA Organization (FFA) is a student-led, instructor-supervised, Career and Technical Student Organization (CTSO) that results in measurable outcomes within a predefined, agreed upon set of AFNR Social-Emotional Standards and Career Ready Practices aligned to a Career Plan of study. FFA teaches social-emotional and leadership skills and knowledge within the affective domain of learning. FFA includes programs that provide essential employability skills such as critical thinking, consensus building, communication, teamwork, and leadership. FFA was founded in 1928 and is federally defined as intracurricular (i.e., within the curriculum; cf. extracurricular: external, co-curricular: alongside) and an integral part (i.e., necessary to form the whole) of School-Based AFNR Education (Public Law No. 116-7).

Leadership/FFA is a required component of an AFNR program, formalized in the FFA Federal Charter in 1950 (Public Law No. 116-7) and reinforced in federal Perkins CTE Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires leadership/FFA as a component of CTE Program Approval (Minn. R. 3505). Table 2 has example FFA opportunities with this pathway, as defined by the National Council for AFNR Education, Perkins V legislation, Department of Education, and the Minnesota FFA Association.

Table 2. Examples of SEL/FFA Curricula and Programs within ABS

FFA Program Area	Examples, Non-Exhaustive
Student Development Programs (Growing Leaders)	● Officer and committee leadership opportunities ● Fruit sales, fundraising, and salesmanship programs ● Recruitment programs
Community Development/ Service (Building Communities)	● Economic development service ● Organize a charity event
Literacy, Advocacy, and Safety (Strengthening Agriculture)	● Agriscience fair ● Ag Issues presentation
Conferences, Conventions, and Banquets	● InTENse ● Horizon conference
Career Development Events (CDE)	● Agricultural Sales ● Commodity challenge ● Farm Business Management ● Risk management essay
Leadership Development Events (LDE)	● Agricultural Issues Forum ● Employment Skills ● Marketing Plan ● Prepared Public Speaking ● Extemporaneous Speaking

MN.ABS.01: Agribusiness Economics and Management

Apply management planning principles in AFNR businesses.

Performance Indicator MN.ABS.01.01

Apply micro- and macro-economic principles to plan and manage inputs and outputs in an AFNR business.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
ABS.01.01.01.a. Examine, apply, and provide examples of microeconomic principles related to decisions about AFNR business inputs and outputs (e.g., trade-offs, supply, demand and equilibrium, elasticity, diminishing returns, productivity, opportunity cost).	ABS.01.01.01.b. Apply microeconomic principles to calculate values associated with different inputs and outputs in AFNR businesses (e.g., price, point of equilibrium, trade-offs, opportunity costs, marginal costs, productivity).	ABS.01.01.01.c. Create strategies to maximize the efficiency of AFNR business inputs and outputs using microeconomic principles.
ABS.01.01.02.a. Examine and provide examples of macroeconomic principles related to AFNR businesses (e.g., Gross Domestic Product, inflation, capital accounts, unemployment rate).	ABS.01.01.02.b. Analyze and describe the relationship between AFNR business and industry outputs and domestic and global macroeconomic trends (e.g., Gross Domestic Product, national income, rate of growth, price levels).	ABS.01.01.02.c. Analyze the impact of the current macroeconomic environment on decisions related to AFNR businesses.
ABS.01.01.03.a. Define and research the nature of monetary policies in different global economic systems (e.g., traditional economic system, command economic system, market economic system, mixed economic system).	ABS.01.01.03.b. Define, assess, and research the nature of monetary policies in different global economic systems (e.g., traditional economic system, command economic system, market economic system, mixed economic system).	ABS.01.01.03.c. Create recommendations for change in monetary policy according to a scenario related to an AFNR business.

MN.ABS.01: Agribusiness Economics and Management, Continued

Apply management planning principles in AFNR businesses.

Performance Indicator MN.ABS.01.02

Read, interpret, evaluate, and write statements of purpose to guide business goals, objectives, and resource allocation.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
ABS.01.02.01.a. Read and interpret statements of purpose (e.g., vision, mission statement, charter).	ABS.01.02.01.b. Assess different approaches for creating statements of purpose for AFNR businesses and choose an appropriate approach to meet organizational needs.	ABS.01.02.01.c. Create and disseminate statements of purpose for activities in AFNR businesses.
ABS.01.02.02.a. Identify the meaning and importance of goals and objectives in AFNR business enterprises.	ABS.01.02.02.b. Prepare short-term, intermediate, and long-term goals and objectives that are consistent with the statements of purpose for an AFNR business.	ABS.01.02.02.c. Evaluate AFNR business goals and objectives, then make revisions based on data and observations.

Performance Indicator MN.ABS.01.03

Apply management skills to organize and run an AFNR business in an efficient, legal, and ethical manner.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
ABS.01.03.01.a. Define and provide examples of management skills used to organize an AFNR business (e.g., management types, organizational structures, time management techniques, conducting business agreements).	ABS.01.03.01.b. Analyze the effectiveness of different management skills used in an AFNR business.	ABS.01.03.01.c. Devise strategies to improve the operation of AFNR businesses using management skills.
ABS.01.03.02.a. Identify and interpret appropriate local, state, federal, international and industry regulations that impact the management and operation of AFNR businesses.	ABS.01.03.02.b. Assess and describe the positive and negative impact of local, state, federal, international and industry regulations on the management and operation of AFNR businesses.	ABS.01.03.02.c. Devise management or operational strategies to address and adhere to local, state, federal, international and industry regulations.
ABS.01.03.03.a. Identify and evaluate the presence or lack of ethical standards in planning and operating AFNR businesses.	ABS.01.03.03.b. Analyze the importance of using ethical standards and develop methods to communicate ethical standards within AFNR businesses.	ABS.01.03.03.c. Design methods for AFNR businesses to implement ethical standards in management skills (e.g., management types, organizational structures, time management techniques, conducting business agreements).

MN.ABS.02: Agribusiness Recordkeeping and Budgets

Use record keeping to accomplish AFNR business objectives, manage budgets, and comply with laws and regulations.

Performance Indicator MN.ABS.02.01

Apply fundamental accounting principles, systems, tools and applicable laws and regulations to record, track, and audit AFNR business transactions (e.g., accounts, debits, credits, assets, liabilities, equity).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
ABS.02.01.01.a. Examine and describe accounting systems and procedures used for record keeping in AFNR businesses (e.g., cash vs. accrual systems, identification of appropriate accounts, double-entry accounting, entry of debits and credits).	ABS.02.01.01.b. Evaluate the implementation and appropriateness of accounting systems and procedures used for record keeping in AFNR businesses.	ABS.02.01.01.c. Select appropriate accounting systems and develop accounting procedures to maintain records for AFNR businesses.
ABS.02.01.02.a. Define and summarize the features of different tools and services for recording, tracking, and auditing AFNR business transactions (e.g., electronic tools, paper-based tools, consultative services, online services, banking services).	ABS.02.01.02.b. Compare and contrast the benefits and limitations of different tools and services for recording, tracking, and auditing AFNR business transactions (e.g., convenience, costs, data security).	ABS.02.01.02.c. Recommend and select tools and services to track, record and audit AFNR business transactions that meet business needs and priorities (e.g., electronic and paper-based systems).

MN.ABS.02: Agribusiness Recordkeeping and Budgets, Continued

Use record keeping to accomplish AFNR business objectives, manage budgets, and comply with laws and regulations.

Performance Indicator MN.ABS.02.02

Assemble, interpret, and analyze financial information and reports to monitor AFNR business performance and support decision-making (e.g., income statements, balance sheets, cash-flow analysis, inventory reports, break-even analysis, return on investment, taxes).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
ABS.02.02.01.a. Compare and contrast the different types of financial reports (e.g., income statements, cash flow statements, equity statements) and their frequency of use (e.g., daily, weekly, monthly, quarterly, annual) for monitoring AFNR business performance.	ABS.02.02.01.b. Prepare and interpret financial reports to describe the performance of AFNR businesses (e.g., efficiency, profitability, net worth, financial ratios, working capital ratio, leverage).	ABS.02.02.01.c. Recommend appropriate financial reports to assemble to support specific AFNR business decisions (e.g., evaluating efficiency, profitability, net worth, financial ratios).
ABS.02.02.02.a. Define and summarize strategies for tracking, reporting, and managing inventory in AFNR businesses (e.g., spreadsheets, databases, word processing, networked systems, and the Internet).	ABS.02.02.02.b. Use accounting information to prepare financial reports associated with inventory in AFNR businesses (e.g., cost of goods sold, margins on goods).	ABS.02.02.02.c. Create recommendations to improve management of inventory in AFNR businesses (e.g., maintaining optimal levels, calculating costs of carrying input and output inventory, supply chain management).
ABS.02.02.03.a. Define and classify different types of taxes that may be paid by AFNR businesses (e.g., income, property, sales, employment, estate).	ABS.02.02.03.b. Analyze and describe reporting requirements for different types of taxes paid by AFNR businesses (e.g., income, property, sales, employment).	ABS.02.02.03.c. Assemble financial information to prepare tax filings for AFNR businesses.

MN.ABS.03: Agribusiness Accounting

Manage cash budgets, credit budgets, and credit for an AFNR business using generally accepted accounting principles.

Performance Indicator MN.ABS.03.01

Develop, assess, and manage cash budgets to achieve AFNR business goals.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
ABS.03.01.01.a. Compare and contrast components of cash budgets (e.g., anticipated revenue, production costs, overhead costs, profit) and identify the appropriate components to include in a budget given the nature of the AFNR enterprise.	ABS.03.01.01.b. Examine, develop, and interpret cash budgets for AFNR businesses.	ABS.03.01.01.c. Develop cash budgets for AFNR businesses.
ABS.03.01.02.a. Define and summarize factors that impact management of cash budgets in AFNR businesses (e.g., changes in price of inputs/outputs, financial investment performance, capital purchases, human resources).	ABS.03.01.02.b. Examine and identify strategies to manage components of cash budgets to minimize liabilities and maximize profit in AFNR businesses (e.g., delayed payment of expenses, prepayment of expenses).	ABS.03.01.02.c. Predict the impact of management decisions on cash budgets in AFNR businesses.

MN.ABS.03: Agribusiness Accounting, Continued

Manage cash budgets, credit budgets, and credit for an AFNR business using generally accepted accounting principles.

Performance Indicator MN.ABS.03.02

Analyze credit needs and manage credit budgets to achieve AFNR business goals.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
ABS.03.02.01.a. Define and summarize the characteristics of different types of credit instruments available to AFNR businesses (e.g., lines of credit, operating notes, alternative sources of capital).	ABS.03.02.01.b. Analyze AFNR business needs to determine the necessity of loans for business operation.	ABS.03.02.01.c. Analyze and assemble the information needed to obtain credit for AFNR businesses.
ABS.03.02.02.a. Examine and interpret the terms and conditions associated with credit instruments used in AFNR businesses (e.g., repayment terms, APR, grace periods, personal liability, interest rates).	ABS.03.02.02.b. Compare and contrast strategies to responsibly manage credit budgets in AFNR businesses.	ABS.03.02.02.c. Analyze AFNR business needs and recommend appropriate uses of available credit budgets to meet goals.

MN.ABS.04: Agribusiness Planning and Operations

Develop a business plan for an AFNR business.

Performance Indicator MN.ABS.04.01

Analyze characteristics and planning requirements associated with developing business plans for different types of AFNR businesses.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
ABS.04.01.01.a. Describe the meaning, importance, and economic impact of entrepreneurship on the AFNR industry and larger economy.	ABS.04.01.01.b. Classify the characteristics of successful entrepreneurs in AFNR businesses.	ABS.04.01.01.c. Demonstrate the application of entrepreneurial skills to conceptualize an AFNR business (e.g., idea generation, opportunity analysis, risk assessment).
ABS.04.01.02.a. Categorize the characteristics of the types of ownership structures used in AFNR businesses (e.g., sole proprietorships, cooperatives, partnerships, and corporations).	ABS.04.01.02.b. Compare and contrast business plans for different types of ownership structures used in AFNR businesses.	ABS.04.01.02.c. Generate conclusions about the successes and failures of AFNR businesses within the global economics system as related to the business ownership structure.
ABS.04.01.03.a. Analyze the information needed and strategies to obtain the information to complete an AFNR business plan (e.g., SMART goals and objectives, needs assessment, cash flow projection).	ABS.04.01.03.b. Prepare a business plan for an AFNR business.	ABS.04.01.03.c. Implement a business plan for an AFNR business.

MN.ABS.04: Agribusiness Planning and Operations, Continued

Develop a business plan for an AFNR business.

Performance Indicator MN.ABS.04.02

Develop production and operational plans for an AFNR business.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
ABS.04.02.01.a. Identify and define the components of operational plans in AFNR businesses (e.g., location, supply and inventory management, production and distribution, organization structure).	ABS.04.02.01.b. Compare and contrast the strengths and weaknesses of operational plans from different AFNR businesses to determine best practices.	ABS.04.02.01.c. Make recommendations to improve operational plans for an AFNR business based on best practices.
ABS.04.02.02.a. Define strategies to illustrate the production process of an AFNR business to produce a specific agricultural product.	ABS.04.02.02.b. Identify and assess alternative production systems for a specific agricultural product.	ABS.04.02.02.c. Create strategies to improve the production process of an agricultural product for an AFNR facility (e.g., SWOT, strengths, weaknesses, opportunities, and threats; supply chain management).

Performance Indicator MN.ABS.04.03

Identify and apply strategies to manage or mitigate risk.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
ABS.04.03.01.a. Assess and classify sources of risk for an AFNR business (e.g., financial risk, public perception of company).	ABS.04.03.01.b. risk management strategies for AFNR businesses (e.g., cash flow projection, analyze market trends).	ABS.04.03.01.c. Determine methods to match risk management strategies to risk situations in an AFNR business.
ABS.04.03.02.a. Define and summarize examples that illustrate the importance of risk and uncertainty within AFNR businesses.	ABS.04.03.02.b. Analyze alternative approaches to reducing risk for AFNR businesses (e.g., insurance for product liability, property, production or income loss for personnel life and health).	ABS.04.03.02.c. Prepare a comprehensive risk management and contingency plan for an AFNR business.

MN.ABS.05: Agribusiness Sales and Marketing

Use sales and marketing principles to accomplish AFNR business objectives.

Performance Indicator MN.ABS.05.01

Analyze the role of markets, trade, competition, and price in relation to an AFNR business sales and marketing plans.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
ABS.05.01.01.a. Distinguish and explain markets related to AFNR businesses (e.g., commodity markets, energy markets).	ABS.05.01.01.b. Analyze and describe the role of trade and price in the market structure as it relates to AFNR businesses.	ABS.05.01.01.c. Evaluate and predict future trends for a specific AFNR product as related to markets, trade, and price (e.g., corn, oil, wheat).
ABS.05.01.02.a. Define and compare different forms of market competition found and how they can be applied to different AFNR businesses in AFNR businesses (e.g., direct competitors, indirect competitors, replacement competitors).	ABS.05.01.02.b. Compare and contrast different forms of market competition and how they can be applied to different AFNR businesses.	ABS.05.01.02.c. Design and conduct experiments to determine market competition effectiveness of different AFNR businesses.
ABS.05.01.03.a. Explain how AFNR market supply is based on seller's cost and the number of sellers in the market, while demand is a reflection of each buyer's willingness and ability to pay and the number of buyers in the market.	ABS.05.01.03.b. Use AFNR demand and supply curves to explain how the equilibrium price and quantity in a market is determined as buyers and sellers adjust their offers in response to shortages or surpluses.	ABS.05.01.03.c. Explain how changes (shifts) in the demand and supply of an AFNR item result in changes in its market price and quantity; explain how these shifts can lead to changes in prices and quantities in other markets.

MN.ABS.05: Agribusiness Sales and Marketing, Continued

Use sales and marketing principles to accomplish AFNR business objectives.

Performance Indicator MN.ABS.05.02

Assess and apply sales principles and skills to accomplish AFNR business objectives.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
ABS.05.02.01.a. Identify and explain components of the sales process for AFNR businesses (e.g., understanding needs, develop solutions, close sale).	ABS.05.02.01.b. Apply the sales process to AFNR businesses and communicate ways of accomplishing the businesses' goals and objectives.	ABS.05.02.01.c. Analyze the sales process of AFNR businesses and create methods to suggest improvements.
ABS.05.02.02.a. Define and summarize examples of different types of sales calls used in AFNR businesses (e.g., cold calls, face-to-face meetings, follow up calls).	ABS.05.02.02.b. Assess different customer reactions that could be encountered during different types of sales calls used in AFNR businesses and prepare an appropriate response (e.g., objections, competitor prices, competing products, post-sale service, complaints about product).	ABS.05.02.02.c. Create strategies for developing plans for different types of sales calls used in AFNR businesses.

MN.ABS.05: Agribusiness Sales and Marketing, Continued

Use sales and marketing principles to accomplish AFNR business objectives.

Performance Indicator MN.ABS.05.03

Assess marketing principles and develop marketing plans to accomplish AFNR business objectives.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
ABS.05.03.01.a. Identify and explain marketing principles used in AFNR businesses (e.g., 4 P's-product, place, price, promotion; attention, interest, desire, action).	ABS.05.03.01.b. Assess and select appropriate alternative marketing strategies (e.g., value-adding, branding, niche marketing) for AFNR businesses using established marketing principles.	ABS.05.03.01.c. Deconstruct and analyze current AFNR marketing plans to determine the effectiveness of implementation of marketing principles and alternative marketing strategies.
ABS.05.03.02.a. Define and categorize different strategies used in marketing programs for AFNR businesses (e.g., internet, direct to customer, social media).	ABS.05.03.02.b. Compare and contrast the strategies of marketing for products and services used in AFNR businesses (e.g., direct marketing, commodities).	ABS.05.03.02.c. Devise plans to implement and evaluate marketing strategies for products and services used in AFNR businesses.
ABS.05.03.03.a. Define and summarize the purpose, components, and process to develop marketing plans for AFNR businesses.	ABS.05.03.03.b. Perform a market analysis to gather information for marketing plans for AFNR businesses (e.g., evaluation of competitors, customers, domestic and international policy, regulations and rules, standards).	ABS.05.03.03.c. Construct comprehensive marketing plans for AFNR businesses.

Primary AFNR Pathways that Align with ABS

Section 9 – Food Products and Processing (FPP) Pathway Frameworks

Introduction

The Food Products and Processing Systems (FPP) pathway encompasses the study of food safety and sanitation; nutrition, biology, microbiology, chemistry, and human behavior in local and global food systems; food selection and processing for storage, distribution, and consumption; and the historical and current development of the food industry. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application, and management of food products and processing in AFNR settings.

Section Contents

Recommended FPP Courses and Pathway Sequence

Students concentrating on the FPP pathway should complete a sequence of at least two courses within the following course offerings based their career goals and interests.

Introductory Courses	Intermediate Courses	Advanced Courses
01 Principles of Ag., Food, and Natural Resources	75 Food Science	13 Agricultural Education, Research, and Development
02 Advanced Principles of Ag., Food, and Natural Resources	76 Advanced Food Science	84 Specialty and Emerging Food Systems Topics
03 Principles of AFNR Biology (Science-Elective Credit)	77 Food Chemistry (Science Credit)	93 Extended/ Summer AFNR Work-Based Learning (SAE) and Leadership (FFA)
04 Advanced Principles of AFNR Biology (Science-Elective Credit)	78 Advanced Food Chemistry (Science Credit)	94 Agricultural Leadership Development
	79 Food Nutrition	95 Agricultural Career Seminar
	80 Advanced Food Nutrition	96 Advanced Agricultural Career Seminar
	81 Food Technology and Safety	97 AFNR Work Experience: Immersion SAE (Adv. Internship/Placement, Entrepreneurship, Research)
	82 Food Processing and Preparation	
	83 Food Processing Operations (Simulated WBL: School Business)	

Recommended Work-Based Learning (WBL) and SAEs within FPP

A Supervised Agricultural Experience (SAE) is a student-led, instructor-supervised, Work-Based Learning (WBL) experience that results in measurable outcomes within a predefined, agreed upon set of AFNR Technical Standards and Career Ready Practices aligned to a Career Plan of study. SAE teaches technical skills and knowledge within the psychomotor domain of learning. SAE includes both experiential learning (i.e., pre-WBL) and WBL (federally defined as sustained interactions with industry or community professionals in real workplace settings, to the extent practicable, or simulated environments, at an educational institution that foster in-depth, firsthand engagement with the tasks required in a given career field, that are aligned to curriculum and instruction; Sec. 3 [20 U.S.C. 2302] 55).

SAE/WBL is a required component of an AFNR program, first established in the Smith-Hughes Act (1917) and reinforced in each of the federal Perkins Career and Technical Education (CTE) Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires WBL/SAE as a component of CTE Program Approval (Minn. R. 3505). Table 1 has example SAE opportunities within this pathway, as defined by the National Council for AFNR Education, Perkins V legislation, and the Minnesota Department of Education.

Table 1. Examples of WBL/SAE Curricula and Programs within FPP

SAE Program Area	Examples, Non-Exhaustive
Experiential Learning (Foundational SAE; Pre-WBL)	● Career exploration ● Review of the HACCP plan for your school lunch program ● Job shadowing at a food processing business ● Ag issues related to country-of-origin labeling ● Attending USDA career day and learning about meat inspection
Internship (Placement SAE; Immersion WBL)	● Working in a food distribution center ● Working for food shipping and packing company ● Working in a food testing business
Apprenticeship (Placement SAE; Immersion WBL)	● More than 450 hours in an internship, combined with coursework ● Contact the Minnesota Department of Education (MDE) for support
Entrepreneurship (Entrepreneurship SAE; Immersion WBL)	● Animal processing business ● Develop a new/unique food product to sell at a farmer's market ● Honey Production Business
Research (Research SAE; Immersion WBL)	● Measuring internal temperature of meat products using common cooking procedures ● Consumers' concerns about *E. coli* in meat production ● Testing nutrient levels in various food products
School-Based Enterprise (School-Based SAE; Simulated WBL)	● Honey Processing SBE WBL ● Salsa or Jam/Jelly SBE WBL ● Aquaculture Operations SBE WBL ● Animal Production/School Farm Operations SBE WBL
FFA Work-Based Learning and SAE Proficiency Award Areas	● Agriscience Integrated Systems Research ● Food Science and Technology ● Ag Processing Placement/Entrepreneurship

Recommended Social-Emotional Learning (SEL) and FFA Opportunities within FPP

The National FFA Organization (FFA) is a student-led, instructor-supervised, Career and Technical Student Organization (CTSO) that results in measurable outcomes within a predefined, agreed upon set of AFNR Social-Emotional Standards and Career Ready Practices aligned to a Career Plan of study. FFA teaches social-emotional and leadership skills and knowledge within the affective domain of learning. FFA includes programs that provide essential employability skills such as critical thinking, consensus building, communication, teamwork, and leadership. FFA was founded in 1928 and is federally defined as intracurricular (i.e., within the curriculum; cf. extracurricular: external, co-curricular: alongside) and an integral part (i.e., necessary to form the whole) of School-Based AFNR Education (Public Law No. 116-7).

Leadership/FFA is a required component of an AFNR program, formalized in the FFA Federal Charter in 1950 (Public Law No. 116-7) and reinforced in federal Perkins CTE Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires leadership/FFA as a component of CTE Program Approval (Minn. R. 3505). Table 2 has example FFA opportunities with this pathway, as defined by the National Council for AFNR Education, Perkins V legislation, Department of Education, and the Minnesota FFA Association.

Table 2. Examples of SEL/FFA Curricula and Programs within FPP

FFA Program Area	Examples, Non-Exhaustive
Student Development Programs (Growing Leaders)	● Agriscience fair or SAE open house ● Personal wellness presentation ● Career day/guest speaker
Community Development/ Service (Building Communities)	● Hunger banquet ● Food drive ● Farm to School initiative ● Composting initiative ● Grow vegetable plants to donate to food shelf or grow fruit/vegetables to donate
Literacy, Advocacy, and Safety (Strengthening Agriculture)	● Food insecurity/hunger campaign ● Food for America ● Food Safety Education
Conferences, Conventions, and Banquets	● InTENse ● Nobel Conference ● Institute of Food Technologists (IFT) trainings
Career Development Events (CDE)	● Food Science ● Meats Evaluation and Technology ● Milk Quality and Products ● Poultry Evaluation
Leadership Development Events (LDE)	● Agricultural Issues Forum ● Marketing Plan ● Prepared Public Speaking ● Extemporaneous Speaking

MN.FPP.01: Food Safety and Quality

Develop and implement procedures to ensure safety, sanitation, and quality in food product and processing facilities.

Performance Indicator MN.FPP.01.01

Analyze and manage operational and safety procedures in food products and processing facilities.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.01.01.01.a. Research and summarize the purposes and objectives of safety programs in food products and processing facilities [e.g., Sanitation Standard Operating Procedures (SSOP); Good Manufacturing Practices, (GMP); worker safety].	FPP.01.01.01.b. Analyze and document attributes and procedures of current safety programs in food products and processing facilities.	FPP.01.01.01.c. Construct plans that ensure implementation of safety programs for food products and processing facilities.
FPP.01.01.02.a. Research and categorize types of equipment used in food products and processing systems.	FPP.01.01.02.b. Assess specifications and maintenance needs for equipment and facilities used in food products and processing systems (e.g., specifications for machines, sanitation procedures, repair protocol).	FPP.01.01.02.c. Devise and implement strategies to maintain equipment and facilities for food products and processing systems.

MN.FPP.01: Food Safety and Quality, Continued

Develop and implement procedures to ensure safety, sanitation, and quality in food product and processing facilities.

Performance Indicator MN.FPP.01.02

Apply food safety and sanitation procedures in the handling and processing of food products to ensure food quality.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.01.02.01.a. Examine and identify contamination hazards associated with food products and processing (e.g., physical, chemical, biological).	FPP.01.02.01.b. Outline procedures to eliminate possible contamination hazards associated with food products and processing.	FPP.01.02.01.c. Identify sources of contamination in food products and processing facilities and develop ways to eliminate contamination.
FPP.01.02.02.a. Research and summarize procedures of safe handling protocols [e.g., Hazard Analysis and Critical Control Points Plan (HACCP); Critical Control Point procedures (CCP); Good Agricultural Practices Plan (GAP)].	FPP.01.02.02.b. Construct plans that ensure implementation of safe handling procedures on food products.	FPP.01.02.02.c. Examine, interpret, and report outcomes from safe handling procedures and results from quality assurance tests.
FPP.01.02.03.a. Research and summarize the purposes and objectives of quality assurance tests on food products (e.g., produce safety regulation, safe food transport, food contaminants).	FPP.01.02.03.b. Design and construct experiments for quality assurance tests on food products.	FPP.01.02.03.c. Interpret and evaluate results of quality assurance tests on food products and examine steps to implement corrective procedures.
FPP.01.02.04.a. Describe the effects foodborne pathogens have on food products and humans.	FPP.01.02.04.b. Explain, document, and execute the procedures of microbiological tests used to detect food-borne pathogens.	FPP.01.02.04.c. Analyze a foodborne illness outbreak to determine the source of the outbreak and route of transmission.

MN.FPP.01: Food Safety and Quality, Continued

Develop and implement procedures to ensure safety, sanitation, and quality in food product and processing facilities.

Performance Indicator MN.FPP.01.03

Apply food safety procedures when storing food products to ensure food quality.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.01.03.01.a. Identify and summarize purposes of food storage procedures (e.g., first in/first out, temperature regulation, monitoring).	FPP.01.03.01.b. Analyze characteristics of food products and determine appropriate storage procedures.	FPP.01.03.01.c. Prepare plans that ensure implementation of proper food storage procedures.
FPP.01.03.02.a. Research and describe different electronic and paper-based documentation methods used to meet food safety and quality goals in food products and processing systems.	FPP.01.03.02.b. Demonstrate and explain methods of documentation procedures within food products and processing systems.	FPP.01.03.02.c. Implement and evaluate the effectiveness of a documentation procedure used within a food products and processing facility and recommend improvements.

MN.FPP.02: Food Nutrition, Biology, and Chemistry

Apply principles of nutrition, biology, microbiology, chemistry, and human behavior to the development of food products.

Performance Indicator MN.FPP.02.02

Apply principles of nutrition and biology to develop food products that provide a safe, wholesome, and nutritious food supply for local and global food systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.02.01.01.a. Research and summarize properties of common food constituents (e.g., proteins, carbohydrates, fats, vitamins, minerals).	FPP.02.01.01.b. Compare and contrast the relative value of food constituents relative to food product qualities (e.g., taste, appearance).	FPP.02.01.01.c. Analyze the properties of food products to identify food constituents and evaluate nutritional value.
FPP.02.01.02.a. Research and report methods of nutritional planning to meet essential needs for the human diet (e.g., My Plate).	FPP.02.01.02.b. Compare and contrast the nutritional needs of different human diets.	FPP.02.01.02.c. Construct methods to design a healthy daily food guide for a variety of nutritional needs.
FPP.02.01.03.a. Recognize that cells are composed primarily of a few elements (e.g., carbon, hydrogen, oxygen, nitrogen, phosphorus, sulfur), and describe the basic molecular structures and the primary functions of carbohydrates, lipids, and proteins.	FPP.02.01.03.b. Recognize that the work of the cell is carried out primarily by proteins, most of which are enzymes.	FPP.02.01.03.c. Design and conduct experiments to determine the chemical and physical properties of food products.

MN.FPP.02: Food Nutrition, Biology, and Chemistry, Continued

Apply principles of nutrition, biology, microbiology, chemistry, and human behavior to the development of food products.

Performance Indicator MN.FPP.02.02

Apply principles of microbiology and chemistry to develop food products to provide a safe, wholesome, and nutritious food supply for local and global food systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.02.02.01.a. Examine and describe the basic chemical makeup of different types of food.	FPP.02.02.01.b. Explain how the chemical and physical properties of foods influence nutritional value and eating quality.	FPP.02.02.01.c. Design and conduct experiments to determine the chemical and physical properties of food products.
FPP.02.02.02.a. Identify common food additives and identify their properties (e.g., preservatives, antioxidants, buffers, stabilizers, colors, flavors).	FPP.02.02.02.b. Describe the purpose of common food additives and how they influence the chemistry of food.	FPP.02.02.02.c. Devise and apply strategies to determine what additives are utilized and why they are included in a variety of food products.
FPP.02.02.03.a. Research and summarize the application of biochemistry in the development of new food products (e.g., value added food products, genetically engineered food products).	FPP.02.02.03.b. Analyze how food products and processing facilities use biochemistry concepts to develop new food products.	FPP.02.02.03.c. Develop and implement plans to engineer new food items using biochemistry concepts.
FPP.02.02.04.a. Explain the arrangement of the elements on the Periodic Table (including the relationships among elements in a given column or row) and the relationship of an element's position on the periodic table to its atomic number and electron configuration.	FPP.02.02.04.b. Identify and compare trends on the periodic table, including reactivity and relative sizes of atoms and ions; use the trends to explain the properties of subgroups, including metals, non-metals, alkali metals, alkaline earth.	FPP.02.02.04.c. Create a model of a periodic table that is formatted similar to the periodic table of elements, utilizing similar trends.
FPP.02.02.05.a. Summarize the law of conservation of mass and explain how the rearrangement of atoms in a chemical reaction illustrates the law of conversation of mass.	FPP.02.02.05.b. Balance chemical equations by applying the laws of conservation of mass and constant composition.	FPP.02.02.05.c. Design and conduct experiments that demonstrate the law of conservation of mass.

MN.FPP.02: Food Nutrition, Biology, and Chemistry, Continued

Apply principles of nutrition, biology, microbiology, chemistry, and human behavior to the development of food products.

Performance Indicator MN.FPP.02.02, Continued

Apply principles of microbiology and chemistry to develop food products to provide a safe, wholesome, and nutritious food supply for local and global food systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.02.02.06.a. Describe a chemical reaction using words and symbolic equations. For example: The reaction of hydrogen gas with oxygen gas can be written: $2H_2 + O_2 \rightarrow 2H_2O$.	FPP.02.02.06.b. Classify chemical reactions as double replacement, single replacement, synthesis, decomposition, or combustion.	FPP.02.02.06.c. Relate exothermic and endothermic chemical reactions to temperature and energy changes. Design and conduct experiments that demonstrate exothermic and endothermic chemical reactions. one
FPP.02.02.07.a. Describe the role of valence electrons in the formation of chemical bonds.	FPP.02.02.07.b. Use International Union of Pure and Applied Chemistry (IUPAC) nomenclature to write chemical formulas and name molecular and ionic compounds.	FPP.02.02.07.c. Determine the molar mass of a compound from its chemical formula and a table of atomic masses; convert the mass of a molecular substance to moles, number of particles, or volume of gas at standard temperature.
FPP.02.02.08.a. Draw the chemical structure of organic compounds, such as hydrocarbons, alcohols, sugars, fats and proteins.	FPP.02.02.08.b. Compare and contrast the structure and properties of organic compounds, such as hydrocarbons, alcohols, sugars, fats, and proteins.	FPP.02.02.08.c. Evaluate the usefulness of organic compounds in different recipes, and compare/contrast the outcome of utilizing different organic compounds in the same recipe.
FPP.02.02.09.a Describe the factors that affect the rate of a chemical reaction, including temperature, pressure, mixing, concentration, particle size, surface area, and catalyst.	FPP.02.02.09.b. Recognize that some chemical reactions are reversible and that not all chemical reactions go to completion.	FPP.02.02.09.c. Relate the properties of acids and bases to the ions they contain and predict the products of an acid-base reaction.
FPP.02.02.10.a. Describe the different forms of energy used in food and food production (mechanical, chemical, nuclear, radiant and electrical).	FPP.02.02.10.b. Conduct calculations to determine the value of a calorie (c) versus a kilocalorie (C), and explain which is used on a food label.	FPP.02.02.10.c. Build a calorimeter and conduct an experiment to determine the number of calories in a food sample.

MN.FPP.02: Food Nutrition, Biology, and Chemistry, Continued

Apply principles of nutrition, biology, microbiology, chemistry, and human behavior to the development of food products.

Performance Indicator MN.FPP.02.03

Apply principles of human behavior to develop food products to provide a safe, wholesome, and nutritious food supply for local and global food systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.02.03.01.a. Examine and explain the importance of food labeling to the consumer.	FPP.02.03.01.b. Examine, interpret, and explain the meaning of required components on a food label.	FPP.02.03.01.c. Determine a strategy to prepare and label foods according to the established standards of regulatory agencies.
FPP.02.03.02.a. Research and summarize relevant factors in planning and developing a new food product (e.g., regulation, creativity, economics).	FPP.02.03.02.b. Determine consumer preference and market potential for a new food product using a variety of methods (e.g., double-blind testing).	FPP.02.03.02.c. Design new food products that meet a variety of goals (e.g., consumer preferences, market, nutritional needs, regulatory requirements).
FPP.02.03.03.a. Describe the role of the senses (i.e., taste, smell, touch, sight) in analyzing a food product.	FPP.02.03.03.b. Describe the different sensory evaluation tests used to analyze food products, and the factors to control to setting up a taste test.	FPP.02.03.03.c. Design and conduct sensory evaluation tests for a food product.

MN.FPP.03: Food Products and Processing

Select and process food products for storage, distribution, and consumption.

Performance Indicator MN.FPP.03.01

Implement selection, evaluation, and inspection techniques to ensure safe and quality food products.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.03.01.01.a. Summarize characteristics of quality and yield grades of food products.	FPP.03.01.01.b. Analyze factors that affect quality and yield grades of food products.	FPP.03.01.01.c. Outline procedures to assign quality and yield grades to food products according to industry standards.
FPP.03.01.02.a. Summarize procedures to select raw food products based on yield grades and quality grades.	FPP.03.01.02.b. Assemble procedures to perform quality-control inspections of raw food products for processing.	FPP.03.01.02.c. Develop, apply, and evaluate care and handling procedures to maintain original food quality and yield.
FPP.03.01.03.a. Identify and describe protocols for inspection and harvesting techniques for animal food products [e.g., pre-mortem and post-mortem inspections; Food Safety Inspection Service guidelines, (FSIS)].	FPP.03.01.03.b. Examine and evaluate inspection and harvesting of animals using regulatory agency approved or industry-approved techniques.	FPP.03.01.03.c. Analyze the inspection plan from a harvesting facility.
FPP.03.01.04.a. Identify and describe foods derived from different classifications of food products (e.g., meat, egg, poultry, fish, dairy, fruits, vegetables, grains, legumes, oilseeds).	FPP.03.01.04.b. Examine and summarize desirable qualities of food products derived from different classifications of food products.	FPP.03.01.04.c. Evaluate and grade food products from different classifications of food products.

MN.FPP.03: Food Products and Processing, Continued

Select and process food products for storage, distribution, and consumption.

Performance Indicator MN.FPP.03.02

Design and apply techniques of food processing, preservation, packaging, and presentation for distribution and consumption of food products.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.03.02.01.a. Identify and explain Metric and Standard (i.e., SAE) measurements used in the food products and processing industry.	FPP.03.02.01.b. Compare weights and measurements of products and perform conversions between units of measure.	FPP.03.02.01.c. Design plans to formulate and package food products using a variety of weights and measures.
FPP.03.02.02.a. Differentiate between methods and materials used for processing food for different markets (e.g., fresh food products, ready to eat food products).	FPP.03.02.02.b. Outline appropriate methods and prepare foods for sale and distribution for different markets.	FPP.03.02.02.c. Evaluate food quality factors on foods prepared for different markets (e.g., shelf life, shrinkage, appearance, weight).
FPP.03.02.03.a. Identify methods of food preservation and give examples of foods preserved by each method.	FPP.03.02.03.b. Analyze and document food preservation processes and methods on a variety of food products.	FPP.03.02.03.c. Devise and apply strategies to preserve different foods using various methods and techniques.
FPP.03.02.04.a. Summarize types of materials and methods used in food packaging and presentation.	FPP.03.02.04.b. Analyze the degree of desirable food qualities of foods stored in various packaging.	FPP.03.02.04.c. Construct and implement methods of selecting packaging materials to store a variety of food products.

MN.FPP.03: Food Products and Processing, Continued

Select and process food products for storage, distribution, and consumption.

Performance Indicator MN.FPP.03.03

Create food distribution plans and procedures to ensure safe delivery of food products.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.03.03.01.a. Assess and describe the environmental impact of distributing food locally and globally.	FPP.03.03.01.b. Research and document ways to reduce environmental impact from food distribution activities.	FPP.03.03.01.c. Devise and defend a strategy to determine ways for food distribution to reduce environmental impacts.
FPP.03.03.02.a. Examine the various paths food products take to get from food processing centers to consumers.	FPP.03.03.02.b. Interpret safety procedures used in food distribution to ensure a safe product is being delivered to consumers.	FPP.03.03.02.c. Make recommendations to improve safety procedures used in food distribution scenarios to ensure a safe product is being delivered to consumers.
FPP.03.03.03.a. Research and summarize different types of market demands for food products (e.g., local food, organic, non-GMO).	FPP.03.03.03.b. Assess and explain how market demand for food products influences the distribution of food products.	FPP.03.03.03.c. Propose distribution plans for food products that meet specific market demands.

MN.FPP.04: Consumer Preferences, Marketing, and Trends

Explain the scope of the food industry and the historical and current developments of food product and processing.

Performance Indicator MN.FPP.04.01

Examine the scope of the food industry by evaluating local and global policies, trends, and customs for food production.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.04.01.01.a. Research and summarize examples of policy and legislation that affect food products and processing systems in the United States (U.S.) and around the world (e.g., labeling, GMOs, biosecurity, food system policy, dietary guidelines).	FPP.04.01.01.b. Analyze the similarities and differences amongst policies and legislation that affect the food products and processing system in the U.S. or around the world.	FPP.04.01.01.c. Articulate and defend a personal point of view on policies and legislation that affect the food products and processing system in the U.S. or around the world.
FPP.04.01.02.a. Examine the impact of consumer trends on food products and processing practices (e.g., health and nutrition, organic, information about food products, local food movements, farm-to-fork supply chains, food system transparency).	FPP.04.01.02.b. Construct and implement methods to obtain data on food consumer trends in a specific market.	FPP.04.01.02.c. Devise and implement a strategy to create food products that meet a specific consumer trend in a specific market.
FPP.04.01.03.a. Compare and contrast cultural differences regarding food products and processing practices.	FPP.04.01.03.b. Analyze food production and distribution outcomes based on cultural customs.	FPP.04.01.03.c. Propose and implement culturally sensitive food processing and distribution practices.

MN.FPP.04: Consumer Preferences, Marketing, and Trends, Continued

Explain the scope of the food industry and the historical and current developments of food product and processing.

Performance Indicator MN.FPP.04.02

Evaluate the significance and implications of changes and trends in the food products and processing industry in the local and global food systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.04.02.01.a. Describe and explain the components of the food products and processing industry (e.g., processing, distribution, byproducts).	FPP.04.02.01.b. Analyze and document significant changes and trends in the food products and processing industry.	FPP.04.02.01.c. Predict and defend upcoming changes and trends in the food products and processing industry.
FPP.04.02.02.a. Identify and explain environ- mental and safety concerns about the food supply.	FPP.04.02.02.b. Research and summarize current issues related to the safety and environmental concerns about foods and food processing (e.g., GMOs, irradiation, microorganisms, contamination).	FPP.04.02.02.c. Examine and respond to consumer concerns about the environment and safety of the food supply using accurate information regarding food products and processing systems and practices.
FPP.04.02.03.a. Research and describe current and emerging technologies related to food products and processing (e.g., high pressure processing of foods, automation, biotechnology).	FPP.04.02.03.b. Evaluate desirable and un- desirable outcomes of emerging technologies used in the food products and processing systems.	FPP.04.02.03.c. Research and evaluate the feasibility of implementing a current or emerging technology to improve a current food product or process used in a facility.

MN.FPP.04: Consumer Preferences, Marketing, and Trends, Continued

Explain the scope of the food industry and the historical and current developments of food product and processing.

Performance Indicator MN.FPP.04.03

Identify and explain the purpose of industry organizations, groups, and regulatory agencies that influence the local and global food systems.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.04.03.01.a. Examine and summarize the purposes of organizations that influence or regulate the food products and processing industry.	FPP.04.03.01.b. Evaluate the changes in the food products and processing industry brought about by industry organizations or regulatory agencies.	FPP.04.03.01.c. Construct and implement methods to obtain data about organizations, groups, and regulatory agencies that affect the food products and processing industry.
FPP.04.03.02.a. Examine and describe the importance and usage of regulatory oversight of food safety and security in food products and processing (e.g., internationally, nationally, state, local).	FPP.04.03.02.b. Assess and summarize the application of industry standards in the food products and processing industry.	FPP.04.03.02.c. Construct and implement plans that ensure adherence to industry standards for food products and processing facilities.

MN.FPP.05: Food Policy

Assess factors that have influenced the evolution of biotechnology in agriculture (e.g., historical events, societal trends, ethical, legal implications).

Performance Indicator MN.FPP.05.01

Investigate and explain the relationship between past, current, and emerging applications of biotechnology in agriculture (e.g., major innovators, historical developments, potential applications of biotechnology).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.05.01.01.a. Research and summarize the evolution of biotechnology in food science.	FPP.05.01.01.b. Analyze the developmental progression of biotechnology and the evolution of scientific knowledge.	FPP.05.01.01.c. Evaluate and explain how scientists use the scientific method to build upon previous findings in current and emerging research.
FPP.05.01.02.a. Examine and categorize current applications and gains achieved in applying biotechnology to food science.	FPP.05.01.02.b. Assess and summarize current work in biotechnology being done to add value to food science and society.	FPP.05.01.02.c. Evaluate the outcomes and impacts of biotechnology on the globalization of food science.
FPP.05.01.03.a. Distinguish between current and emerging applications of biotechnology in food science.	FPP.05.01.03.b. Analyze, and document, emerging problems and issues associated with food science biotechnology.	FPP.05.01.03.c. Design a potential application of biotechnology to meet emerging food science and societal needs.
FPP.05.01.04.a. Compare and contrast the benefits and risks of biotechnology compared with alternative approaches to improving food science.	FPP.05.01.04.b. Assess the benefits and risks associated with using biotechnology to improve food science.	FPP.05.01.04.c. Evaluate the short-term and long-term benefits and risks of applying biotechnology to food science.

Performance Indicator MN.FPP.05.02

Analyze the relationship and implications of bioethics, laws, and public perceptions on applications of biotechnology in agriculture (e.g., ethical, legal, social, cultural issues).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.05.02.01.a. Research and summarize public perceptions of biotechnology in food science (e.g., social and cultural issues).	FPP.05.02.01.b. Analyze the impact of public perceptions on the application of biotechnology in different AFNR systems.	FPP.05.02.01.c. Design studies to examine public perceptions of scientifically based arguments regarding biotechnology in food science and reflect on the reasons why the public may support or resist significant breakthroughs using biotechnology.

MN.FPP.06: Food Science and Technology

Demonstrate proficiency by safely applying appropriate laboratory skills to complete tasks in a biotechnology research and development environment (e.g., standard operating procedures, record keeping, aseptic technique, equipment maintenance).

Performance Indicator MN.FPP.06.01

Read, document, evaluate, and secure accurate laboratory records of experimental protocols, observations, and results.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.06.01.01.a. Compare and contrast common record-keeping methods used in a laboratory (e.g., paper notebook, electronic notebook).	FPP.06.01.01.b. Maintain and interpret laboratory records documented in a laboratory to ensure data accuracy and integrity (e.g., avoid bias, record any conflicts of interest, avoid misinterpreted results).	FPP.06.01.01.c. Evaluate the strengths and weaknesses of using research documentation and propose improvements to ensure study reproduction and utility in future studies.
FPP.06.01.02.b. Research and summarize the need for data and information security in a laboratory and demonstrate best practices.	FPP.06.01.02.b. Assess when security procedures for data and information collected in a laboratory should be implemented.	FPP.06.01.02.c. Devise a strategy for ensuring the security of data and information collected in a laboratory.

Performance Indicator MN.FPP.06.02

Implement standard operating procedures for the proper maintenance, use and sterilization of equipment in a laboratory.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.06.02.01.a. Identify, interpret, and implement standard operating procedures for laboratory equipment.	FPP.06.02.01.b. Develop a maintenance program for laboratory equipment based upon the standard operating procedures.	FPP.06.02.01.c. Perform ongoing maintenance of laboratory equipment according to the standard operating procedures (e.g., calibration, testing).
FPP.06.02.02.a. Categorize and identify laboratory equipment according to its purpose in scientific research.	FPP.06.02.02.b. Manipulate basic laboratory equipment and measurement devices (e.g., water bath, electrophoresis equipment, micropipettes, laminar flow hood).	FPP.06.02.02.c. Operate advanced laboratory equipment and measurement devices (e.g., thermal cycler, imaging system).
FPP.06.02.03.a. Differentiate between sterilization techniques for equipment in a laboratory (e.g., media bottles vs. laminar flow hood).	FPP.06.02.03.b. Create a plan for sterilizing equipment in a laboratory according to standard operating procedures.	FPP.06.02.03.c. Perform sterilization techniques for equipment in a laboratory using standard operating procedures.

MN.FPP.06: Food Science and Technology, Continued

Demonstrate proficiency by safely applying appropriate laboratory skills to complete tasks in a biotechnology research and development environment (e.g., standard operating procedures, record keeping, aseptic technique, equipment maintenance).

Performance Indicator MN.FPP.06.03

Apply standard operating procedures for the safe handling of biological and chemical materials in a laboratory.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.06.03.01.a. Classify and document basic aseptic techniques in the laboratory.	FPP.06.03.01.b. Demonstrate advanced aseptic techniques in the laboratory (e.g., sterile work area, sterile handling, personal hygiene).	FPP.06.03.01.c. Conduct assays and experiments under aseptic conditions.
FPP.06.03.02.a. Examine and implement standard operating procedures for the use of biological materials according to directions and their classification (e.g., proper handling of bacteria or DNA before, during, and after use).	FPP.06.03.02.b. Analyze and select an appropriate standard operating procedure for working with biological materials based upon their classification.	FPP.06.03.02.c. Create a standard operating procedure for a biological process.
FPP.06.03.03.a. Categorize and label the types of solutions that are commonly prepared in a laboratory (e.g., buffers, reagents, media).	FPP.06.03.03.b. Formulate and prepare solutions using standard operating procedures (e.g., proper labeling, storage).	FPP.06.03.03.c. Verify the physical properties of solutions (e.g., molarity, percent mass/volume, dilutions).

Performance Indicator MN.FPP.06.04

Safely manage and dispose of biological materials, chemicals, and wastes according to standard operating procedures.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.06.04.01.a. Classify different types of personal protective equipment and demonstrate how to properly utilize the equipment.	FPP.06.04.01.b. Assess the need for personal protective equipment in a variety of situations and select the appropriate equipment to wear when working with biological and chemical materials.	FPP.06.04.01.c. Evaluate the benefits and limitations of personal protective equipment.

MN.FPP.06: Food Science and Technology, Continued

Demonstrate proficiency by safely applying appropriate laboratory skills to complete tasks in a biotechnology research and development environment (e.g., standard operating procedures, record keeping, aseptic technique, equipment maintenance).

Performance Indicator MN.FPP.06.05

Examine and perform scientific procedures using microbes, DNA, RNA, and proteins in a laboratory.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.06.05.01.a. Differentiate types of organisms and demonstrate safe handling to maintain organism purity and personal safety (e.g., plant and animal tissue, cell cultures, microbes).	FPP.06.05.01.b. Characterize the physical and biological properties of organisms.	FPP.06.05.01.c. Isolate, maintain, quantify, and store cell cultures according to standard operating procedures.
FPP.06.05.02.a. Compare, and contrast, the structures of DNA and RNA and investigate how genotype influences phenotype.	FPP.06.05.02.b. Analyze and interpret the molecular basis for heredity and the tools and techniques used in DNA and RNA manipulations.	FPP.06.05.02.c. Evaluate factors that influence gene expression.
FPP.06.05.03.a. Extract and purify DNA and RNA according to standard operating procedures.	FPP.06.05.03.b. Perform electrophoretic techniques and interpret electrophoresis fragmentation patterns (e.g., gel electrophoresis, southern blotting).	FPP.06.05.03.c. Manipulate and analyze DNA and RNA through advanced scientific procedures [e.g., southern blotting; cloning; polymerase chain reaction (PC); reverse transcription-polymerase chain reaction (RT-PCR)].
FPP.06.05.04.a. Examine and document the role and applications of proteins in agricultural biotechnology.	FPP.06.05.04.b. Demonstrate protein separation techniques and interpret the results.	FPP.06.05.04.c. Evaluate the biochemical properties of proteins to explain their function and predict potential uses.
FPP.06.05.05.a. Synthesize the relationship between proteins, enzymes, and antibodies.	FPP.06.05.05.b. Analyze and document how antibodies are formed and describe how they can be used in agricultural biotechnology.	FPP.06.05.05.c. Use antibodies to detect and quantify antigens by conducting an Enzyme-Linked Immunosorbent Assay (ELISA).

MN.FPP.07: Biotechnology in FPP

Demonstrate the application of biotechnology to solve problems in AFNR systems (e.g., bioengineering, food processing, waste management, horticulture, forestry, livestock, crops).

Performance Indicator MN.FPP.07.01

Apply biotechnology principles, techniques, and processes to enhance the production of food through the use of microorganisms and enzymes.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
FPP.07.01.01.a. Summarize reasons for detecting microbes and identify sources of microbes.	FPP.07.01.01.b. Assess and describe the use of biotechnology to detect microbes.	FPP.07.01.01.c. Design and perform an assay to detect a target microorganism in food or water.
FPP.07.01.02.a. Examine enzymes, the changes they cause, and the physical and chemical parameters that affect enzymatic reactions (e.g., food, cellulosic bioenergy).	FPP.07.01.02.b. Analyze processes by which enzymes are produced through biotechnology.	FPP.07.01.02.c. Conduct studies using scientific techniques to improve or discover enzymes for use in biotechnology (e.g., microbial strain selection).
FPP.07.01.03.a. Identify and categorize foods produced through the use of biotechnology (e.g., fermentation) to change the chemical properties of food for an intended purpose (e.g., create desirable nutritional profile, preservation, flavor).	FPP.07.01.03.b. Compare, and contrast, the effectiveness, purpose, and outcomes associated with biotechnology as well as conventional processes used in food processing.	FPP.07.01.03.c. Process food using biotechnology to achieve an intended purpose (e.g., preservation, flavor enhancement).

Primary AFNR Pathways that Align with FPP

Section 10 – Biotechnology Systems (BS) Pathway Frameworks

Introduction

The Biotechnology Systems (BS) Career Pathway encompasses the study of using data and scientific techniques to solve problems concerning living organisms with an emphasis on applications to agriculture, food, and natural resource (AFNR) systems. Students completing a program of study in this pathway will demonstrate competence in the application of principles and techniques for the development, application, and management of biotechnology in the context of AFNR.

Section Contents

Recommended BS Courses and Pathway Sequence

Students concentrating on the BS pathway should complete a sequence of at least two courses within the following course offerings based their career goals and interests.

Introductory Courses	Intermediate Courses	Advanced Courses
01 Principles of Ag., Food, and Natural Resources	85 Animal and Plant Biotechnology	13 Agricultural Education, Research, and Development
02 Advanced Principles of Ag., Food, and Natural Resources	86 Advanced Animal and Plant Biotechnology	90 Specialty and Emerging Biotechnology Systems Topics
03 Principles of AFNR Biology (Science-Elective Credit)	87 Agricultural Biotechnology and Biology (Science-Elective Credit)	93 Extended/ Summer AFNR Work-Based Learning (SAE) and Leadership (FFA)
04 Advanced Principles of AFNR Biology (Science-Elective Credit)	88 Advanced Agricultural Biotechnology and Biology (Science-Elective Credit)	94 Agricultural Leadership Development
	89 Biofuels, Bioproducts, and Bioengineering	95 Agricultural Career Seminar
		96 Advanced Agricultural Career Seminar
		97 AFNR Work Experience: Immersion SAE (Adv. Internship/Placement, Entrepreneurship, Research)

Recommended Work-Based Learning (WBL) and SAEs within BS

A Supervised Agricultural Experience (SAE) is a student-led, instructor-supervised, Work-Based Learning (WBL) experience that results in measurable outcomes within a predefined, agreed upon set of AFNR Technical Standards and Career Ready Practices aligned to a Career Plan of study. SAE teaches technical skills and knowledge within the psychomotor domain of learning. SAE includes both experiential learning (i.e., pre-WBL) and WBL (federally defined as sustained interactions with industry or community professionals in real workplace settings, to the extent practicable, or simulated environments, at an educational institution that foster in-depth, firsthand engagement with the tasks required in a given career field, that are aligned to curriculum and instruction; Sec. 3 [20 U.S.C. 2302] 55).

SAE/WBL is a required component of an AFNR program, first established in the Smith-Hughes Act (1917) and reinforced in each of the federal Perkins Career and Technical Education (CTE) Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires WBL/SAE as a component of CTE Program Approval (Minn. R. 3505). Table 1 has example SAE opportunities within this pathway, as defined by the National Council for AFNR Education, Perkins V legislation, and the Minnesota Department of Education.

Table 1. Examples of WBL/SAE Curricula and Programs within BS

SAE Program Area	Examples, Non-Exhaustive
Experiential Learning (Foundational SAE; Pre-WBL)	● Career exploration ● Job shadowing a biological technician ● Interview a naturalist ● Field trip to local research university
Internship (Placement SAE; Immersion WBL)	● Working for a biotechnology company ● Working for the natural resources and conservation district ● Working for a food testing laboratory ● Maintain laboratory equipment aligned to standard procedures
Apprenticeship (Placement SAE; Immersion WBL)	● More than 450 hours in an internship, combined with coursework ● Contact the Minnesota Department of Education (MDE) for support
Entrepreneurship (Entrepreneurship SAE; Immersion WBL)	● Produce plants using plant-breeding techniques ● Conduct habitat restoration ● Sell safely processed food items at the local Farmer's Market (e.g., fermented, preserved)
Research (Research SAE; Immersion WBL)	● Public perceptions of scientific arguments in biotechnology ● Evaluate plant propagation techniques ● Evaluate biofuels
School-Based Enterprise (School-Based SAE; Simulated WBL)	● Greenhouse Management/Operations SBE WBL ● Aquaculture Operations SBE WBL ● Forest/Natural Resources Operations SBE WBL
FFA Work-Based Learning and SAE Proficiency Award Areas	● Agricultural Processing ● Nursery Operations ● Veterinary Science

Recommended Social-Emotional Learning (SEL) and FFA Opportunities within BS

The National FFA Organization (FFA) is a student-led, instructor-supervised, Career and Technical Student Organization (CTSO) that results in measurable outcomes within a predefined, agreed upon set of AFNR Social-Emotional Standards and Career Ready Practices aligned to a Career Plan of study. FFA teaches social-emotional and leadership skills and knowledge within the affective domain of learning. FFA includes programs that provide essential employability skills such as critical thinking, consensus building, communication, teamwork, and leadership. FFA was founded in 1928 and is federally defined as intracurricular (i.e., within the curriculum; cf. extracurricular: external, co-curricular: alongside) and an integral part (i.e., necessary to form the whole) of School-Based AFNR Education (Public Law No. 116-7).

Leadership/FFA is a required component of an AFNR program, formalized in the FFA Federal Charter in 1950 (Public Law No. 116-7) and reinforced in federal Perkins CTE Acts (1984 – I; 1990 – II; 1998 – III; 2006 – IV; 2018 – V, Public Law No. 115-224). Minnesota also requires leadership/FFA as a component of CTE Program Approval (Minn. R. 3505). Table 2 has example FFA opportunities with this pathway, as defined by the National Council for AFNR Education, Perkins V legislation, Department of Education, and the Minnesota FFA Association.

Table 2. Examples of SEL/FFA Curricula and Programs within BS

FFA Program Area	Examples, Non-Exhaustive
Student Development Programs (Growing Leaders)	● Officer and committee leadership opportunities ● Agriscience fair or SAE open house ● Career day/guest speaker
Community Development/ Service (Building Communities)	● Collect used pesticide containers ● Assist local organizations with GMO field trials ● Donate processed produce from the school garden following all approved food safety measures
Literacy, Advocacy, and Safety (Strengthening Agriculture)	● Agricultural Issues presentation on bioremediation ● Learn about safe handling of biological and chemical waste in agriculture ● Attend demonstration of genetic testing on livestock
Conferences, Conventions, and Banquets	● InTENse ● World Food Prize conference ● Horizon conference
Career Development Events (CDE)	● Agricultural Mechanics and Technology ● Agronomy ● Food Science ● Meats ● Milk Quality and Products ● Soils ● Veterinary Science
Leadership Development Events (LDE)	● Agricultural Issues Forum ● Marketing Plan ● Prepared Public Speaking ● Extemporaneous Speaking

MN.BS.01: Biotechnology Ethics and Policy

Assess factors that have influenced the evolution of biotechnology in agriculture (e.g., historical events, societal trends, ethical and legal implications).

Performance Indicator MN.BS.01.01

Investigate and explain the relationship between past, current, and emerging applications of biotechnology in agriculture (e.g., major innovators, historical developments, potential applications of biotechnology).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
BS.01.01.01.a. Research and summarize the evolution of biotechnology in agriculture.	BS.01.01.01.b. Analyze the developmental progression of biotechnology and the evolution of scientific knowledge.	BS.01.01.01.c. Evaluate and explain how scientists use the scientific method to build upon previous findings in current and emerging research.
BS.01.01.02.a. Examine and categorize current applications and gains achieved in applying biotechnology to agriculture.	BS.01.01.02.b. Assess and summarize current work in biotechnology being done to add value to agricultural and society.	BS.01.01.02.c. Evaluate the outcomes and impacts of biotechnology on the globalization of agriculture.
BS.01.01.03.a. Distinguish between current and emerging applications of biotechnology in agriculture.	BS.01.01.03.b. Analyze and document emerging problems and issues associated with agricultural biotechnology.	BS.01.01.03.c. Design a potential application of biotechnology to meet emerging agricultural and societal needs.
BS.01.01.04.a. Compare and contrast the benefits and risks of biotechnology compared with alternative approaches to improving agriculture.	BS.01.01.04.b. Assess the benefits and risks associated with using biotechnology to improve agriculture.	BS.01.01.04.c. Evaluate the short-term and long-term benefits and risks.

MN.BS.01: Biotechnology Ethics and Policy, Continued

Assess factors that have influenced the evolution of biotechnology in agriculture (e.g., historical events, societal trends, ethical and legal implications).

Performance Indicator MN.BS.01.02

Evaluate the scope and implications of regulatory agencies on applications of biotechnology in agriculture and protection of public interests (e.g., health, safety, and environmental issues).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
BS.01.02.01.a. Compare and contrast differences between regulatory systems worldwide.	BS.01.02.01.b. Assess and summarize the role and scope of agencies that regulate biotechnology.	BS.01.02.01.c. Explain and critique a decision made by a major agency that regulates agricultural biotechnology.
BS.01.02.02.a. Research and document major regulatory issues related to biotechnology in agriculture.	BS.01.02.02.b. Analyze the impact major regulatory issues have on public acceptance of biotechnology in agriculture.	BS.01.02.02.c. Critique and propose a solution for a major regulatory issue pertaining to biotechnology in agriculture.
BS.01.02.03.a. Explain the relationship between regulatory agencies and the protection of public interests such as health, safety, and the environment.	BS.01.02.03.b. Research and summarize factors and data that regulatory agencies use to evaluate the potential risks a new application of biotechnology may pose to health, safety, and the environment.	BS.01.02.03.c. Evaluate data to determine if new technologies present a major regulatory issue to health, safety, and the environment.

MN.BS.01: Biotechnology Ethics and Policy, Continued

Assess factors that have influenced the evolution of biotechnology in agriculture (e.g., historical events, societal trends, ethical and legal implications).

Performance Indicator MN.BS.01.03

Analyze the relationship and implications of bioethics, laws, and public perceptions on applications of biotechnology in agriculture (e.g., ethical, legal, social, and cultural issues).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
BS.01.03.01.a. Research and summarize the emergence, evolution and implications of bioethics associated with biotechnology in agriculture.	BS.01.03.01.b. Analyze the implications bioethics may have on future advancements in AFNR.	BS.01.03.01.c. Devise and support an argument for or against an ethical issue associated with biotechnology in agriculture.
BS.01.03.02.a. Research and summarize legal issues related to biotechnology in agriculture (e.g., protection of intellectual property through patents, copyright, trademarks).	BS.01.03.02.b. Determine the significance and impacts of legal issues related to biotechnology in agriculture.	BS.01.03.02.c. Propose a solution for a legal issue associated with biotechnology in agriculture.
BS.01.03.03.a. Research and summarize public perceptions of biotechnology in agriculture (e.g., social issues, cultural issues).	BS.01.03.03.b. Analyze the impact of public perceptions on the application of biotechnology in different AFNR systems.	BS.01.03.03.c. Design studies to examine public perceptions of scientifically based arguments regarding biotechnology in agriculture and reflect on the reasons why the public may support or resist significant breakthroughs using biotechnology.

MN.BS.02: Scientific Applications within Biotechnology

Demonstrate proficiency by safely applying appropriate laboratory skills to complete tasks in a biotechnology research and development environment (e.g., standard operating procedures, record keeping, aseptic technique, equipment maintenance).

Performance Indicator MN.BS.02.01

Investigate and explain the relationship between past, current, and emerging applications of biotechnology in agriculture (e.g., major innovators, historical developments, potential applications of biotechnology).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
BS.02.01.01.a. Compare and contrast common record-keeping methods used in a laboratory (e.g., paper notebook, electronic notebook).	BS.02.01.01.b. Maintain and interpret laboratory records documented in a laboratory to ensure data accuracy and integrity (e.g., avoid bias, record any conflicts of interest, avoid misinterpreted results).	BS.02.01.01.c. Evaluate the strengths and weaknesses of using research documentation and propose improvements to ensure study reproduction and utility in future studies.
BS.02.01.02.a. Research and summarize the need for data and information security in a laboratory and demonstrate best practices.	BS.02.01.02.b. Assess when security procedures for data and information collected in a laboratory should be implemented.	BS.02.01.02.c. Devise a strategy for ensuring the security of data and information collected in a laboratory.
BS.02.01.03.a. Evaluate the role of bioinformatics in agriculture and summarize the types of databases that are available (e.g., genomic, transcriptomics).	BS.02.01.03.b. Analyze and document the security procedures for data collected using bioinformatics.	BS.02.01.03.c. Critique an application of bioinformatics to solve an agricultural issue and recommend procedures.

MN.BS.02: Scientific Applications within Biotechnology, Continued

Demonstrate proficiency by safely applying appropriate laboratory skills to complete tasks in a biotechnology research and development environment (e.g., standard operating procedures, record keeping, aseptic technique, equipment maintenance).

Performance Indicator MN.BS.02.02

Implement standard operating procedures for the proper maintenance, use and sterilization of equipment in a laboratory.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
BS.02.02.01.a. Identify, interpret, and implement standard operating procedures for laboratory equipment.	BS.02.02.01.b. Develop a maintenance program for laboratory equipment based upon the standard operating procedures.	BS.02.02.01.c. Perform ongoing maintenance of laboratory equipment according to the standard operating procedures (e.g., calibration, testing).
BS.02.02.02.a. Categorize and identify laboratory equipment according to its purpose in scientific research.	BS.02.02.02.b. Manipulate basic laboratory equipment and measurement devices (e.g., water bath, electrophoresis equipment, micropipettes, laminar flow hood).	BS.02.02.02.c. Operate advanced laboratory equipment and measurement devices (e.g., thermal cycler, imaging system).
BS.02.02.03.a. Differentiate between sterilization techniques for equipment in a laboratory (e.g., media bottles vs. laminar flow hood).	BS.02.02.03.b. Create a plan for sterilizing equipment in a laboratory according to standard operating procedures.	BS.02.02.03.c. Perform sterilization techniques for equipment in a laboratory using standard operating procedures.

MN.BS.02: Scientific Applications within Biotechnology, Continued

Demonstrate proficiency by safely applying appropriate laboratory skills to complete tasks in a biotechnology research and development environment (e.g., standard operating procedures, record keeping, aseptic technique, equipment maintenance).

Performance Indicator MN.BS.02.03

Apply standard operating procedures for the safe handling of biological and chemical materials in a laboratory.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
BS.02.03.01.a. Classify and document basic aseptic techniques in the laboratory.	BS.02.03.01.b. Demonstrate advanced aseptic techniques in the laboratory (e.g., sterile work area, sterile handling, personal hygiene).	BS.02.03.01.c. Conduct assays and experiments under aseptic conditions.
BS.02.03.02.a. Examine and implement standard operating procedures for the use of biological materials according to directions and their classification (e.g., proper handling of bacteria or DNA before, during and after use).	BS.02.03.02.b. Analyze and select an appropriate standard operating procedure for working with biological materials based upon their classification.	BS.02.03.02.c. Create a standard operating procedure for a biological process.
BS.02.03.03.a. Categorize and label the types of solutions that are commonly prepared in a laboratory (e.g., buffers, reagents, media).	BS.02.03.03.b. Formulate and prepare solutions using standard operating procedures (e.g., proper labeling, storage).	BS.02.03.03.c. Verify the physical properties of solutions (e.g., molarity, percent mass/volume, dilutions).

MN.BS.02: Scientific Applications within Biotechnology, Continued

Demonstrate proficiency by safely applying appropriate laboratory skills to complete tasks in a biotechnology research and development environment (e.g., standard operating procedures, record keeping, aseptic technique, equipment maintenance).

Performance Indicator MN.BS.02.04

Safely manage and dispose of biological materials, chemicals, and wastes according to standard operating procedures.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
BS.02.04.01.a. Classify different types of personal protective equipment and demonstrate how to properly utilize the equipment.	BS.02.04.01.b. Assess the need for personal protective equipment in a variety of situations and select the appropriate equipment to wear when working with biological and chemical materials.	BS.02.04.01.c. Evaluate the benefits and limitations of personal protective equipment.
BS.02.04.02.a. Classify and describe hazards associated with biological and chemical materials.	BS.02.04.02.b. Inventory biological and chemical materials and maintain accurate records of supplies and expiration dates.	BS.02.04.02.c. Create a plan for stocking and maintaining supplies of biological and chemical materials in a laboratory.
BS.02.04.03.a. Summarize what happens to waste after it leaves the laboratory and identify opportunities to reduce waste and unnecessary costs.	BS.02.04.03.b. Perform waste disposal according to the standard operating procedures.	BS.02.04.03.c. Propose a management plan to reduce laboratory waste and prevent ecological or health problems related to waste disposal.

MN.BS.02: Scientific Applications within Biotechnology, Continued

Demonstrate proficiency by safely applying appropriate laboratory skills to complete tasks in a biotechnology research and development environment (e.g., standard operating procedures, record keeping, aseptic technique, equipment maintenance).

Performance Indicator MN.BS.02.05

Examine and perform scientific procedures using microbes, DNA, RNA, and proteins in a laboratory.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
BS.02.05.01.a. Differentiate types of organisms and demonstrate safe handling to maintain organism purity and personal safety (e.g., plant and animal tissue, cell cultures, microbes).	BS.02.05.01.b. Characterize the physical and biological properties of organisms.	BS.02.05.01.c. Isolate, maintain, quantify, and store cell cultures according to standard operating procedures.
BS.02.05.02.a. Compare and contrast the structures of DNA and RNA and investigate how genotype influences phenotype.	BS.02.05.02.b. Analyze and interpret the molecular basis for heredity and the tools and techniques used in DNA and RNA manipulations.	BS.02.05.02.c. Evaluate factors that influence gene expression.
BS.02.05.03.a. Extract and purify DNA and RNA according to standard operating procedures.	BS.02.05.03.b. Perform electrophoretic techniques and interpret electrophoresis fragmentation patterns (e.g., gel electrophoresis, southern blotting).	BS.02.05.03.c. Manipulate and analyze DNA and RNA through advanced scientific procedures [e.g., southern blotting; cloning; polymerase chain reaction (PCR); reverse transcription polymerase chain reaction (RT-PCR)].
BS.02.05.04.a. Examine and document the role and applications of proteins in agricultural biotechnology.	BS.02.05.04.b. Demonstrate protein separation techniques and interpret the results.	BS.02.05.04.c. Evaluate the biochemical properties of proteins to explain their function and predict potential uses.
BS.02.05.05.a. Synthesize the relationship between proteins, enzymes, and antibodies.	BS.02.05.05.b. Analyze and document how antibodies are formed and describe how they can be used in agricultural biotechnology.	BS.02.05.05.c. Use antibodies to detect and quantify antigens by conducting an Enzyme-Linked Immunosorbent Assay (ELISA).

MN.BS.03: Biotechnology Techniques

Demonstrate the application of biotechnology to solve problems in AFNR systems (e.g., bioengineering, food processing, waste management, horticulture, forestry, livestock, crops).

Performance Indicator MN.BS.03.01

Apply biotechnology principles, techniques, and processes to create transgenic species through genetic engineering.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
BS.03.01.01.a. Summarize biological, social, agronomic, and economic reasons for genetic modification of eukaryotes.	BS.03.01.01.b. Analyze and document the processes and describe the techniques used to produce transgenic eukaryotes (e.g., microbial synthetic biology, gene knockout therapy, traditional gene insertion).	BS.03.01.01.c. Design and conduct experiments to evaluate an existing transgenic eukaryote.
BS.03.01.02.a. Summarize the process of transformation of eukaryotic cells with transgenic DNA.	BS.03.01.02.b. Assess and argue the pros and cons of transgenic species in agriculture.	BS.03.01.02.c. Transform plant or animal cells by performing a cellular transformation.
BS.03.01.03.a. Analyze the benefits and risks associated with the use of biotechnology to increase productivity and improve quality of living species (e.g., plants, animals such as aquatic species).	BS.03.01.03.b. Research and evaluate genetic engineering procedures used in the production of living species.	BS.03.01.03.c. Conduct field or clinical trials for genetically modified species.
BS.03.01.04.a. Define and summarize epigenetics and synthesize the relationship between mutation, migration, and evolution of transgenes in the environment.	BS.03.01.04.b. Analyze data to identify changes and patterns of transgenic species in the environment.	BS.03.01.04.c. Conduct studies to track the movement of transgenes in the environment.

MN.BS.03: Biotechnology Techniques, Continued

Demonstrate the application of biotechnology to solve problems in AFNR systems (e.g., bioengineering, food processing, waste management, horticulture, forestry, livestock, crops).

Performance Indicator MN.BS.03.02

Apply biotechnology principles, techniques, and processes to enhance the production of food through the use of microorganisms and enzymes.

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
BS.03.02.01.a. Summarize reasons for detecting microbes and identify sources of microbes.	BS.03.02.01.b. Assess and describe the use of biotechnology to detect microbes.	BS.03.02.01.c. Design and perform an assay to detect a target microorganism in food, water, or the environment.
BS.03.02.02.a. Examine enzymes, the changes they cause and the physical and chemical parameters that affect enzymatic reactions (e.g., food, cellulosic bioenergy).	BS.03.02.02.b. Analyze processes by which enzymes are produced through biotechnology.	BS.03.02.02.c. Conduct studies using scientific techniques to improve or discover enzymes for use in biotechnology (e.g., microbial strain selection).
BS.03.02.03.a. Identify and categorize foods produced through the use of biotechnology (e.g., fermentation) to change the chemical properties of food for an intended purpose (e.g., create desirable nutritional profile, preservation, flavor).	BS.03.02.03.b. Compare and contrast the effectiveness, purpose, and outcomes associated with biotechnology as well as conventional processes used in food processing.	BS.03.02.03.c. Process food using biotechnology to achieve an intended purpose (e.g., preservation, flavor enhancement).

MN.BS.03: Biotechnology Techniques, Continued

Demonstrate the application of biotechnology to solve problems in AFNR systems (e.g., bioengineering, food processing, waste management, horticulture, forestry, livestock, crops).

Performance Indicator MN.BS.03.03

Apply biotechnology principles, techniques, and processes to protect the environment and maximize use of natural resources (e.g., biomass, bioprospecting, industrial biotechnology).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
BS.03.03.01.a. Examine the consequences of agricultural practices on natural populations.	BS.03.03.01.b. Analyze how biotechnology can be used to monitor the effects of agricultural practices on natural populations.	BS.03.03.01.c. Evaluate the impact of modified organisms on the natural environment.
BS.03.03.02.a. Define and summarize industrial biotechnology and categorize the benefits and risks associated with its use in manufacturing (e.g., fabrics, plastics).	BS.03.03.02.b. Apply the processes used in the production of molecules for use in industrial applications.	BS.03.03.02.c. Monitor and evaluate processes used in the synthesis of a molecule.
BS.03.03.03.a. Research and summarize the potential applications of bioprospecting in biotechnology and agriculture.	BS.03.03.03.b. Assess and document the pros and cons of bioprospecting to achieve a research or product development objective.	BS.03.03.03.c. Propose opportunities to use bioprospecting after weighing the short-term and long-term impacts on the environment.

MN.BS.03: Biotechnology Techniques, Continued

Demonstrate the application of biotechnology to solve problems in AFNR systems (e.g., bioengineering, food processing, waste management, horticulture, forestry, livestock, crops).

Performance Indicator MN.BS.03.04

Apply biotechnology principles, techniques, and processes to enhance plant and animal care and production (e.g., selective breeding, pharmaceuticals, biodiversity).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
BS.03.04.01.a. Research and describe the aims and techniques involved in selective plant-breeding process.	BS.03.04.01.b. Choose techniques and identify tools used to monitor and direct plant breeding.	BS.03.04.01.c. Perform plant-breeding techniques (e.g., plant tissue culture).
BS.03.04.02.a. Examine and classify biotechnology processes applicable to animal health (e.g., genetic testing).	BS.03.04.02.b. Assess the benefits, risks and opportunities associated with using biotechnology to promote animal health.	BS.03.04.02.c. Design animal-care protocols to ethically monitor and promote animal systems associated with biotechnology.
BS.03.04.03.a. Research and categorize the types of pharmaceuticals developed for animals and humans through biotechnology.	BS.03.04.03.b. Distinguish the difference between plant-based and animal-based pharmaceuticals and describe their role in agriculture.	BS.03.04.03.c. Evaluate the process used to produce pharmaceuticals from transgenic organisms (e.g., hormones for animals).
BS.03.04.04.a. Summarize the need for global biodiversity and applications of biotechnology to reduce threats to biodiversity.	BS.03.04.04.b. Assess whether current threats to biodiversity will have an unsustainable impact on human populations.	BS.03.04.04.c. Select and utilize techniques to measure biodiversity in a population.

MN.BS.03: Biotechnology Techniques, Continued

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Performance Indicator MN.BS.03.05

Apply biotechnology principles, techniques, and processes to produce biofuels (e.g., fermentation, transesterification, methanogenesis).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
BS.03.05.01.a. Examine and synthesize the need for biofuels (e.g., cellulosic bioenergy).	BS.03.05.01.b. Analyze the impact of the production and use of biofuels on the environment.	BS.03.05.01.c. Evaluate and support how biofuels could solve a global issue (e.g., environmental, agricultural).
BS.03.05.02.a. Differentiate between biomass and sources of biomass.	BS.03.05.02.b. Assess the characteristics of biomass that make it useful for biofuels production.	BS.03.05.02.c. Conduct a review of the technologies used to create biofuels from biomass and weigh the pros and cons of each method.
BS.03.05.03.a. Research and explain the process of fermentation and its potential applications.	BS.03.05.03.b. Correlate the relationship between fermentation and the process used to produce alcohol from biomass.	BS.03.05.03.c. Produce alcohol and co-products from biomass.
BS.03.05.04.a. Define and summarize the process of transesterification and its potential applications.	BS.03.05.04.b. Analyze and document the process used to produce biodiesel from biomass.	BS.03.05.04.c. Produce biodiesel and co-products from biomass.
BS.03.05.05.a. Examine the process of methanogenesis and its potential applications.	BS.03.05.05.b. Analyze and describe the process used to produce methane from biomass.	BS.03.05.05.c. Produce methane and co-products from biomass.

MN.BS.03: Biotechnology Techniques, Continued

Demonstrate the application of biotechnology to solve problems in AFNR systems (e.g., bioengineering, food processing, waste management, horticulture, forestry, livestock, crops).

Performance Indicator MN.BS.03.06

Apply biotechnology principles, techniques, and processes to improve waste management (e.g., genetically modified organisms, bioremediation).

Introductory Course Benchmarks	Intermediate Course Benchmarks	Advanced Course Benchmarks
BS.03.06.01.a. Compare and contrast the use of natural organisms and genetically engineered organisms in the treatment of wastes.	BS.03.06.01.b. Analyze the process by which organisms are genetically engineered for waste treatment.	BS.03.06.01.c. Conduct studies to evaluate the treatment of a waste product using a genetically engineered organism.
BS.03.06.02.a. Summarize the purpose of microorganisms in biological waste management.	BS.03.06.02.b. Assess and describe the processes involved in biotreatment of biological wastes.	BS.03.06.02.c. Monitor and evaluate the treatment of biological wastes with microorganisms.
BS.03.06.03.a. Analyze the role of microorganisms in industrial chemical waste treatment.	BS.03.06.03.b. Evaluate and describe the processes involved in biotreatment of industrial chemical wastes.	BS.03.06.03.c. Monitor and review the treatment of industrial chemical wastes with microorganisms.
BS.03.06.04.a. Provide examples of instances in which bioremediation can be applied to clean up environmental contaminants.	BS.03.06.04.b. Analyze and summarize the risks and benefits of using biotechnology for bioremediation.	BS.03.06.04.c. Design a bioremediation project including plans to effectiveness of the effort.

Primary AFNR Pathways that Align with BS