Virginia Whole Farm Planning:

An Educational Program for Farm Startup and Development

VIRGINIA Beginning Farmer & Rancher COALITION PROGRAM

Sustainable Farming Practices: The Place and The Product

The purpose of the *Sustainable Farming Practices: The Place and the Product* module is to help beginning farmers and ranchers in Virginia learn the basic fundamental production practices and concepts necessary to make informed decisions for whole farm planning.

This is one of five modules designed to guide you in developing the whole farm plan by focusing on the following areas:

- Introduction to Whole Farm Planning
- Marketing
- Whole Farm Business Management and Planning
- Land Acquisition and Tenure
- Sustainable Farming Practices

Each module is organized at the introductory to intermediate stage of farming knowledge and experience. At the end of each module, additional resources and Virginia service provider contact information are available to help continue the farm planning process.

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Funding for this curriculum is sponsored by the Beginning Farmer and Rancher Development Program (BFRDP) of the USDA-National Institute of Food and Agriculture (NIFA), Award # 2010-49400. Contact Kim Niewolny, Program Director, at niewolny@vt.edu or 540-231-5784, for more information.

Preface

Welcome to the Virginia Beginning Farmer and Rancher Coalition Project's Whole Farm Planning Curriculum!

How to use this Workbook. This material is organized into five modules that may be used as stand-alone resources to address specific areas of whole farm planning. However, we suggest that the modules may be most beneficial to beginning farmers and ranchers if they are used as a series of educational sessions designed to encourage reflection, goal setting, and steps to organize a new farming enterprise.

Advice for Beginning Farmers. We encourage you to begin by exploring the Introduction to Whole Farm Planning module. This resource will offer you the opportunity to examine your personal and business goals and priorities. Once you have completed this introduction module, you are welcome to explore the other resources in a sequence that best addresses your questions and ideas for your farming enterprise.

Advice for Service Providers. Thank you for choosing to use our curriculum in your whole farm planning educational program. As an experienced education service provider, we encourage you to adapt these resources to best serve the needs of people you work with. The materials are intended to be used as stand-alone pieces or in various combinations of instructional formats, as needed by your program participants.

Modules. Each module is organized at the introductory to intermediate stage of farming knowledge and experience. At the end of each module, additional resources and Virginia service provider contact information are available to help continue the farm planning process.

Module I. Introduction to Whole Farm Planning – The purpose of the first module is to help beginning farmers and ranchers in Virginia make informed farm planning decisions by introducing them to the whole farm planning process.

Module II. Marketing – The marketing module is designed to help beginning farmers and ranchers develop and implement their goals for market analysis, product establishment, and development of viable marketing channels.

Module III. Whole Farm Business Management – In this module, you will develop and implement early financial and resource management goals as part of the whole farm plan.

Module IV. Land Acquisition and Tenure – This module will help beginning farmers and ranchers to develop and implement farm tenure and transfer goals as part of the whole farm plan. Established farmers who are planning for the transfer of their farm may also find this module useful.

Module V. Sustainable Farming Practices – The last module is designed to help beginning farmers and ranchers develop and hone their skills and knowledge in the fundamental production practices associated with establishing and growing a wide range of plants and animals. This module is divided into five sections, each focused on specific aspects of production agriculture: 1. The Place and the Products; 2. Farm Biodiversity; 3. Organisms in the Ecosystem: Beneficials, Pests and Diseases; 4. Soil Management; 5. Animal Husbandry.

Why this Curriculum? The Beginning Farmer Situation

Emerging trends in U.S. agriculture suggest that in order to enhance our agricultural resource base, we need to establish, sustain, and preserve our farms, farmers, and farmland. A growing number of nongovernmental groups, cooperative extension services, and U.S. Department of Agriculture agencies are working to improve the viability of new farms and the economic, social, and environmental fabric in which they are entrenched (Niewolny and Lillard 2010). These initiatives are responding to the overwhelming concern about the steady decline in the number of individuals entering into agriculture, coupled with an increase in the number of exiting farmers and ranchers (Ruhf 2001).

The current population of beginning farmers and ranchers is diverse and varies by location across the nation (Ahearn and Newton 2009). Beginning farmers on average operate smaller farms — in size and gross dollars — compared to established farmers (Ahearn, Yee, and Korb 2005). While beginning farmers tend to be younger than established farmers, about a third of beginning farmers are at least 55 years of age or older (Ahearn and Newton 2009). Beginning farmers, along with limited-resource and socially disadvantaged farmers, make up at least 40 percent of all U.S. farms (Nickerson and Hand 2009).

The Bureau of Labor Statistics (U.S. Department of Labor 2009) recently reported a large job decline for farmers and ranchers and projects an 8 percent decrease in the number of farmers and ranchers between 2008 and 2018. The age distribution of today's farmers and ranchers is also a critical issue. According to the "2007 Census of Agriculture" (USDA-NASS 2009a), the average age of a principal farmer is 57 years old. More than 63 percent of all established farms in 2007 were headed by a principal farmer age 55 or older; only 5 percent of all principal farmers were 35 or younger (Ahearn and Newton 2009). The aging population of U.S. farmers and ranchers is expected to increase by the next census while the number of young farmers is likely to decline.

The 2007 Virginia census also illustrates a significant need to establish and retain beginning farmers and ranchers based on the economic structuring of the industry. Agriculture provides $55 billion in income per year and about 357,000 jobs, making it an important industry for the commonwealth. Of the 47,383 farms in Virginia, 92 percent reported less than $100,000 in

sales, while 8 percent of the total farms accounted for 85 percent of total farm sales (USDA-NASS 2009b).

Virginia is also among the most expensive states for farmland, making it difficult for aspiring agriculturists to purchase suitable acreage. The average farm comprises 171 acres, while 77 percent of the total farms in Virginia operate on fewer than 180 acres (USDA-NASS 2009b).

Little is known about the 13,206 principal farmers in Virginia who have been on their current farms or ranches for nine or fewer years. The majority of all farmers in Virginia are white males, though the number of minority farmers such as women and African Americans is on the rise (USDA-NASS 2009b). Production crops and practices differ regionally and culturally, especially between rural and urban centers. Consumer demand for local and regional food, however, is growing at an increasing rate throughout Virginia.

Background on the USDA Beginning Farmer Rancher Development Program (BFRDP)

Beginning farmer education for adult and young audiences in the United States can be generally traced back to the advent of the 1862 and 1890 Morrill Land Grant Acts. But for the first time, the Food, Conservation, and Energy Act of 2008 (the 2008 Farm Bill), appropriated $75 million for fiscal year 2009 to fiscal year 2012 to develop and offer education, training, outreach, and mentoring programs to enhance the sustainability of the next generation of farmers.

The reasons for the renewed interest in beginning farmer and rancher programs are:
• The rising average age of U.S. farmers.
• The 8 percent projected decrease in the number of farmers and ranchers between 2008 and 2018.
• The growing recognition that new programs are needed to address the needs of the next generation of beginning farmers and ranchers.

According to the 2008 Farm Bill, a beginning farm is considered one that is operated by one or more operators who have 10 or fewer years of experience operating a farm or ranch. In 2007, approximately 21 percent of family farms met that definition.

Since its inception, BFRDP has funded many projects to train, educate, and provide outreach and technical assistance to beginning farmers on one or more of the following topics:
• Production and management strategies to enhance land stewardship by beginning farmers and ranchers.
• Business management and decision support strategies that enhance the financial viability of beginning farmers and ranchers.

• Marketing strategies that enhance the competitiveness of beginning farmers and ranchers.
• Legal strategies that assist beginning farmers with farm or land acquisition and transfer.
• Other priority topics to enhance competitiveness and sustainability of beginning farmers and ranchers for the next generation.

Background on the Virginia Beginning Farmer and Rancher Coalition Project

The Virginia Beginning Farmer and Rancher Coalition Program aims to improve opportunities for beginning farmers and ranchers to establish and sustain viable agricultural operations in Virginia through the development and enhancement of whole farm planning programs, online resources, and farmer mentoring networks.

Beginning Farmer Audience

This curriculum is aimed at addressing the needs of the spectrum of beginning farmers and ranchers in Virginia. We recognize a diversity of farming experiences, backgrounds, and aims held by Virginia's beginning farmers and ranchers. Many groups find it useful to look at the stages of commitment, decision-making, and skills that farmers pass through as they begin a career in farming. Drawing on the work of Sheils (2004), the following categories are a helpful guide to understanding this pathway.

Prospective or explorer farmers – Individuals interested in starting a farm or ranch. This includes next-generation farm family members as well as those who do not come from a farming background.

Startup farmers – Individuals who are in the early stages of their agricultural operation, often within the first one to three years of farming or ranching.

Re-strategizing farmers – Farmers who are making changes to their operations after farming for approximately four to seven years. These individuals usually have increased decision-making responsibility and commitment to farming.

Establishing farmers – Farmers who are expanding, diversifying, and stabilizing within years eight to 10 of the beginning farmer period.

Transitioning farmers – Individuals who are family farm members who have decision-making roles on the farm without having primary farm operator status.

These categories of farmers are a modification of those referred to by the New England Small Farm Institute. For the full reference, see "What Does the Term 'Farmer' Mean?"(Sheils 2004).

Preface written by Kim Niewolny and Matt Benson, Department of Agricultural and Extension Education, Virginia Tech.

Acknowledgements

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Organizational Members of the Virginia Beginning Farmer and Rancher Coalition

The Virginia Beginning Farmer and Rancher Coalition comprises innovative farm businesses and organizations from across the Commonwealth. These include:

AgrAbility Virginia
Agricultural Development, Fauquier County
Appalachian Sustainable Development
Attimo Winery
Bracketts Farm
Farm Service Agency, U.S. Department of Agriculture
Fauquier Education Farm
Grayson LandCare
Hethwood Market
Laurel Farm
Local Food Hub
Mountain View Farm and Vineyard
Natural Resource Conservation Service, U.S. Department of Agriculture
Piedmont Environmental Council
Rural Development, U.S. Department of Agriculture
SustainFloyd
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Virginia Department of Agriculture and Consumer Services
Virginia Farm Bureau Young Farmers
Virginia Farm Credit
Virginia Forage and Grasslands Council
Virginia State University
Virginia Team Ag Ed
Virginia Tech
VT Earthworks
Young Farmers of Virginia

Steering Committee

The Steering Committee consists of seven committed individuals from the Coalition who represent both farmer and service provider perspectives in Virginia. This elected committee is responsible for guiding project activity to best address the expressed needs of the Coalition.

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The Virginia Beginning Farmer and Rancher Coalition Program is a collaborative effort represented by a range of beginning farmer stakeholders across the Commonwealth of Virginia. It is housed in Virginia Tech's Department of Agricultural and Extension Education. Funding is sponsored by the Beginning Farmer and Rancher Development Program (BFRDP) of the USDA-National Institute of Food and Agriculture (NIFA), Award # 2010-49400. To find more resources and programs for beginning farmers and ranchers please visit www.Start2Farm.gov, a component of the Beginning Farmer and Rancher Development Program. Contact Kim Niewolny, Program Director, at niewolny@vt.edu or 540-231-5784, for more information.

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www.vabeginningfarmer.org

Sustainable Farming Practices: The Place and The Product

Planning to Teach this Module

Primary resource materials for this module:

Clark, A (ed.). 2007. Managing cover crops for profitability. Sustainable Agriculture Network, Handbook No. 9). 248 pp.

Magdoff & Van Es. 2009. Building Soils for Better Crops, 3rd Edition

Magdoff, F. 2007. Ecological Agriculture: Principles, practices, and constraints. Renewable Agriculture and Food Systems 22:109-117.

Tugel et al. 2000. Soil Biology Primer. Soil and Water Conservation Society

Virginia Association for Biological Farming information sheets on soil and cover crops. *www.vabf.org,* click on Library and Resources

In preparation for the planning activities used in this module, we recommend participants…

Contact your Natural Resources Conservation Service (NRCS) district office to find out what soil series (types) are present on your farm, and learn more about your soils at the NRCS web page, Official Soil Series Descriptions, *http://soils.usda.gov/technical/classification/osd/index.html*.

Sustainable Farming Practices Module is divided into five Sections

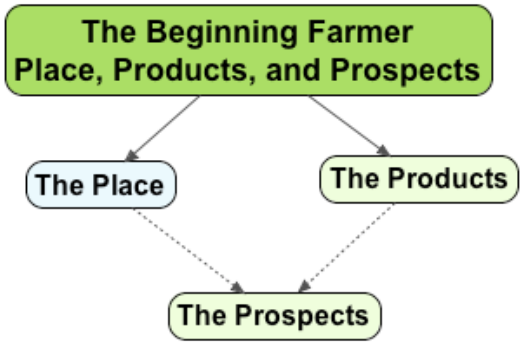
1. ***The Place and The Products***
2. ***Farm Biodiversity***
3. ***Soil Management***
4. ***Non-Crop Organisms in Agroecosystems***
5. ***Animal Husbandry***

Sustainable Farming Practices: Module 1 - The Place and The Products

Introduction

Assess where you are

In the Introduction to Whole Farm Planning Module you began a discussion that included your inventory and goals. This module consists of three units that will help you better assess your existing or potential farm situation (Unit 1: The Place), further defining and refining your farm products (Unit 2: The Products), and to assist in selecting appropriate management tools to sustain your farm (Unit 3: The Practices).



Do you know where you want to farm, or already own the land? Your focus moves to assessing that place, deciding which products are suitable, and which will be most effective in helping you achieve your plan.

Do you already know what products you want to raise? Are there other you should consider? Your focus moves to finding a place that provides the biophysical needs for your products, aligns with your cultural expectations, and offers effective economic opportunities.

Perhaps you already know the place and have a good idea which products you would like to raise. Congratulations! But seldom do place and products match perfectly. Your focus will be to gain insight into factors that may affect productivity, marketing, or community interactions. Here is an opportunity to verify the suitability of your earlier decisions, to double check some things you may have overlooked, and perhaps to gain an understanding of the obstacles you will need to overcome to realize your vision of a sustainable farm operation.

Finally, you will need to use sustainable practices to improve, maintain, and protect your products and the farm resources needed to produce them. How will you deal with pests and avoid diseases? How will you ensure soil fertility and productivity? What will you do when the rains do not come? How will you manage the land that is not used for raising products? How will you protect herd or flock health, and deal with questions of animal housing?

Reflecting on your responses, does your previous discussion of the sustainable farming practices of your plan still accurately represent your whole farming plan?

Assess where you want to be.

What are your particular questions regarding your planning for your sustainable farming practices?

What do you need to get there?

Individuals who complete this module

The *Sustainable Farming Practices* module is designed to….

The module includes concepts, worksheets, and examples to help you assess your resources and preferences for successful start-up planning.

Participants will understand

-
-
-
-

Portfolio Pieces Developed in this Module

-
-
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Unit 1: The Place

Teaching & Learning Tools

What you will be able to produce and how much you can sell will depend on climate, how much land and water you have, the soil quality, the lay of the land, your management skills, available labor, how close you are to markets, and your personal inclinations.

When starting a farm you may already know what you would like to produce and are willing to relocate to find the right place to develop the operation you have in mind. Conversely, you may already know the place you want to live, and need determine what type land is available and what you can raise. (If you are fortunate, you may know both location and products.) In either situation it is important to know the key the attributes of the place in which you will farm, and the requirements of the products you will grow, and make sure they align.

Not all locations and farms have the same potential for raising agricultural products. They vary widely in their suitability and potential as a function of the physical resources that are difficult or impossible to change.

In this module we will first consider these important attributes of place that lay provide the foundation of your farm, and present challenges to be overcome or worked around.

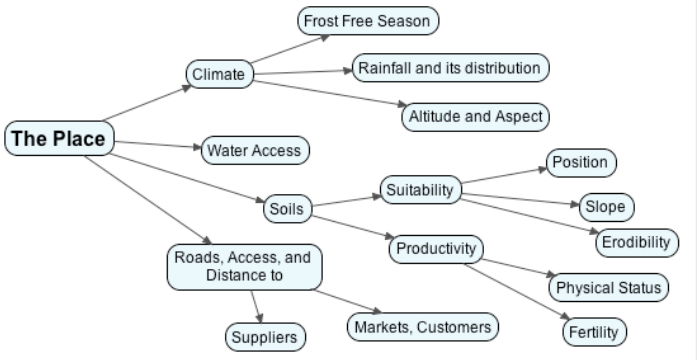

Figure 1. Some attributes of "Place" affecting a farm.

1.1 Climate and Microclimate

Farmers deal with actual weather, but generally plan based on what they have experienced and learned in the past. As a new farmer you will need to plan based on local knowledge and historical records of weather, or climate. An area's climate refers to the generally predictable patterns and ranges of temperature and rainfall across the seasons. Climate information usually considers the daily maximum and minimums as well as average and means of temperature and precipitation. Summaries over time can help in assessing the probability of conditions that improve or limit productivity throughout the year.

Climate limits the crops you can grow (for example, mangos or peaches) based on the plant's ability to survive the area's temperature extremes and the potential for enough heat to mature the crop, or enough cold to allow the crop to flower.

Some crops must accumulate a certain number of heat units (the number of degrees above a critical minimum temperature, taken as the average high and low each day) during the growing season to mature. Many crops or cultivars require more heat units than are available in some locations (e.g., certain wine grape varieties cannot be grown above 2500 feet in the mountains). Some fruit trees do not initiate and properly regulate flowering unless they accumulate a certain number of hours below a critical temperature (chilling hours) during the winter. For many crops, considerations such as sun exposure, rainfall amounts and pattern, air movement, and frost are critical to success.

The crops already grown in an area are a reasonable indication of climatic limitations. If your proposed crop is not grown locally, there might be some very good reasons for its absence. This does not necessarily mean it cannot be grown, but there might be some significant limitations to its production that you must discover and include in your management plans.

Climatic Zones of Virginia

Few states have a more diverse climate than that of Virginia, with its proximity to the oceans, and significant changes in elevation resulting from the presence of three different mountain systems.

Virginia has six major climatic divisions (Fig. 2) as defined by the

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National Oceanic and Atmospheric Administration (NOAA). The six climate divisions, 1) Tidewater, 2) Eastern Piedmont, 3) Western Piedmont, 4) Northern, 5) Central Mountains, and 6) Southwestern Mountains, represent regions within Virginia that are, as nearly as possible, climatically homogeneous. The divisions help researchers in hydrology, agriculture, energy supply, and others who require data averaged over an area of a state rather than for a point (weather station).

Figure 2. Climatic Divisions of Virginia. 1) Tidewater, 2) Eastern Piedmont, 3) Western Piedmont, 4) Northern, 5) Central Mountains, and 6) Southwestern Mountains. Source: National Weather Service Climate Prediction Center: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/regional_monitoring/CLIM_DIVS/virginia.gif

These six divisions differ from each other in atmospheric conditions (for example, source of weather fronts and amount of moisture they contain), as well as in distance from the coast, in elevation, and in other ground conditions that moderate or intensify atmospheric activity (bodies of water and land use).

The Piedmont divisions typically have long growing seasons and infrequent subzero temperature minimums, while winters on the northern Blue Ridge frequently produce bitterly cold temperatures more like those of Chicago. Similarly, annual rainfall totals can vary from a sparse thirty-three inches typical of the Shenandoah Valley to more than sixty inches in the mountains of southwestern Virginia. The

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Resources:

Climate Data for Virginia

- NOAA National Climatic Data Center http://www.ncdc.noaa.gov
- Southeast Regional Climate Center (SERCC) http://www.sercc.com

Atlantic Ocean and the warm waters of the Gulf Stream moderate temperatures along the coast, and bring the potential for hurricanes and heavy rainfall in late summer. The average winter along the coast does not have a major coastal snowstorm. Winter storms tend to follow the boundary between the cold land and the warmer Gulf Stream. Such storms grow rapidly and can bring moisture-laden air to the Piedmont and eastern slopes of the Blue Ridge Mountains. Snow is more common in the Piedmont divisions, but heavy winter snows are typically confined to the higher elevations of the Mountain divisions. Elevation changes affect precipitation amounts in both summer and winter. Moist air tends to release more precipitation as it rises up the slopes, and much less as it descend the other side. The New River and Shenandoah Valleys lie in this "rain shadow" of the Appalachian Mountains when storms approach from the North and West, and of the Blue Ridge when storms approach from the south and east. As a result, both the New River and the Shenandoah River valleys are the driest portions of the state, receiving rainfall similar to thethat of the eastern margin of the great plains. This same effect causes more precipitation when predominant air flows are up the river valleys, and less when predominant air flows are across peaks and down the valleys.

Microclimate

Microclimate is related conditions at a particular location that affect light, temperature, and moisture, and how air drains and collect on the land. Shade, topographic variations, and water bodies can all affect these factors, and cause them to be very different over relatively short distances. The tendency for a farm, or an area on a farm, to have early or late frosts, or to avoid frost, is an example of a microclimate. In some instances, a microclimate can make it possible to grow a crop not normally grown in an area, or it can make it impossible to grow some crops that are grown on surrounding farms. Some of the factors affecting microclimate are discussed below.

Obtaining Climate Information for Virginia

Although many internet sites provide general climate information, the most comprehensive and current information can be found at the NOAA National Climatic Data Center (http://www.ncdc.noaa.gov). However, this information does not summarize the data into convenient historical summaries. The Southeast Regional Climate Center (SERCC) produces historical summaries of the NOAA data for a large number of weather stations in Virginia. These are very useful for beginning farmers who have not experienced the impacts of past

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Activity:

We will use examples of these summaries for Blacksburg in the following discussions on temperature and precipitation. Most of the data is available as either tables or graphs.

weather events on their farm. Important historical summaries include:

- Daily Extremes and Averages
- Spring 'Freeze' Probabilities
- Fall 'Freeze' Probabilities
- 'Freeze Free' Probabilities
- Monthly Total Precipitation
- Daily Extreme and Average Precipitation

Climate Topics

- Temperature aspects of climate
- Rainfall and its distribution
- Water Balance
- Elevation and Landscape Elements
- Temperature Aspects of Climate

There are several temperature related aspects of climate limit or at least strongly affect the crops and varieties that you will be able to grow on your farm. This section briefly describes the use of data from the SERCC to estimate these for the region in which your farm is located.

Cold intolerant plants

Extreme low temperatures can affect growth and survival of perennial plants such as fruits and ornamentals. The USDA Plant Hardiness Zone map provides a generalized map of the expected minimum temperatures on a regional and national scale to aid in growers selecting plants adapted for their region.

Most suppliers of plants and root stock test their cultivars for adaptation, and supply this information with their products.

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Activity cont:
To find data nearer to you, use the map or list of weather stations from the SERCC web page (http://www.sercc.com/climateinfo/historical/historical_va.html . You will be presented with a wide range of data summaries available for that particular station.

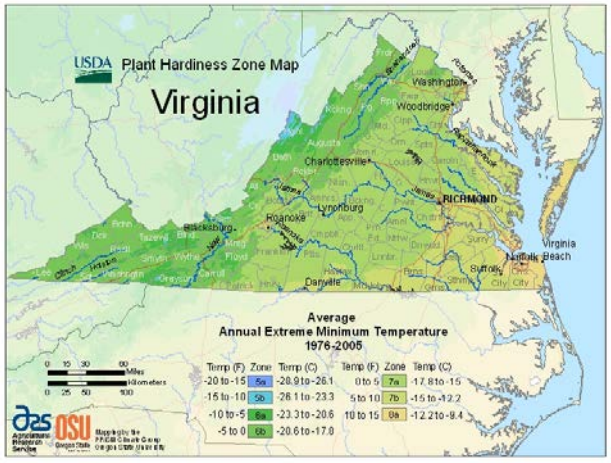

Figure 4. USDA 2012 Plant Hardiness Zone Map for Virginia. Source: http://planthardiness.ars.usda.gov/PHZMWeb/

While general information such as the USDA Plant Hardiness Zone Map (http://planthardiness.ars.usda.gov/PHZMWeb/) is very useful, the Extreme and Average Temperature charts supplied by the SERCC can give you more accurate information about extreme low temperatures closer to your location and help you avoid plantings of crops not well adapted to your site. As noted earlier, the Hardiness Zone Map is best suited for siting of cold tolerant perennial. Since it is based solely on minimum expected temperature, it does not explicitly incorporate information on maximum temperature nor planting dates.

Freezing Temperatures

The last frost of spring can damage, reduce yields, or kill emerging seedlings, flowering fruit, and other plants just breaking dormancy if they are sensitive to frost. Knowing when the last frost is likely to occur is critical for timing the planting of cold-sensitive crops and in selecting varieties that do not break dormancy too early in the spring. For crops damaged by frost, it is likewise important that spring and summer plantings are timed so that plants are mature before the first frost of the fall is expected. The number of days between these events is called the freeze-free season length.

Since records only look backward, and cannot guarantee that a frost

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will not occur after a given date in the spring, the numbers are reported in terms of the probability of a critical temperature (28, 32, 36 degrees F) occurring after a given date. Thus, in the Blacksburg there is a 90% probability (9 years in 10) of a temperature less than 32.5 degrees occurring after April 14, a 50% probability after May 2, and only a 10% probability after May 15. For high value crops, the time and expense of planting must be weighed against the value of getting products to market earlier and the risk of losing a a young crop to a late frost.

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BLACKSBURG 3 SE, VIRGINIA

Spring 'Freeze' Probabilities (Jan. 1 - Jul. 31)

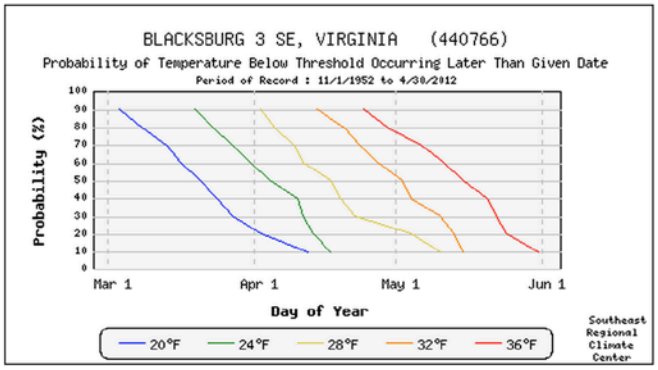

Figure 5. Spring Freeze Probabilities. From Southeastern Regional Climate Center, Virginia historical data, for Blacksburg, VA. http://www.sercc.com/cgi-bin/sercc/cliMAIN.pl?va0766

Note that many information suppliers, and even some seed suppliers will recommend a planting date based on the USDA Plant Hardiness Zone maps. This map is intended for a totally different purpose (minimum low temperature), and may not be accurate for planting decisions in your location. As an example, one seed supplier provides a last frost date for the Blacksburg zip code of April 15, yet there is a 90% probability of frost after that date.

In the fall, the probabilities are reversed with a 10% probability of frost before September 23, a 50% probability before October 8, and 90% probability after October 23.Nov.

Knowledge of the frost dates can also be important in managing non

freeze-protected water supplies for poultry and livestock.

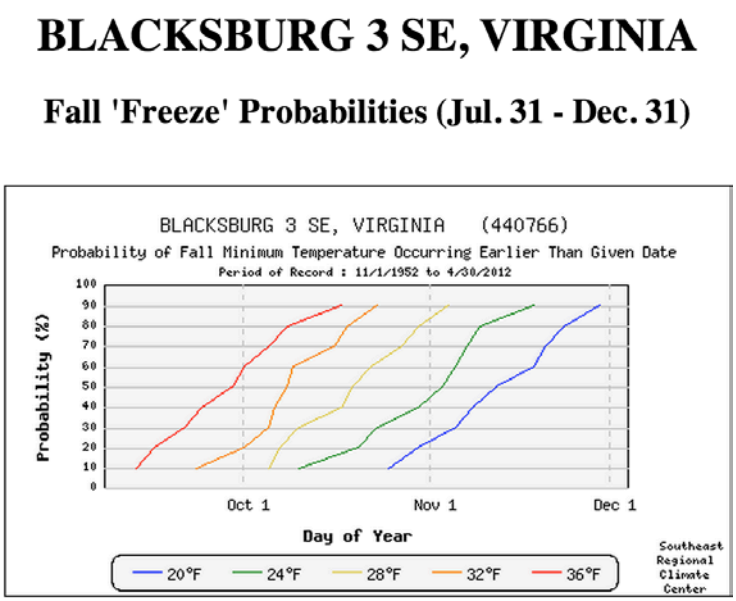

Figure 6. Fall Freeze Probabilities. From Southeastern Regional Climate Center, Virginia historical data, for Blacksburg, VA. http://www.sercc.com/cgi-bin/sercc/cliMAIN.pl?va0766

Freeze Free Season

The length of the growing season can also eliminate the use of some plants or cultivars with very long growing seasons. Plants may be adapted to mature as day length decreases in the fall, and thus not mature before first frost. Plants may also require a certain amount of heat units (growing degree days) to accumulate in order to mature.

This length of growing season for various plants and cultivars is usually supplied with the seed, plant, or by the root stock supplier. This can also be important for planning intensive cropping systems with multiple plantings in the same growing space in a single season. Although it is primarily an indicator of seasonal extreme temperature, many annual seed suppliers use the USDA Hardiness Zone maps as an indicator of season length.

The Freeze free season length (32 degrees F) for Blacksburg ranges from 135 (90% probability), 159 (50% probability), to 184 (10%

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probability) days.

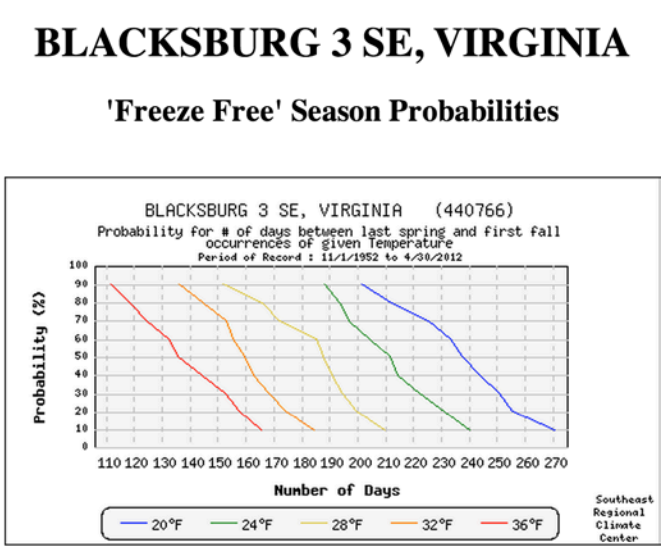

Figure 7. Example of freeze free season probabilities. From Southeastern Regional Climate Center, Virginia historical data, for Blacksburg, VA. http://www.sercc.com/cgi-bin/sercc/cliMAIN.pl?va0766

Chilling Period

Perennial plants adapt to cold climates by going dormant. In the spring, they emerge and rapidly transition to production of flowers, fruit, and seed. This transition may be triggered by shorter nights/longer days or the plants ability to sense that enough cold hours have passed that dormancy is complete. For example, pears need 1000 to 1200 hours below 45 degrees in order to complete dormancy. If a plant with a high chilling requirement does not experience enough cold, the transition to bloom will be delayed and once flowering begins, blooming will generally extend over a much longer period of time. Plants adapted for warmer climates may bloom too early and be damaged by frost when planted in colder regions.

Plants with low chilling period requirements will complete dormancy earlier (better adapted to warmer regions) and will provide early season products, but are more likely to be damaged by frost in colder regions. Longer chilling requirements result in

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Resources:

Chilling Units

•http://aggie-horticulture.tamu.edu/stonefruit/chillacc.html

•http://fruitsandnuts.ucdavis.edu/Weather_Services/chilling_accumulation_models/about_chilling_units/

later emergence, but these plants are less likely to be damaged by late frosts.

Growing Degree Days (GDD)

Many agriculture products and many insects mature at a rate that is directly affected by the temperature during the growing season. For corn, growth begins at temperatures above 50 degrees, its base-line temperature. By subtracting the baseline temperature from the average daily temperature you can calculate the number of growing degree days for each day in the season.

(Maximum Temperature +Minimum Temperature) - Baseline Temp= Daily GDD

2

By adding the GDD since the planting, you can estimate the stage of growth, and use predicted temperature to estimate when critical stages of growth will occur, such on-set of pollination (tasseling). Since insects display similar temperature related growth, growing degree days can also be used to predict when they will emerge and become potential problems. This is particularly useful for insects affecting woody perennials and some turf-dwelling species such as Japanese beetles.

Although the baseline temperature may vary from plant to plant, the accumulated GDD is useful for management of many insect pests and plants such as cotton, corn, small grains, soybean, peanuts, as well as many perennial plants including fruits, vines, and ornamentals.

The SERCC climate data summaries supply average growing degree by month accumulated during the growing season for baseline temperatures of 40, 45, 50, 55, and 60 degrees F.

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Resources:

Growing Degree Days

- Kowalski, T. And S. Clark. 2010. Using Growing Degree-Days for Insect Pest Management. http://ccesuffolk.org/assets/Horticulture-Leaflets/Using-Growing-Degree-Days-for-Insect-Pest-Management.pdf
- Using the Virginia Cooperative Extension Climate Analysis Web Tool to Better Manage and Predict Wheat Development http://pubs.ext.vt.edu/424/424-004/424-004.html
- Using the Virginia Cooperative Extension Climate Analysis Web Tool to Monitor, Predict, and Manage Corn Development http://pubs.ext.vt.edu/424/424-055/424-055.html

BLACKSBURG 3 SE, VIRGINIA

Period of Record General Climate Summary - Growing Degree Days

From Year=1952 To Year=2012													
Station:(440766) BLACKSBURG 3 SE													
Averages Daily Extremes													
Growing Degree Days for Selected Base Temperature (F)													
Base	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
40 M	30	45	150	354	615	819	968	938	709	397	164	51	5241
40 S	30	75	225	579	1194	2013	2981	3919	4628	5025	5189	5241	5241
45 M	10	17	77	231	462	669	813	783	559	261	84	21	3987
45 S	10	27	104	335	797	1466	2279	3062	3621	3882	3966	3987	3987
50 M	3	5	33	134	317	519	658	628	412	148	35	7	2899
50 S	3	8	41	175	492	1011	1669	2297	2709	2857	2892	2899	2899
55 M	0	1	11	66	190	372	503	473	272	67	11	1	1968
55 S	0	1	13	78	269	640	1143	1617	1888	1956	1966	1968	1968
60 M	0	0	2	24	91	231	348	320	150	22	2	0	1192
60 S	0	0	2	26	117	349	697	1017	1168	1190	1192	1192	1192

Table 1. Example of growing degree day summary, From Southeastern Regional Climate Center, Virginia historical data, for Blacksburg, VA. http://www.sercc.com/cgi-bin/sercc/cliMAIN.pl?va0766

Teaching & Learning Tools

High temperatures

Some crops are very sensitive to high temperatures, resulting in premature flowering, poor photosynthetic efficiency, or if high enough, inhibition of fruit set or pollination. All result in reduced yields or lower quality. The daily Extremes and Average Temperature summaries from SERCC can help you avoid planning your farm around plantings of sensitive crops that would be affected by high temperatures. Many such sensitive crops are planted in the fall rather than in the spring, but spring plantings are possible in areas with cooler summers and at higher elevations with cooler temperatures.

This is taken into account for the growing degree calculations mentioned above. For calculating the growing degree days for corn, the daily average temperature is set to no more than 86 degrees, since temperatures higher than do not contribute to additional growth.

During high temperature periods, animals may also require shade,

additional water, and other care during periods of high temperature. This data can help you anticipate the probability of such events.

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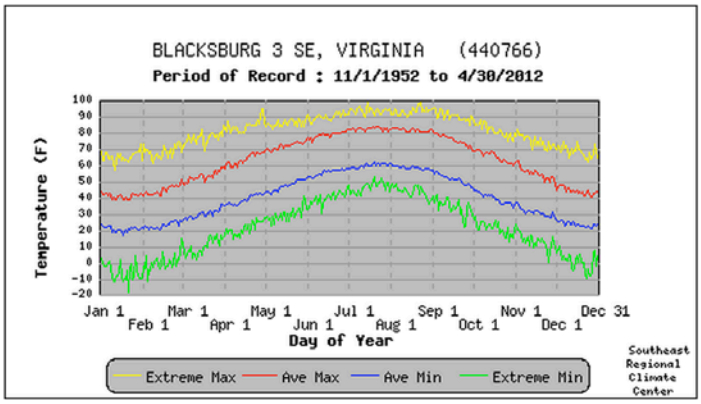
BLACKSBURG 3 SE, VIRGINIA

POR - Daily Temperature Averages and Extremes



- Extreme Max. is the maximum of all daily maximum temperatures recorded for the day of the year.
- Ave. Max. is the average of all daily maximum temperatures recorded for the day of the year.
- Ave. Min. is the average of all daily minimum temperatures recorded for the day of the year.
- Extreme Min. is the minimum of all daily minimum temperatures recorded for the day of the year.

Figure 8. Daily Temperature Averages and Extremes . From Southeastern Regional Climate Center, historical data, for Blacksburg, VA. http://www.sercc.com/cgi-bin/sercc/cliMAIN.pl?va0766

Cool season versus warm season plants

Some plants perform much better in cooler climates (cool season or C3 plants), and others in warmer (warm season, or C4 plants) climates. This has to do with the way in which these plants convert carbon dioxide in the atmosphere to plant biomass. Temperature affects both the capacity and efficiency of this process.

Virginia lies in the transition zone between cool and warm seasons, with warm season tendencies near the coast, and cool season tendencies in the Piedmont and Mountains. As a result, warm

season grasses for turf and forages predominate in the Coastal division, and cool-season types predominate elsewhere in the state. Both types may survive and be productive in both zones under average conditions, temperature extremes can reduce productivity and threaten survival.

Precipitation and Its Distribution

Annual average precipitation varies from around 33 inches in parts of the Shenandoah Valley to over 60 inches in the mountains of the southwest. While annual amounts are important, the distribution of rainfall during the year, and especially during the growing season is even more important.

Table 2 shows average monthly precipitation (the row labeled PPT) for locations within each of the six climatic divisions in Virginia. Precipitation for Virginia is typically well distributed throughout the year, with the highest amounts occurring during the months of May, June, July, August, and September. Row crops and vegetables are common in the Tidewater, while forages, corn for silage, and small grains are more common in the Northern, Central Mountains, and Southwestern Mountains. While part of this is related to soil types, slopes, and other factors, the amount and distribution of precipitation plays a role.

Location		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
							inches							
Williamsburg	ET	0.20	0.28	0.97	2.27	3.86	5.23	6.14	5.61	3.97	2.21	1.01	0.36	32.09
Tidewater	PPT	3.74	3.49	4.22	2.98	4.40	4.21	5.23	4.68	4.42	3.56	3.21	3.43	47.57
	Water Balance	3.54	3.21	3.25	0.71	0.54	-1.02	-0.91	-0.93	0.45	1.35	2.20	3.07	15.48
Farmville	ET	0.15	0.26	1.01	2.34	3.81	5.13	6.00	5.41	3.71	2.04	0.88	0.27	32.09

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Eastern	PPT	3.46	3.30	3.89	3.16	3.82	3.63	4.24	4.07	3.38	3.51	3.17	3.30	42.93
Piedmont	Water Balance	3.31	4.04	2.88	0.82	0.01	-1.50	-1.76	-1.34	-0.33	1.47	2.29	3.03	11.93
Chatham	ET	0.12	0.21	0.91	2.14	3.71	4.96	5.83	5.28	3.69	2.02	0.87	0.25	29.99
Western	PPT	3.41	3.32	4.16	3.54	3.89	3.60	3.94	3.80	3.79	3.55	3.09	3.39	43.48
Piedmont	Water Balance	3.29	3.11	3.25	1.40	0.18	-1.36	-1.89	-1.48	0.10	1.53	2.22	3.14	13.49
Woodstock	ET	0.02	0.12	0.81	2.08	3.63	4.94	5.75	5.21	3.63	1.97	0.80	0.17	29.14
Northern	PPT	2.40	1.98	2.92	2.85	3.23	3.48	3.61	3.47	3.22	2.92	2.30	2.34	34.72
	Water Balance	2.38	1.86	2.11	0.77	-0.40	-1.46	-2.14	-1.74	-0.41	0.95	1.50	2.17	5.58
Staunton	ET	0.01	0.07	0.74	2.00	3.52	4.77	5.52	4.95	3.47	1.88	0.76	0.15	27.84
Central Mtns	PPT	2.53	2.19	3.19	2.79	3.36	3.03	3.51	3.40	3.55	3.26	2.56	2.55	35.92
	Water Balance	2.52	2.12	2.45	0.79	-0.16	-1.74	-2.01	-1.55	0.08	1.38	1.80	2.40	8.08
SW Mount	ET	0.05	0.18	0.93	2.14	3.59	4.72	5.45	4.97	3.60	1.96	0.75	0.19	28.53

Pennington Gap	PPT	4.88	4.40	5.75	4.35	4.39	4.17	5.07	3.76	3.47	2.96	3.89	4.66	51.75
	Water Balance	4.83	4.22	4.82	2.21	0.80	-0.55	-0.38	-1.21	-0.13	1.00	3.14	4.47	23.22

Table 2. Monthly Average Month Potential Evapotranspiration, Average Monthly Precipitation and Water Balance in inches for locations within each of the six Climatic Divisions of Virginia. ET= Evapotranspiration, PPT=Precipitation, Water Balance = PPT-ET.

Water Balance

While most locations in Virginia receive adequate precipitation for rain-fed production of forages and row crops, that does not mean that there is adequate water each month to meet all the needs of crop. Every part of the state experiences periods of water deficit during the summer. This is illustrated in Fig. 9. The term ET refers to the combined loss of water from soil surfaces (evaporation or E) and plant leaves (transpiration or T) to the atmosphere. The solid line represents precipitation, and the dashed line the evapotranspiration. When ET exceeds the amount supplied in precipitation for a given month, a water deficit (a negative water balance) results. So by subtracting ET from precipitation for a given location, we obtain an estimate of the monthly water balance. This is shown by the bars on the figure, which fall below the 0 line during the hot summer months. At this point, plants must rely on water stored in the soil from previous months, if any remains.

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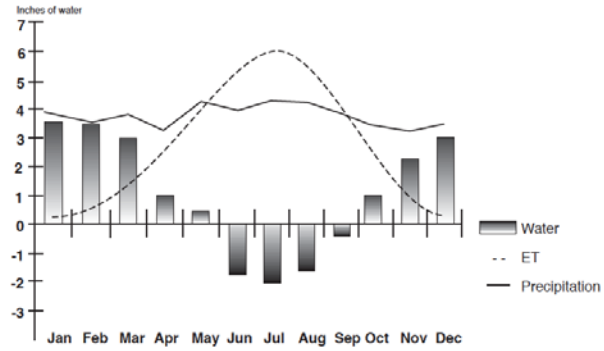

Note: Evapotranspiration (ET) is the total of water loss from the soil (evaporation) and the water used or lost from plants (transpiration).

Figure 9. Distribution of precipitation, evapotranspiration (ET) and water balance across months. .

The amount of potential water loss is strongly affected by temperature, humidity, sunlight, and wind. These factors can be used to calculate Potential ET for a location. Calculations of ET and water balance are shown for locations within each of the six climatic divisions. The annual water balances (last column) show a low of 5.58 inches for Woodstock to a high of 23.32 inches for Pennington Gap. While this looks promising, a closer look at the monthly balances shows that during the summer growing season, every location has at least three consecutive months with a predicted water deficit. Several locations within Virginia have as many as five consecutive months with a negative water balance during the growing season. Furthermore, when large positive balances occur (typically in late fall and winter), the amount entering the soil often exceeds the water holding capacity of the soil, and the water passes on through the soil into the groundwater. So all of the positive water balance shown in the last column is no longer available to plants.

Where summer temperatures are high and precipitation is low or erratic, soil water supplies can quickly be exhausted. The resulting plant water stress reduces yields and quality. If water deficits occur during bloom and pollination periods, or during peak fruit and grain fill periods, yields can be markedly reduced. While farmers can use practices like mulching to reduce evaporation from the soil, such practices are limiting in their ability to reduce PET. This makes supplemental irrigation especially important in parts of the state where water deficits are severe or prolonged, and soil water holding

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capacity is limited. For high value crops such as vegetables, fruits, and vines, as well as some intensively managed row crops grown in such areas, irrigation will enhance consistency and profitability.

Likewise, when the water balance remains negative for several weeks, flows from surface springs and small streams may slow or dry up. Animals relying on these sources may need supplemental water supplies as well.
The availability of supplemental water from surface or groundwater sources can be critical for success of farming operations during water deficit periods.

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Elevation and Landscape Elements

Elevation
An increase in elevation (height above sea level) generally increases light intensity, decreases daily average temperature, and increases the difference between daytime and nighttime temperatures. An increase of 1000 feet in elevation results in an average temperature decline of about 3.6 degrees F. For high value perennial crops with a rather narrow optimum temperature range such as grapevines, elevation can be one of the most important site characteristics. These change can be beneficial during the summer, and detrimental during the freeze-sensitive periods of early spring and fall.

The decrease in temperature with elevation also lowers the ability of the atmosphere to hold water, resulting in a lower humidity.

Landscape position
Low positions in the landscape, especially in hilly and mountainous areas can be affected by downward flows of colder, air resulting in ponding of potentially damaging colder temperatures at the base of slopes and low spots in a field. These low spots are typically more prone to untimely frosts in spring and fall. This downward movement of cold air and its replacement with warmer air on side slopes can act to protect crops planted in these locations.

Low landscape positions are frequently more subject to flooding as well. On the other hand, lower positions often have better soils because they are formed from stream sediments or topsoil eroded from higher positions.

Hill summits may be less prone to frosts on cold nights than lower positions, but are typically more exposed to winter winds. Winds can increase transpiration losses from plants, and dry them out.

Slope

Slope is the inclination of a land surface from horizontal, and is usually expressed in terms of percent; a 7 percent slope would fall 7 feet in elevation over a horizontal distance of 100 feet. Increasing slope results in increasing downward movement of both air and water, and thus increases the potential for erosion. Slopes greater than 15% become hazardous for equipment operation.

Aspect

Aspect is the prevailing compass direction in which the slope faces. In highly sloping lands, the angle at which sunlight hits the surface will be changed. North facing slopes may receive significantly less sunlight than south facing slopes, particularly during late fall to early spring. They are typically cooler, and the last place in which snow melts. In addition to lower photosynthetic potential and warm up in the spring, this can also affect early morning drying, and potential spread of diseases.

Presence of Water Bodies

Water retains it temperature much more readily than adjacent land, and tends to moderate air temperatures. As a result, temperature extremes near water bodies are reduced in summer and winter, and these areas are less prone to late frosts in spring, and early frost in the fall.

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Resource:
Application of Using Climate Data for Suitability
•Virginia Vineyard Suitability Investigative Tool"
http://vmdev.cgit.vt.edu/Vineyards/

1.2 The Land - The Types and Properties of Your Soils

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Previous Use of the Land

Some limitation arise from inherent properties of soils, and others from how the land was previously used and managed. Previous land use could affect your plans. Learning about, and documenting how the land was previously used and managed could provide you with important information.

- Use of biosolids or previous use of synthetic fertilizers or pesticides could affects organic certification, or at least the timeline
- Be aware of potential biohazards - dumps, biohazards
- Previous use may be an indicator of suitability for certain crops

Now lets consider how the soils on your farm may affect your plans, and how you can find out what you need to know about them.

The Roles of Soil in Agriculture

1. Soils provide a medium for plant growth.

Soils supply the basic mechanical strength to allow roots to penetrate and physically hold plants in place. The soil structure and chemical properties may either separately or together prevent roots from penetrating to an adequate depth to provide structural support. Shallow soils, extremely sandy soils, poorly structured clayey soils, or soils with root-limiting layers may not be suitable for high value crops such as orchards and vegetables. On the other hand, soils with high percentages of sand, but with some silt and clay

2. Soils supply nutrients.

Depends on soil chemical environment, nutrient retention capacity (cation exchange capacity), and amount of soil organic matter present, parent material, and past management.
The current status of the soil can be assessed via soil testing for nutrients, pH, and organic matter content.

3. Soils receive, retain, and supply water to plants

Soils receive rainfall, which either moves into the soil (infiltrates) or leaves the field as runoff. Once moisture enters the soil, it is either retained by the soil particles, or it continues to move through the soil,

often taking nutrients in the soil water with it. The ability of the soil to hold water is called the (plant) available water holding capacity, and it varies with the amount of soil organic matter, and the proportion of sand (large particles), silt (flour-sized, fine particles), and clay (microscopic fine particles). The more organic matter, silt, or clay, the more water the soil can hold, and eventually resupply to plants. These same properties can also influence the ability of precipitation to infiltrate into the surface of the soil. The more soil organic matter, and in this case sand-sized particles, the greater the rate at which water can move into the soil, and the less that runs off the surface.

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4. Soils provide habitat, food, and energy for soil organisms:
Many of the benefits we as humans derive from soils could not function without the "non-crop" organisms that live in the soil. These organisms increase nitrogen in the soil through the process of nitrogen fixation, usually linking with a legume species to do so. Organic residues are transformed into highly desirable humus, soils are formed , wastes are detoxified, pathogen organisms are kept in check, and in some cases, fungi infect the root systems and improve the ability of infected plants to find soil and water essential for growth. The incredible thing is that they do this in an environment where there is no sun to provide energy. By breaking down plant and animal residues, releasing the stored energy and nutrients, nutrients are cycles so that other plants and animals can reuse these important resources.
When functioning well, these processes capture energy and nutrients so that they do not leave the system in large amounts

Highly productive soils provide a strong mix of these roles, and this is a function of their soil properties.

Physical Properties

- Texture, Structure, Pore space, and Bulk density, Available water-holding capacity, drainage, depth, and slope (organic matter content)
- Of these, only structure and bulk density are subject to significant change over time under normal management practices, and even these affect primarily the surface layer.

Soil Structure. Pore Space, and Bulk Density

Soil structure is the manner in which soil particles are arranged to

form aggregates or larger particles. As a result, structure is strongly influenced by soil texture and the nature of the aggregates which are formed. Organic matter is also very important in binding aggregates together. Soils high in organic matter can have excellent structure, even if there is high proportion of clay.

The size and stability of soil aggregates determine the size and shape of the air space (the soil pores) surrounding the soil solids. In turn, the amount and size of soil pores affects the ability of water, air, and plants to penetrate into and through the soils and the ease with which a soil can be worked (tilth). A loose granular structure, in which the aggregates are not too firm or too large is ideal for most plants. Soils with small pores between particles tend to slow movement of air and water, and present challenges for plant root growth. This is frequently occurs as a result of compaction, either during soil forming processes, or as a result of running heavy equipment on soils that are moist, and thereby subject to structural breakdown.

The degree of compaction is measured in terms of weight per unit volume, and known as bulk density. Essentially, as more soil solids are compressed into a space, there is less pore space, and the bulk density increases. A solid block of soil with no air space would have an average bulk density of 2.65 grams per cubic centimeter. A desirable bulk density, with half of the soil volume as pore space, would be 1.33 g per cubic centimeter or less, while bulk densities above 1.8 can prevent root penetration and reduce water flow. Since organic matter has a very low bulk density (1 g per cubic centimeter or less) and contributes to improved structure, organic matter additions can lower bulk density.

Available Water Holding Capacity

A soil's ability to hold water against the force of gravity is a function of the particle size and the soil structure. As particle and pore sizes get smaller and smaller, more water is held in the soil and does not flow downward. Eventually, the water is held with such force that even a plant root is unable to pull water from the soil surfaces and pores. The important property from a plant production view is not the total amount of water a soil can hold, but the amount of water that can be held AND is available to plants. A generalized range of available water holding capacity for soils of different textures is shown in Table 3. These can be improved by improving structure and organic matter content.

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Table 3. Available water holding capacity in a one inch depth of soil with different soil textures.

Soil Texture	Available Water Holding Capacity (Inches water/inch of soil)
Coarse sand	0.02–0.06
Fine sand	0.06–0.09
Loamy sand	0.06–0.12
Sandy loam	0.11–0.15
Fine sandy loam	0.14 – 0.18
Loam and silt loam	0.17-0.23
Clay loam and silty clay loam	0.14-0.21
Silty clay and clay	0.13-0.18

Drainage and Wetness

The soil drainage describes the rate at which water moves through the soil under the pull of gravity (also called leaching or percolation). Using a sponge as an example, a sponge setting in a glass of water drains very slowly since there is nowhere for the water to go. The analogous situation in a soil, would be called a poorly drained soil with a high water table. In this case, the depth of the water table is much more important than the texture.

On the other hand, if two sponges having different hole sizes were filled with water and allowed to drain, gravity would most quickly pull water from sponge with the largest holes. This is because the smaller the hole, the more the pore begins to act like a capillary tube, and the more water is retained in the pore. A soil with very fine pores is said to have poor internal drainage because the high degree of interaction between soil and the water limits water movement.

Poorly drained and soils have limited suitability for agricultural production since plant roots require oxygen. Such soils must be artificially drained in order to improve their suitability. This can be expensive, and is considered illegal if wetland soils are involved. Somewhat poorly drained soils frequently suffer water logging (the soil pores are filled with water), during at least part of the growing season. At the other in of the scale deep sandy soils are considered excessively well drained, because they rapidly loose water to the force of gravity and evaporative losses.

Depth and Slope

- Shallow soils and highly sloping soils are poorly suited for most forms of agriculture without drastic management interventions (raised beds, terracing, rock excavation, and soil building).
- In an ideal marketing situation, or where no other options exist such actions might be economically justified, but assess the environmental impacts as well.
-

Chemical Properties

- Soil Reaction or pH, Cation Exchange Capacity, Nutrient Status, Soil Acidity, (and Organic matter)

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Soil Reaction (pH)

Soil reaction is a measure of the soil acidity or alkalinity, and is measured using a pH meter. Most soils in Virginia are acidic to neutral in pH. Soils that are extremely acid will generally inhibit growth of agricultural plants, and must be amended using limestone to increase the pH to a favorable range (usually 6.0 to 7.0). However, some native and domesticated plants are well adapted to low pH values and may even perform better at low pH (blueberry, rhododendron, pines). Soils with pH greater than 7.0 are unusual in Virginia, but can occur for example, around construction sites, outcrops of limestone and soluble mineral, and areas exposed to sea breezes. These soils may exhibit poor availability of micronutrients, a condition that can be difficult to correct.

The pH is an important measure of soil health, much like blood pressure or temperature are measures for human health. This value is important in its own right, but it is also highly correlated with the base status of the soil, that is the relative amounts of calcium + magnesium relative to the amounts of acidic elements (hydrogen and aluminum) present on the soil surface and in the soil solution.

Nutrient Status

Plants need 16 elements to grow effectively, and the levels of toxic elements must be low. Nutrient status, or soil fertility, is a function of the parent material and past management. Assessment is site specific an is best accomplished through a chemical analysis (a soil fertility test, or soil test) that is correlated with plants ability to assimilate nutrients in the field. Soil fertility testing commonly provides results for plant available levels of phosphorus, potassium, calcium, magnesium, micronutrients, soil acidity and soil pH, and provides an indication of nutrient status (low, medium, high, or adequate). Most laboratories will also perform a soil organic matter analysis as well.

Soil testing and other ways of assessing nutrient status will be discussed in Module 3 - Sustainable Farming Practices - Soil Management

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Biological

Biological activity is almost entirely a function of how the land has been managed in recent years. Since biological processes are very attuned to changes in environmental conditions, the numbers obtained could be very different over a very short amount of time. While there are several biological properties that could be measured, such tests would seldom be used to decide if a site were suitable for production of a particular product. Organic matter content, like pH in the chemical realm, provides a key indicator of the biological status.

Soils in Virginia

Virginia has a very diverse range of landforms and underlying materials, resulting in over 600 soil series being mapped in Virginia (Figure 11). These range from the relatively flat and sandy soils of the Coastal Plain region near the ocean, to the red, often clayey soils and rolling hills of the Piedmont region, and the complex soils developed from many rock types and sediments, often in highly sloping soils, of the Blue Ridge Mountains, Ridge and Valley, and Appalachian Plateau regions of the Commonwealth.

Based on their properties, it is possible to classify soils into groups, each with a similar range of properties called a soil series. These soil series can then be recognized in the field and marked on a map showing their location. (Note: the units on a map are called mapping units rather than soil series. Since very small areas of different soils series cannot be marked separately at the scale of most maps. The mapping units are predominantly one series, but may contain small inclusions of other soil series.)

The range in properties from one soil series to another can be enormous, and so can the suitability for different uses such as growing different agricultural products. The soil maps, or surveys, then become a means of identifying the suitability of your soils for different uses and crops. Fortunately, most counties in Virginia have a completed soil survey with a map of the soils and a description of the mapping units that are marked on the maps.

Teaching & Learning Tools

Read
Soils of Virginia. Agronomy Handbook VCE Publication 424-100
See Resources.

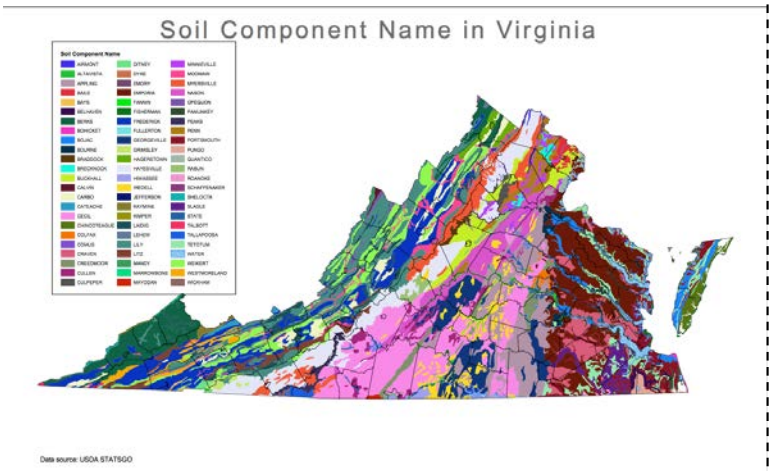

Figure 11. Example of the diversity of soils in Virginia. Soils component map. Virginia View - Digital Atlas, CNRE, Virginia Tech. (Note: Not all 600+ soil series in Virginia are shown in the legend!) http://virginiaview.cnre.vt.edu/digital_atlas.html.

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Read
Getting Started with Web Soil Survey
http://websoilsurvey.nrcs.usda.gov/app/GettingStarted.htm

What soils are present on your farm and how can you find the information needed?

Accessing Soil Surveys

If you have high speed access to the internet, soil surveys for nearly the entire country are available at the NRCS Web Soil Survey site (http://websoilsurvey.nrcs.usda.gov/). This useful tool allow you select areas of interest to you from a map image. The tool then identifies the soil series on the map. After this, you can access information on soil properties and assessments of suitability of your soils for crops and a host of other uses. You can generate a report containing all this information, and download it in PDF format as a reference.

For some counties in Virginia, a published soil survey is available online for the entire county. These may be found online in PDF format (http://soils.usda.gov/survey/online_surveys/virginia/) for a limited number of counties. Paper copies of county soil surveys may also be available at your local Soil and Water Conservation District/NRCS office or Cooperative Extension office.

Brief Instructions for Using Web Soil Survey

1. Navigate the browser to http://websoilsurvey.nrcs.usda.gov and click the green "Start WSS" button.
2. Zoom into your area of interest by using the map, or any of the quick navigation tools on the right.
3. To delineate the area of interest (AOI) for collection of data, select one of the buttons above the map that are labeled (AOI) and outline the desired area. Double click on the map once the area is outlined to create the AOI. The area will show in light blue. The area can be named in the left column.
4. Clicking on the soil data explorer tab at the top of the page brings up an interface to select suitabilities and limitations ratings and soil reports. Select vegetative productivity, and crop productivity index, and then view rating. If the report is available it will appear to the right with a delineated map, table, and description.
5. To add this to the final report click add to shopping cart at the top of the page. Every time this is clicked the information on the page will be compiled into a final report. This can be repeated for yields of non-irrigated crops and the specific crop can be selected to obtain specialized data. The numbers returned are weighted averages based on a multitude of factors.
6. Once all the needed data is added to the shopping cart, select "Shopping Cart (Free)" at the top of the page. From here the added data is listed under a table of contents to the left and reports can be deselected. Click check out and enter your email address to receive a download link for your report. Note the report will be delivered in a "PDF" format.

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Read

Soils of VirginiaBaker, J. 2000. Soils of Virginia. Agronomy Handbook-Part VI. Virginia Cooperative Extension. Publication 424-100. Pp 69-74. http://pubs.ext.vt.edu/424/424-100/424-100.html

Soil Survey
Published soil surveys, USDA-NRCS or County Extension office

Web soil survey
http://websoilsurvey.nrcs.usda.gov/

1.3 Water

Introduction

All sources of freshwater start as precipitation from the atmosphere. As this strikes the ground, it may run off the surface, carrying with it organic and mineral matter, soil particles, and microorganisms. When the water infiltrates into subsoil and out of the plant root zone, it forms groundwater. As the groundwater level increases and rises above surface level due to varying land formations, it oozes out as springs or small intermittent streams. In their movement toward the sea, these sources combine with others to form surface water bodies such as streams, rivers and lakes.

The source of water available on your farm has a major effect on water quantity and the expense of tapping into this vital resource. Water quality also varies with source, and the level of treatment required to use it. For a farmer in Virginia, the most important characteristic of a water source is that it be able to supply adequate quantities of water to meet your needs, especially during critical periods.

Carefully consider your water supply needs. Depending on your plans, you may need water for domestic use if you live on the farm, as well as for irrigation, animals, cleaning, and processing.

The capacity and quality of your water supply are key considerations in defining the options available to you. The less water you have, the fewer options you will have in designing your farm and your management practices. You will need to assess the available sources, quantities, and quality of water for your farm.

The focus of this section is on features of the water supply affecting domestic use and farming operations. The management and maintenance of water supplies is not considered here.

For more information on testing and maintenance of rural water supplies see the Virginia Household Water Quality Program website. http://www.wellwater.bse.vt.edu/

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Water Supply Considerations

- Type of Use: Domestic, Irrigation, and Processing
- Source
- Quantity and Rate of Flow
- Rate of Flow

- Distance from operations
- Quality

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Types of Use

If you live on the farm, you will need water for both domestic and farm uses.

Domestic Water Supply

- Water quality should be adequate for its intended use. You are responsible for the safety of your family's water! This means you should take steps toward maintaining and protecting your water supply and testing your water.
- The amount of water you will need for domestic use depends on your household's daily water needs. Water needs for an individual home vary depending on water use, water storage, and water-saving devices within the home. However, the average home will require approximately 50 to 75 gallons of water a day per person.
- Irrigation and other Agricultural Uses
- While the same supply may serve both uses, the large volumes required for practices such irrigation may make it necessary to use one source for high quality domestic supplies and another for your various agricultural operations.
- Irrigation requirements during peak water demand periods with no rainfall can be two inches per week or more, depending on the method of irrigation. This is the equivalent of 54,308 gallons per acre per week.
- If water that is used to irrigate or spray protective chemicals onto crops becomes contaminated with harmful microorganisms, it can spread the pathogens to the crops. Where water quality is unknown or cannot be controlled, growers should use other good agricultural practices to minimize the risk of contamination.
- Be aware of current and historical use of land.
- Consider irrigation water quality and use. where water quality is unknown or cannot be controlled, consider irrigation practices that minimize contact between water and the edible portion of the crop

Processing

- Processing water should be of such quality that it does not contaminate produce.

- Water used during the post-harvest handling of fruits and vegetables often involves a high degree of water-to-produce contact.
- Practices to help ensure adequate water quality may include ensuring that wells supplying processing waters are properly constructed and protected, or treating water to reduce microbial loads, or using alternative application methods that reduce or avoid water-to-produce contact.
- Animals
- Animals require clean, fresh sources of drinking water on a daily basis. See discussion below for more information.
- Washing and manure management. Water will be required for cleaning barns, milking parlors, and equipment. Some of this may be recycled.

Food and Drug Administration. 1998. Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables. http://www.fda.gov/downloads/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/ProduceandPlanProducts/UCM169112.pdf

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Sources of Water

- County or Municipal Water Systems
- Groundwater
- Wells
- Surface Water
- Springs
- Streams, Rivers, or Lakes
- Rainwater Harvesting in Cisterns
-

County or Municipal Water

Depending on your location, you may be able to purchase water from a municipal water supplier. Municipal water is of high quality and usually is delivered at a minimum pressure of 40 pounds per square inch (psi). However, municipal water suppliers may place limits on how much water can be used and when. While you may wish to use municipal supplies for domestic use, generally, the large amounts of water required make it very costly to use municipal water to irrigate agricultural crops.

Groundwater

Groundwater in Virginia is generally of good quality and frequently is used to supply homes and farmsteads. It also can be a good source of irrigation water. Ground water is readily available in the Coastal Plain region of the state from dug ponds and wells that tap into the ground water aquifers. Across the state, about 2 million Virginians, or 34%, depend entirely on wells for drinking water. However, wells outside the Coastal Plain region generally provide too little water except for the smallest irrigation systems.

Locating and drilling a well that will provide adequate, high quality water is a difficult and expensive task that may not always be successful. Because groundwater is stored in soil and rock below the soil surface where it cannot be seen, there is no guarantee that sufficient groundwater is available to meet irrigation needs. If you plan to develop a groundwater irrigation supply, you should consult a hydrogeologist. Local well drillers also can be a source of information on well yields in your area.

Well Location

- Your well should be at least 100 feet away from potential contaminants sources such as chemical storage facilities, oil tanks, septic tanks or cesspools, pastures, and barnyards, and at least 25 feet from a silo.
- The ground should slope away from your well to prevent surface water from pooling around the casing, which can cause contamination and damage your system.
- Make sure the well is properly constructed. Well casing should be high enough (12”) so that surface water can never enter your well. You should also have a sealed sanitary cap or sturdy concrete cover (on a bored well) to prevent contamination from insects, small mammals, and other surface contamination.

Surface water

Surface water invariably originates from rainfall and is a mixture of surface runoff and groundwater exposed to the atmosphere. Typically this source includes ponds, streams, rivers, lakes, and reservoirs. Springs will be addressed separately below. Surface waters commonly have low mineral contents and hardness, high turbidity and bacterial count since they are more often than not exposed to serious pollution due to domestic and industrial wastes.

There are instances when groundwater cannot be used as a source of

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water on the farm due to one or more of the following reasons:

- groundwater is not available in sufficient quantity;
- groundwater is only available at great depths;
- quality of the groundwater is not acceptable (especially for domestic use) due to high mineral or organic matter content or color.
-

Surface Water for Domestic Use

Municipal and county water systems in Virginia frequently rely entirely on surface water sources. This usually involves watershed protection areas, elaborate and expensive intake and treatment systems to treat pathogens and remove particulates.

Waters accessible to farmers: These water sources are frequented daily for collecting drinking and cooking water, washing clothes, bathing, livestock washing, etc. Mostly, these waters are unsafe for consumption due to contamination by fecal matters as well as by their heavy use. water from polluted sources is carried over long distances

For farmers, unable to control upstream activities, the ease with which contaminant enter surface waters present too many hazards, and the expense of installing and maintaining treatment systems often limit the use of surface water for domestic use. A major exception are springs, are discussed below.

Surface Water for Irrigation

In Virginia, most irrigation systems use untreated surface water or groundwater.
Surface water runoff from local watersheds can be collected, stored in a pond, and used for irrigation during periods of lower than normal precipitation and for critical growth periods. In Virginia, about 2 acres of watershed tributary provide approximately 1 acre-foot of water annually. (An acre-foot is the volume that would cover 1 acre to a depth of 1 foot.) Much of this water (about 40 to 60 percent) is lost to seepage through the pond bottom and to evaporation on the pond surface. Therefore, you will need about 4 acres of watershed to supply 1 acre-foot of irrigation water per year.

If the area to be irrigated is located near a stream fed by a large

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watershed, it may be possible to draw water from the stream without building a storage pond. Water withdrawn from streams usually is free when used for irrigation.

Costs associated with using surface water for irrigation are determined by the size of the pump and power plant required to lift the water from the source (stream or pond) to the field where the water will be used.

Location of Inlet Supplies

Be very aware of what is upstream from where surface water is drawn. Upstream areas that are heavily grazed or have animal access to the stream pose a higher risk of contamination that could affect your crop and when it is safe to market

Storm water flows, agricultural fields, and other uses such as fuel tanks, chemical injection systems, and areas that receive nutrient and pesticide applications should be downstream and more than 100 feet from any inlet for surface water.

Springs

Springs occur wherever ground water flows out from the earth's surface. Springs typically occur along hillsides, low-lying areas, or at the base of slopes. A spring is formed when natural pressure forces groundwater above the land surface. This can occur at a distinct point or over a large seepage area.

Springs are sometimes used as water supplies and can be a reliable and relatively inexpensive source of drinking water if they are developed and maintained properly.

Springs are highly susceptible to contamination since they are fed by shallow groundwater, which usually flows through the ground for only a short period of time and may interact with surface water. Special precautions are needed for domestic use, but springs can be safely used for watering most animals. If an adequate flow rate is available, springs can be used for animal watering on demand. If, however, the flow rate is low, then storage capacity must be provided.

Domestic Use

- When considering using a spring as your source of drinking water, it is important to ensure that the rate of flow is reliable during all

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seasons of the year. Spring flow that fluctuates greatly throughout the year is an indication that the source is unreliable or may have the potential for contamination. It may be possible to learn about historical spring flow from the previous owner or a neighbor. Springs used for drinking water supplies should yield at least 2 gallons per minute throughout the entire year unless water storage is going to be used.

- Most springs will need some treatment before the water is considered a safe source of drinking water. Spring water should be analyzed at a local water testing laboratory to ensure that it can be efficiently and economically treated to make it safe for human consumption.
- Make sure the spring box is sealed to prevent contamination.

http://www.wellwater.bse.vt.edu/files/10TipsWellBrochure4-7-09.pdf

Rainwater Harvesting

Cisterns are essentially storage tanks that collect rainfall directly from a surface exposed to the atmosphere, such as a roof. They are primarily used in areas without springs, wells, or other suitable sources of drinking water or where excess impurities in other sources make treatment impractical.

Cisterns have four essential components

- A suitably sized storage tank to meet demand for the expected rainless interval
- The water collection surface with delivery to the collection system (usually a roof with gutters, preferably not asphalt)
- A roof cleaning device that diverts the first several minutes of rainwater away from the collection tank, thereby cleaning the collection surface and reducing potential contaminants entering the tank
- A screen and filter system at the tank inlet to capture contaminants before they enter the tank.

Location of the cistern:

- As close to the house or place of water use as possible
- If located above ground, water is subject to freezing during winter, and warming during summer
- The tank entrance must be protected from surface water flows, and upslope and at least 50 feet from vault privies, animal stables, septic tank absorption lines

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- There should be no trees in proximity to the roof in order to reduce debris and associated organics.
- Bacterial Pollution
- Bacterial contamination may be found in any cistern water. Cisterns should be tested for coliform bacteria, which can indicate the possible presence of pathogenic bacteria.
- Maintenance should include a regular cleaning and disinfection of the system.

Instead of a large storage system, rain barrels located at gutter downspouts can also be used as temporary storage tanks for small scale irrigation.

More Information Rainwater Harvesting

- Young, E. S. Jr., W.E. Sharpe. Rainwater Cisterns. Design, construction, and water treatment. Penn State Cooperative Extension. Special circular 277. Available at http://www.wellwater.bse.vt.edu/files/RainCisterns.PDF . Accessed July, 2013.
- Virginia Rainwater Harvesting Manual Cabell Brand Center. http://www.cabellbrandcenter.org/Downloads/RWH_Manual2009.pdf
- VDH. 2011. Virginia Rainwater Harvesting and Use Guidelines. http://www.vdh.state.va.us/EnvironmentalHealth/ONSITE/gmp/documents/2011/pdf/GMP_154.pdf

Water and Animals

Water is a critical nutrient for livestock and poultry. An adequate and safe water supply is essential to the production of healthy livestock and poultry.

You can get by without a nearby water supply, but if your barn is any distance from your house, you'll find that hauling water and equipment back and forth is a lot of work.
Some people are fortunate enough to have a creek or a pond that goats can use for a water supply. Both are convenient but have the disadvantage of being more liable to become contaminated from urine, feces, and debris or from becoming stagnant.

If you plan to use either of these sources, get the water tested first to determine whether it's safe for drinking

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- Animals can live for many days or a few weeks without food but will die within a few days without water. Water needs to be fresh, clean, and plentiful to ensure maximum intake and good growth. Limitations in water intake depress animal performance more quickly than any other nutrient deficiency.
- Close. Ideally pastures should be divided into paddocks with a waterer in every paddock. If the water is some distance from the pasture, or if it is located in the shade, the herd will tend to congregate around the water source and not return to the pasture and grazing. A water source should not be more than 500 feet from the nearest corner of the pasture.
- Season proof. Water supplies must be available whenever animals are present, regardless of the season.
- Animals seem to perform best when water temperature is between 40 and 70 ° F are best, but will readily consume water up to 90 ° F.
- Adequate supplies must be maintained when temperatures drop below freezing. Insulated waterers with heaters will be needed.
- Surface water supplies to which livestock have ready access are always potential candidates for contamination, creating problems for downstream users, and potentially for the health of the herd.
- Acceptable Quality. It is important that livestock are provided with adequate amounts of quality water, free of contamination. Contaminated water can contain disease-causing organisms which can rapidly spread if animals are drinking from the same trough.
- The primary concerns are with high pH and alkalinity (rare in Virginia), blue-green algae in stagnant water, which can produce toxins that can poison livestock, and coliform bacteria which may indicate the presence of pathogenic organisms.
- A high level of suspended solids and an objectionable taste, odor or color in water can cause animals to drink less than they should.
- Desired and problematic levels of selected water quality contaminants are shown in Table 4.
- Leptospirosis and Fusobacterium are two bacterial contaminants that often use water and mud, respectively, as modes of transportation from animal to animal.
    - Leptospirosis is spread through urine of carrier animals.
    - Fusobacterium, an infection is more commonly known as "foot-rot", is a soil-borne organism found virtually throughout the United States. It is carried on the feet of

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animals, and transmitted to any body of water they enter. The bacteria then enter through cuts, bruises, or puncture wounds on damaged feet of other animals.

Table 4. Desired and problematic levels of contaminants in water for livestock. From Pfost and Fulhage, 2001.

Substance	Desired range	Problem range
Total bacteria/100 ml	<200	>1,000,000
Fecal coliform/100 ml	<1	>1 for young animals >10 for older animals
Fecal strep/100 ml	<1	>3 for young animals >30 for older animals
pH	6.8–7.5	<5.5 or >8.5
Dissolved solids, mg/L	<500	>3,000
Total alkalinity, mg/L	<400	>5,000
Sulfate, mg/L	<250	>2,000
Phosphate, mg/L	<1	not established
Turbidity, Jackson units	<30	not established

Note: 1 milligram per liter (mg/L) is approximately equal to 1 part per million (ppm).

Water Amounts Required by Animals

Water requirements for various animals are given in Table 4. A good rule of thumb for cattle is that they require 1.5 gallon each day for every 100 pounds of body weight. The water demand by animals (as well as animal cooling and cleaning operations) should be considered as you balance water supply and animal numbers.

Table 5. Livestock water consumption for various animals.

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Livestock	Avg. Consumption (gal/day)	Hot Weather (gal/day)
Milking cow	20-25	25-40
Dry cow	10-15	20-25
Calves	4-5	9-10
Beef	8-12	20-25
Sheep	2-3	3-4
Horse	8-12	

Laurie Marsh. 2009. Pumping Water from Remote Locations for Livestock Watering. Virginia Cooperative Extension Service Publication Number 442-755.

Irrigation

In Table 2 [Precipitation and its Distribution], we saw that average annual precipitation for several sites in Virginia ranges from 34.72 to 51.75 (average 42.7) inches each year and evapotranspiration (ET) ranges from 28.53 to 32.09 inches per year. Net water balance (PPT-ET) ranged from 5.58 to 23.22 inches per year. In every case, there is more water in than the losses from the surface. This look pretty good until we look a little deeper.

We also need to remember that not all the precipitation enter the soil. For fields planted to crops, runoff averages less than 0.5 to 3.0 inches per year. If we assume the worst, even for the site with a water balance of 5.58 inches, runoff of 3.0 inches would still result in a net positive water balance for the year (5.58-3.0 = 2.28 inches). Based on these simple calculations, a farmer might expect all the crop needs should be met by expected rains each year. The story is actually much more complicated.

Much of the rain falls at a time when no crops are present in the field (late fall, winter, and early spring). The amounts that fall during this time period exceed the capacity of our soils to retain the water. As a result, at least 8 to 10 inches (and up to 23 inches) of precipitation moves through the soil and into the groundwater annually. This water is not available for plant uptake during periods of monthly water deficit.

Realistically, we also know that average rainfall does not take into account the year to year or even the within month variability. Variations in rainfall pattern from year to year, and within months can result in severe water deficits, particularly in those locations in which ET exceeds precipitation for three or more consecutive months. Soil supplies are intensively tapped during these periods, and many soils simply do not have the storage to supply crop demands for extended periods.

Even so, precipitation is usually sufficient for growing many agronomic and some horticultural crops in Virginia without irrigation. The numbers make it very clear however, that crops will frequently benefit from supplemental irrigation in many Virginia locations.

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Review

Table 2 in Module 1.1 Precipitation and its Distribution

Resources

Stephen Boyles. Livestock and water. Ohio State University, http://beef.osu.edu/library/water.html

Laurie Marsh. 2009. Pumping Water from Remote Locations for Livestock Watering. Virginia Cooperative Extension Service Publication Number 442-755.

Donald L. Pfost and Charles D. Fulhage, 2001. Water Quality for Livestock Drinking. Mo, Coop Extension. Publication EQ381

Uneven precipitation during the season can cause plant stress during critical growth periods, which will affect both crop productivity and produce quality. Most horticultural crops require irrigation to minimize plant stress. Proper timing of water applications during appropriate periods can increase the yield and quality of most horticultural crops in Virginia in most years. Most, although not all, high-value crops require irrigation. Nurseries are heavy users of irrigation, as are vegetable operations.

So how much water might be needed? The irrigation water source must be large enough to provide sufficient water when it is needed. Because irrigation is not totally efficient, the water supply rate must exceed the rate of crop use. During very dry years, crops like corn (other even more) will consume nearly two inches of water per acre per week during the critical demand periods. If there is no rain, irrigation would need to supply this amount just to keep the soil water content from dropping. Since irrigation methods are not 100% efficient, the amount of water required each week to maintain soil water content could be as little as 2.11 inches for drip irrigation (95% efficient), or in excess of 4.0 inches (50% efficient) for sprinkler irrigation. Adding one inch of precipitation to one acre of land requires 27,154 gallons of water (0r 62.3 gallons per 100 square feet).

Because stream flow and shallow groundwater sources are strongly influenced by weather, they might not provide enough water during the dry part of the year, when irrigation is needed most.

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See Module 3 Sustainable Farming Practices: Soil Management, Unit 2 for more information on irrigation management

Laws Affecting Agricultural Water Use in Virginia

Permits

In Virginia, property owners with land adjacent to a river or lake (riparian landowners) are entitled to withdraw water from the water body so long as the withdrawal does not unreasonably affect the usage of other riparian land owners. The Virginia Water Protection permit program currently regulates withdrawals from wetlands, stream channels, lakes, springs, and ponds. Currently, agricultural withdrawals from non-tidal waters that total less than one million gallons in a single month are exempt from permitting requirements.

Rights to ground water allow for unlimited use without a permit so long as the use is not wasteful and is in a manner consistent with the use of the land lying above the water. However, a permit is required for any person or entity wishing to withdraw 300,000 gallons per month or more in a declared ground water management area must obtain a permit. There are two declared ground water management areas in the state. The Eastern Virginia Ground Water Management Area comprises an area east of Interstate 95

and south of the Mattaponi and York rivers. The Eastern Shore Ground Water Management Area includes Accomack and Northampton counties.

Reporting

Although permits may not be required, the Virginia Water Withdrawal Regulation requires reporting of both surface and ground water for agricultural uses if they exceed the following thresholds:

- Any withdrawal (ground or surface water) with a daily average withdrawal during any single month exceeding 10,000 gallons per day, with the exception of crop irrigation. Reportable withdrawals include, but are not limited to, those for public water supply, manufacturing, mining, commercial, institutional, livestock watering, golf courses, artificial fish culture, and steam-electric power generation uses.
- Crop irrigation withdrawals exceeding one million gallons in any single month. Crop irrigators need not report withdrawals from ponds collecting diffuse surface water unless the ponds are dug ponds that intercept the ground water table. Water users exempted from the regulation are encouraged to report their water withdrawals voluntarily

Waste Water Treatment Systems

Unless you are connected to a sewer system, you will likely have a on-site septic treatment system for your domestic waste water. If there is an existing system, you need to verify it is functioning correctly and that it has been properly maintained. If there is no existing system, or if the old system must be replaced, Virginia requires that the site be approved by the Department of Health or a state certified on-site evaluator. Finding an appropriate site for a traditional on-site treatment system can be complicated, and is not guaranteed. A new traditional systems can be expensive, but a custom designed alternative system will be even more.

Separate waste water treatment systems may be required for agricultural operations involving liquid and slurry forms of manure or other processing by-products.

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For more information, contact the DEQ Office of Water Supply. http://www.deq.state.va.us/Programs/Water.aspx

Withdrawing surface water in Virginia http://www.deq.virginia.gov/Portals/0/DEQ/Water/WaterSupplyPlanning/VWP_VWUDS_handout_2013.pdf

Resources

Virginia Household Water Quality Program. http://www.wellwater.bse.vt.edu/

Penn State Agricultural Alternatives http://agalternatives.aers.psu.edu

DEQ Website - Regulations http://www.deq.state.va.us/Programs/Water.aspx

1.4 Infrastructure and Other Resources

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Whether you live on a small farm on the edge of a large city or in a rural area, to be successful you will need access to markets, processing facilities, input suppliers, agricultural service providers, and the information required by your operations.

While you have already completed several worksheets on goals, personal skills, and resources, as we focus on place, it is helpful to consider how the physical location may also affect your farming operation and the implementation of your plan.

Farm House

While this is obvious, you will need a place to live. If you will live on the farm, the farm house should suit your needs both practically and aesthetically.

Some key considerations:

Location

- Commuting time and distance: it is very likely that someone will be working off the farm.
- The distance to markets, input suppliers, service providers, tools, parts and repair shops should also not be ignored. There may be a good reason that nice piece of land is priced much lower than expected.
- Amenities: school systems, churches, entertainment, restaurants, etc.

State of Repair

- The house will generally be a substantial part of any purchase (new or existing). Treat it as you would any real estate purchase and do your homework. It is difficult enough to start a farming operation. To do so and assume the burden of a home in need of repair can easily prove too much.

Utilities

What utilities are available that you must rely on? This may have a big impact what you can do in terms of getting the farm up and running, maintaining daily operations, and capacity for on-farm processing.

- Electricity:
  - Are electrical lines in place already?
  - How dependable is the supply?

- Will backup generators be required?
- Are existing electrical circuits adequate to supply power for critical operations?

- Water:
  - Is a city or county water supply available
- Gas:
  - If you need gas for cooking, drying or processing, is natural gas available or will you need propane tanks?
- Waste disposal:
  - How will you handle processing water and wastes?
  - How far will you need to go to dispose of materials that cannot be recycled?
  - Are there limits on types and amounts of material that can be disposed of?
- Cell phone coverage
  - There are still parts of Virginia with poor cell phone coverage, especially from the major providers. Farmers heavily engaged in marketing and managing multiple enterprises find cell phones an essential part of doing business. Is there adequate cell phone coverage in your location?
- Internet service
  - Many parts of the state still do not have access to high speed internet service through DSL or cable. Is high speed internet service available at your location?
- Alternative transportation
  - Will you (and your family) be totally reliant on personal vehicles, or are there alternative transportation options such as busses?

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Woodlot

If you intend to cut firewood to supplement your income, or as a renewable energy source for you home, hoophouse, or workshop, a woodlot or source of wood is critical. Woodlots serve as a source of biodiversity, and refuge as well.

Roads and Markets

- Distance from markets or from potential customer base if marketing directly from the farm
  -
  -

Market Opportunities

Farming depends on numerous types of community support.

- If you intend to market directly from the farm, what distance will customers routinely travel, and are you within that range?
- Not only the distance, but the quality of the roads could affect customers' willingness to venture out to your farm.
  - Is the access to the farm convenient?
  - Is the approach to the farm paved or graveled?
  - Can access roads safely accommodate two vehicles?
  - Is there an adequate and safe parking area

If you will not be selling direct from the farm you will need to take products to customers, or rely on other channels.

How far is this place from:

- Processing and slaughter facilities?
- direct market outlets (farmers markets, restaurants, individual consumers)?
- Aggregators, Coops, or Distributors receiving products at wholesale prices?
- Buying points for grains and other commodities?
- Auction sales for animals?

How else is selling this product, and where are they located?

Farm Buildings, Storage, and Work Space

Not all of the items below apply to every farm, but be aware that many do. Does the farm you envision require these facilities, and are they already in place? If not you need to include them as you develop your plan and your farm.

- Farm shop with tools for construction, making repairs
- Office space
- Space for hand tools
- Equipment and Supply storage (see below)
- Mixing and loading area for large capacity (tractor-borne) sprayers to protect soil, ground, and surface water quality (Reference needed)

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Resource

Seavey, D. and J. Porter. 2009. Housing and Space Guidelines for Livestock Univ. New Hampshire Coop. Extension. Rep. 493. http://extension.unh.edu/resources/files/Resource000471_Rep493.pdf

- Animal housing: chicken house, milking parlors, birthing facilities, etc.
- Storage area for hay (barn, staging area, left in field (wrapped or unwrapped)
- Sanitary facilities for workers (toilets, hand-washing, and cleanup)
- Greenhouse(s), cold frames, hoop houses
- On-farm Marketing Facilities
- Library: for seed catalogs, weed and pest manuals for ID and management, etc. (Often rotate through the cab of the pickup truck)
- storage for equipment, livestock, feed, fertilizer, fuel, and crops.
- What types of buildings will be needed for the agricultural enterprise you are considering?
- Will I have livestock that need housing? Remember, livestock facilities need to be correctly sized.
- Will I need storage facilities for livestock feed, equipment or for product that I will produce?
- Will I need a barn, greenhouse, washing/grading/packing shed for vegetable and fruit production? Is refrigeration needed, or will I need specialized facilities for processing?
- Inventory existing buildings such as barns, outbuildings, sheds and houses. Are these in good repair? Are they adequately sized for your enterprise?

Teaching & Learning Tools

Post harvest Handling and Storage

Will you need facilities for washing, packing, or storing your products prior to marketing them?

- Post Harvest Processing, Packing
- Post Harvest Storage: refrigeration, for milk, eggs, other value-added products
- Bulk Storage: facilities for grains, silage, hay

Equipment and Tools

While you may purchase an existing farm with some equipment, generally you will purchasing your own equipment and tools. Make sure you have your needs in mind, and that you can provide space for storage and protection of equipment and tools

Equipment

- Tractors, tillers, other traction
- Tillage and Cultivation Implements
- Planters
- Transplanters
- Harvesters and combines
- Irrigation materials
- Manure and fertilizer spreaders
- Sprayers: pump backpack, or tractor-mounted
- Feed mill (if using home grown grains for livestock)
- irrigation equipment (e.g., pumps, pipes, drip lines, sprinklers)
- Hay equipment: , mowers, tedders, crimpers, wheel rakes, balers
- livestock handling & watering equipment;
- harvesting equipment (e.g., knives, baskets/crates);
- post-harvest handling equipment (e.g., hoses, washtubs, knives, scrub brushes, cooling equipment, packaging supplies, storage);
- Lifting equipment (e.g., hand truck, forklift, pallet jack);
- Transport Vehicles: Trucks, trailers, wagons, carts, wheelbarrows
- Coolers/freezer lockers

Tools

- Hand tools/shop tools & supplies:
- hoes, rakes, spading forks, shovels, clippers, post-hole digger;
- wrenches, pliers, grease gun, tape measure, hammers, saws, nails, nuts and bolts
- bench grinder, air compressor, jacks
- General farm supplies & materials
- seed, fertilizer, other inputs
- stakes, trellises
- veterinary supplies,
- Max/min thermometer
- rain gauge
- Pest traps

Teaching & Learning Tools

Keep the list, shorten, or delete?

Fencing

On most farms, fencing is expensive and is there to serve a functional purpose. Fencing may be required to keep animals in, to manage grazing, or to protect your farm plant and animal products (including household

landscaping and pets) from herbivores such as deer, rabbits, raccoons, and other hungry wildlife or from predators such as coyotes and foxes.

Teaching & Learning Tools

- To prevent livestock crossing property lines
- To protect livestock from predators
- To exclude deer (and other damaging wildlife) from high value horticultural and ornamental crops. Do not underestimate the damage deer can to a high value crops. In some cases, it will be essential to have deer fencing in place to ensure a harvest.

Fences, may also serve as a visual and often decorative barrier between your property and the that of your neighbors, especially in the areas around the home.

The type of fence needed is determined by the type of farming you will do, and your budget. Once again, if you need a high quality fence and it does not exist on the farm already, this should be considered in your economic plans,

You should also be aware of the legal and economic ramifications of a fence along property lines shared with your neighbors.

Type of Fencing

Depending on the type of animals you (or your neighbors) raise, a sufficient perimeter fence to protect your animals or to prevent livestock movement across property lines will be essential. Fencing within the property boundaries will be needed to provide further protect livestock, and improve management, and could be moveable.

The type of fencing required will depend on the animals and predators present. Fences can be either permanent, as at property boundaries, or moveable, as in rotation grazing situations. In some cases, state or federal programs offer financial assistance for fencing that will improve water quality on your farm.

Essentially, goats and pigs require substantial fences. Sheep and cattle can be contained more easily with barbed wire or simple electrified fences. Predators can be excluded with woven wire or electrified fences, but often guard animals (dogs, donkeys, and llamas) as used to provide further

security. Chickens should be protected with chicken wire or other barriers that will exclude mammals such as fox, raccoons, mink, and rats.

A wide variety of fencing materials and characteristics are available. These include:

Permanent

- Board Fences (Wood and Plastic)
- Woven wire
- Barbed wire
- High tensile

Moveable - Electric fencing

- T Posts
- Step in posts
- Wired and solar electric sources

The Fence Law in Virginia

If you intend to raise animals, or if you live next to a farm that does, fencing may be required to limit damage (and legal liability) associated with livestock moving across property lines. Virginia counties treat liability for livestock damage from adjacent property in two different ways. In a "Fence-Out' county a landowner that wishes to protect against livestock encroaching on the property must build a fence sufficient to keep livestock out. In "Fence-In" counties, a landowner that keeps livestock is obligated to restrain the movements of his livestock by erecting a fence sufficient to prevent them from leaving the property. In either case, a livestock owner who knowingly permits livestock to enter a public road is very likely to be found negligent should the animals cause an accident, regardless of whether the locality is "Fence-In" or "Fence-Out."

If such a division fence is erected (or is in need of repair) between two properties under different ownership, and both owners keep livestock, one owner may require the other to erect, repair, or pay half the costs of the fence separating their properties. A recent revision of this requirement removed the burden of cost sharing from an adjacent landowner who "chooses to let his land lie open".

Fencing can be a complicated issue, and in some cases, can be a joint responsibility between you and your neighbors. We provide this information to make you aware of the law, but you should seek legal advice regarding your particular situation.

Teaching & Learning Tools

For more information see the following publication:

VCE Publication 442-131. 2009. Fencing Materials For Livestock Systems.

http://www.pubs.ext.vt.edu/442/442-131/442-131.html

Read

Eberly, E. 2010. Legal Considerations for Building a Line Fence in Virginia. Farm Business Management Update December 2009 – January 2010. http://pubs.ext.vt.edu/news/fbmu/2009/12/article_4_pdf.pdf

Input Suppliers

While some inputs can be ordered and delivered by vendors, many cannot. You will also find that inputs and supplies will be needed that were not anticipated.

Some examples:

- Nutrients,
- lime,
- compost,
- seeds,
- bedding plants,
- rootstock,
- nursery stock,
- crop protection sprays (organic or synthetic otherwise)

Are there sources of these materials within a reasonable distance, or will you need to order materials for delivery from some distance away?

Labor

You will very likely need additional labor during peak work periods. While some jobs can be filled by students looking for summer jobs, planting and harvests often occur when schools are still in session.

- Is there a trained labor force in the area?
- Can you managed with unskilled labor, or will you need to hire labor from some distance away?

Farmer Friendly Communities

What information sources are available to you as a new farmer?

- Extension agents, University researchers?
- Farmer organizations?
- Nearby farmers?

How are taxes assessed in your county?

- Land use (based on the value of agricultural production)?
- Market Value?
    - This can make a big difference in your property taxes, especially if development moves into your area.

Teaching & Learning Tools

Are there regulations limiting land uses for agricultural purposes

How does the town or county deal with

- Off-site signs to attract and direct farm stand customers?
- Roadside stands or pick-your-own operations?
- Farm stands needing to sell produce purchased elsewhere? (If you have a crop failure, can you maintain your customer base otherwise?)
- agricultural structures in their building and safety codes?

Does your town or county

- have data on how much agriculture is in the area?
- consider agriculture in their planning documents?
- encourage conservation easements, discretionary easements, and purchase of farmland? to preserve its future use for agriculture?
- support agriculture in visible ways such as a county fair or agriculturally related festivals?
- have farmers serving on local land use planning or zoning Board?
- know where to go to get advice and assistance on farm questions?

Teaching & Learning Tools

Resources for Farm Infrastructure
Whole Farm Planning Module : Worksheets 7-10

Exploring The Small Farm Dream. New England Small Farm Institute.

New England Beginning Farmers Initiative
http://nebeginningfarmers.org/2012/04/03/3-infrastructure-considerations/

Unit 2: The Products

Teaching & Learning Tools

While further references are given, there is no attempt here to describe in detail the management aspects of each product. The goal is to gain enough information to look deeper, or to move on to another more suitable product.

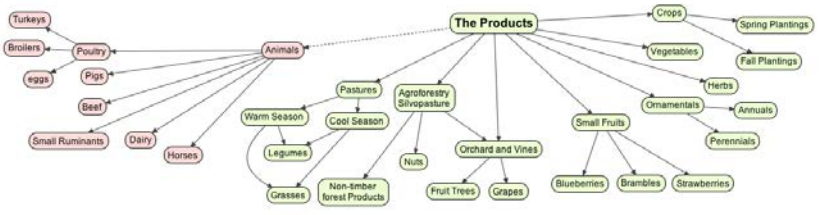
Choosing the products you will produce on your farm is *not* a linear process. You must align your goals, skills, and passions; market demand; and your available climate, soil, climate, and infrastructure. These things are all interconnected, and interdependent. So you will feel at times like you're going in circles.

This section is to help you gather information about potential products, and give you a sense of their suitability and productivity in the place you have chosen, or if you have products in mind, it will help you look for the right place. Keep refining your ideas until you find some options that seem feasible.

There are about six basic types of farm operations:

- Field crops and forages
- Fruits
- Market gardens or truck farming
- Poultry and livestock for meat and eggs
- Dairy
- Diversified subsistence production (feeding the farm family rather than selling products)

Most farmers concentrate on one or two of these farm operations when raising products for sale. The diagram below describes categories of potential products commonly produced on farms in Virginia.



The next consideration is the range of possible products, given the unique requirements of the various products one could consider in Virginia climates and soils, etc.

While we cover a number of potential classes of products, this is only a general treatment, and does not necessarily mean that if a product has been left out that it cannot be grown in Virginia. Nor will we attempt to overwhelm with details on how to raise the various products. The goal is to assess the suitability and potential for success.

Several initial plans have been developed in earlier modules. Here is a place to test some of those ideas, and either modify the Products or the Place, or at least to recognize the obstacles standing in the way.

For example, mangos cannot are unsuitable for climatic reasons, blueberries are ill-suited for high pH soils, and certain types of winegrapes should not be grown above 2500 feet. On the other hand, the season is may be too short for direct seeding of some crops in the cooler part of the state, but by transplanting young plants into a black plastic mulch after danger of frost, these plants will mature and bear before freezing weather returns in the fall.

Teaching & Learning Tools

Resource
For a very comprehensive list of potential products, check out the Missouri Alternatives Center webpage. http://agebb.missouri.edu/mac/links/index.htm

2.1 Plant Products

Plant Groups Considered

Annuals

- Field Crops
- Forages
- Vegetables and Specialty Crops
- Fruit Trees
- Small Fruits
- Vines
-

2.11 Field Crops

Factors to Consider for All Field Crops

- Relatively low profit per acre compared to fruits and vegetables, so many more acres are needed to support farm livelihoods.
  - Tobacco and peanuts typically higher value
- Large size of the operation requires mechanization to reduce labor costs: Field crop farmers need to enjoy working with and maintaining farm equipment.
- On-farm storage may be essential to obtain best prices
- Because mechanization is required, slopes should be no greater than 15%, and generally less if soils are to be tilled prior to planting.
- In Virginia, these crops are generally rainfed, meaning little or no

supplemental irrigation is applied
  - Some irrigation capacity can be important for tobacco

Corn
- Adapted State-wide
- Planted near last killing frost day (plus or minus a week)
  - Germinate at 50, grows at 60, sensitive to high temp, 86
  - Does not perform as well on poorer soils as other grains
  - Well adapted for No-till
- Double Cropping: Can be planted after small grains until July 1, yields suffer
- Soils
  - pH to 5.8
  - Well drained to somewhat poorly drained statewide
- Cultivars
  - season length?
  - glyphosate tolerant and BT genes common
- Uses: grain or silage

Sorghum
- Adapted State-wide
- Planted one week later than corn
  - Recovers better than corn from high temperatures and drought
  - Yields abut 80 to 90% as well as adapted cultivars of corn, about the same nutrient requirements
  - Benefits from narrow row spacings
  - Well adapted for No-till
- Double Cropping: early and mid season cultivars planted after small grains
- Soils
  - pH to 5.8
  - Well drained to somewhat poorly drained statewide
- Cultivars: Cultivar or variants for forage and syrup making are also available.
- Uses: grain, hay, or silage
- Note: Small seed size can complicate harvest, transport, and drying for farmers used to larger corn grains.
-

- Soybean
- Adapted State-wide
- Planted two weeks later than corn
  - Legume: no nitrogen required
  - Benefits from narrow row spacings

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- Well adapted for No-till
- Double Cropping: can be planted after small grains
- Rotation: must be rotated with non-legume crops
- Pests: several nematodes
- Soils
  - pH to 5.8
  - Well drained to somewhat poorly drained statewide
- Cultivars
  - Extremely sensitive to day length
    - short days: maturity groups 3 and 4:
    - Long days: maturity groups 5 and 6
  - Glyphosate tolerant and Bt-containing cultivars dominate commercial plantings, but none GMO varieties are still available, and are actively being bred at Virginia Tech.
- Uses: grain, hay, or silage

Tobacco

- Planting and cultivation
  - Tobacco is typically transplanted after soils begin to warm.
  - Wide spacings between plants: 48 in rows, 24 between plants in the row
  - Some beneft from cultivation before canopy begins to close in the row.
- Four types: Burley, Dark-fired, Flue-Cured, Sun-Cured
  - Adapted State-wide, but soils, management, harvesting, and processing differ
- Soils:
  - Well drained soils with pH 5.5 to 6.0 (to reduce disease)
  - Burley : silt loams, highest N rates (Piedmont, Mountains)
  - Dark-fired: loams and silt loams (Piedmont)
  - Flue cured: sandy loam surface, lowest N rates (Coastal Plain, Piedmont)
  - Sun cured: well drained loams and silt loams (Piedmont)
- Double Cropping: Not applicable.
- Harvest: Flue cured can last 8 to 12 weeks.
  - Others involve whole stalk harvest and curing in late August
- Rotations: critically important for pest and disease regulation
- Specialized Curing facilities, practices
- Marketing contracts essential

Cotton

- Adaptation: Limited to eastern shore and southeastern Virginia
- Plant after soil warms (above 65 degrees F)
-

Teaching & Learning Tools

- Well adapted for No-till
- Double Cropping: Not applicable
- Soils
  - Well drained sandy loams and loams mostly, does well on finer textured soils with good internal drainage
  - pH to 5.8 to 6.2
- Cultivars
  - glyphosate tolerant and BT genes common
- Uses: fiber, seed for oil, animal feed, fertilizer

Peanut

- Adaptation: east of the mountains, but low yields and quality on clayey soils
- Plant after soil warms (above 65 degrees F)
- Unique features:
  - Several market types: Large seeded Virginia, Runner, Valencia, and Spanish; distinguished by size, flavor, maturity
  - Legume, No nitrogen required
  - Flower on the stem, fertilized "peg" bearing ovaries elongates into the soil, and seed forms underground
  - Very high calcium demand, for large seeded peanuts, supplemental applications of gypsum (calcium sulfate) are required.
- Double Cropping: Not applicable
- Soils
  - pH to 5.8 to 6.5
  - Well drained, light sandy soils produce best.
- Uses: human consumption, (roasted, roasted or boiled in shell), animal feed, oil, hay
- Cotton and Peanut should be planted after soils warm to 60 or 65 degrees F
-

Small grains (Wheat, Barley, Rye)

- Adaptation: Statewide
  - Winter oats not recommended west of the Blue Ridge
- Planting date around the time of First killing frost in the fall.
  - Rye is most winter hardy, and tolerates lower pH, poorly drained soils better than other small grains,
  - Oats: winter oats require vernalization (chilling hours) to initiate heading; can be rotated with wheat or barley since it does not share diseases
  -

Teaching & Learning Tools

- Plant in narrow rows (6-8") or solid seeded to improve competitive advantage
- Harvested in late May to early June.
  - Can be double cropped by planting immediately after harvest with soybean, sorghum, or possibly corn
  - Barley matures 1 to 2 week earlier than others, giving a double crop advantage, but wheat has a market advantage.
- Since these crops grow primarily in the winter and spring, and there is less frequency of drought during their prime growing season, they tend to perform better on droughty soils (low available water holding capacity) than do summer crops grown on the same soils.
- Under no-till conditions, lower yields often occur during the initial years of no-till adoption.
- Straw crop can be important in some areas.
- Soils: Any moderately well drained or well drained soil
  - rye tolerate acid or poorly drained soils better than wheat or barley does.
  - Oats, Wheat, Rye: Soil pH 5.8 to 6.
  - Barley: 6.0 to 6.5 (very sensitive to low pH)
  - Rye better on poor soils than w, o, b
- Uses: Grain, grazing, silage, cover crops

Oats

- Adaptation:
  - Winter oats not recommended west of the Blue Ridge
  - Spring oats not recommended in eastern Virginia
- Planting date Fall or Mid-winter in around the time of First killing frost in the fall.
  - Winter oats: Fall or mid-winter (Feb 1 - Mar1) :
    - requires vernalization (chilling hours) to initiate heading;
  - Spring Oats: Mid-march
- Plant in narrow rows (6-8") or solid seeded to improve competitive advantage
- Can be rotated with wheat or barley since it does not share diseases
- Harvest: late June to mid-July for winter oats, July 1 to July 15 for Spring oats
- Double crop: Not applicable after July 1
- Straw crop can be important in some areas.
- Soils: Any moderately well drained or well drained soil
  - tolerates acid or poorly drained soils better than wheat or barley does.
  - Soil pH 5.8 to 6.
- Uses: Grain, hay, grazing, silage

Teaching & Learning Tools

Resources

Agronomy Handbook. Virginia Coop. Extension Publication 434-100 http://pubs.ext.vt.edu/424/424-100/424-100.html

Organic Grains Organic Grain Production Guide. North Carolina Cooperative Extension. http://www.cefs.ncsu.edu/resources/organicgrainfinal.pdf

2.12 Forages

Growth Patterns
Climate
Soil
Integration with animals

- A wide diversity of forage crops can be grown successfully throughout Virginia if species and management are tailored to match the soils and climate in that region of the state.
- In this section we will lay out the types of forage crops that are adapted for use in Virginia, how they are used, and the important factors that affect their suitability and productivity in various locations throughout the state

Types of Forages

A large number of forage species are adapted to Virginia, but none that produce forage in all seasons (see Figure 1.). Plant seasonality has advantages and disadvantages, and you will need to understand the limitations and benefits. Use of plants that produce in different seasons, as well as plants that provide different functions will help you provide nearly yearlong grazing.

This section describes the various categories of forages, and some specific soil adaptations.

NOTE: Johnsongrass is a non-native introduced species once used for forage production. It is now considered an invasive species, and classed as a NOXIOUS weed in Virginia. Its seed is a prohibited contaminant in commercial seed , and it is against the law to seed this plant in Virginia.

Teaching & Learning Tools

Read
For more information on use and management, please see the Agronomy Handbook entry http://pubs.ext.vt.edu/424/424-100/424-100.html

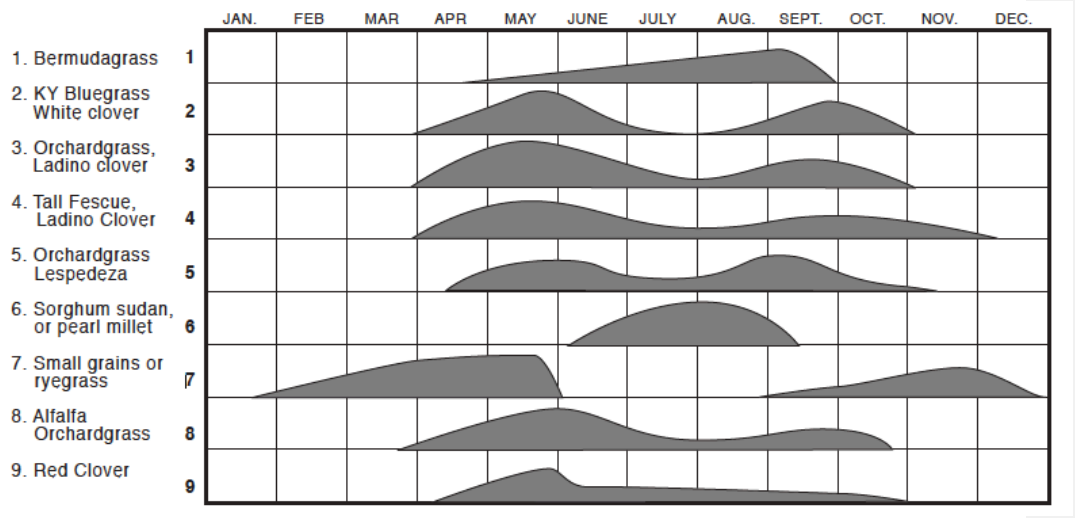

Figure 1. Seasonal growth of selected forages.

Legumes

In a mutually beneficial relationship with certain soil microorganisms, legumes obtain their nitrogen requirement from soil air, and require no supplemental N. Legumes are cool-season crops that include perennial, annual, or biennial species. Their protein content and digestibility make legumes important for feeding livestock. Legume are not as long-lived as grasses, and are less adapted to adverse management and environmental conditions. They are however more more tolerant of warm temperatures than tall fescue, and can contribute to the forage on offer during if they are present in the pasture mix.

Teaching & Learning Tools

Perennial Legumes

- Alfalfa
  - Deep, well drained soils, with sandy clay loam to clay subsoils.
  - Use grazing-tolerant varieties under continuous stocking, pH 6.8-7.0.
- Alsike Clover
  - Well-drained to somewhat poorly drained soils. More tolerant to a high water table and acid soils than other clovers, pH of 5.8-6.5.
- Birdsfoot Trefoil
  - Does best on well drained soil, but can be grown with impervious subsoils, pH of 5.8-6.5
- Hairy Vetch
  - Well drained to moderately well drained sandy loams to clay loams, pH of 6.0-6.5
- Sericea Lespedeza
  - Will grow on almost any well drained soil. Very tolerant of acid soil and low fertility.
- Red clover (often behaves as biennial, short lived)
  - Well drained to moderately well drained loams and silt loam soils properly limed and fertilized, pH 6.0 to 6.5.
- White Clover
  - Well drained and moderately well drained loams and silt loams, pH of 5.8-6.5
- Ladino White Clover
  - Well drained and moderately well drained loams and silt loams, pH 6.0-6.5.

Annual or Biennial Legumes

- Austrian Winter Pea
  - Well drained soils, pH 6.0-6.5.
- Crimson Clover
  - Well drained and moderately well drained soils; best suited to the Coastal Plain and Eastern Piedmont, pH 5.8-6.5.

- Sweet Clover
  - Well drained to moderately well drained soils, pH 6.0-6.5.
  -

Teaching & Learning Tools

Grasses

Cool-season grasses (C3 photosynthetic process) start growth early in the spring, go dormant in the summer as it gets hot and dry, then resume growth in the fall and early winter. Optimum growth occurs around 65 to 75° F and nitrogen fertilization is needed to promote growth. Cool season grasses require more moisture than warm-season plants. Both perennial and annual forms are adapted to Virginia conditions. Both produce seed in May or June.

Warm-season grasses (C4 photosynthetic process) start growth around the time of last frost in spring, grow rapidly in the summer, and go dormant in late fall as freezing temperatures occur. Warm season grasses are more competitive at higher summer temperatures, and require less water than cool season grasses. Nitrogen fertilization is required to promote growth. Late frosts can sometimes result in significant "winter kill" of warm season grasses at higher elevations. Both perennial and annual forms are adapted to Virginia conditions.

Teaching & Learning Tools

Perennial Cool-season Grasses

- Bluegrass 6.0-6.5
  - Best suited to fine-textured, well drained soils.
- Smooth Bromegrass not well adapted disease
  - 5.8–6.7
  - Well drained, fertile soils
- Tall Fescue
  - Adapted to practically all tillable soils. Tolerant to both dry and wet soils.
  - Tall fescue is the predominant forage species on over one million acres of hay and pastureland in Virginia and over 35 million acres across the USA.
  - It is a cool-season perennial grass that is well adapted to much of Virginia's soils and climate.
  - Tall fescue has many desirable agronomic and forage attributes. It is relatively easy to establish, forms a dense persistent sod once established, and is tolerant of a wide range of management regimes.
  - On some shallow, drought-prone soils and in certain regions, tall fescue is the most reliable perennial cool-season grass.
  - Tall fescue is superior to all other perennial cool-season grasses in its ability to be stockpiled for late fall and winter grazing.
  - Despite its positive agronomic traits, many Virginia producers are often disappointed with the performance of livestock grazing on tall fescue. Mid-summer performance of livestock grazing primarily tall fescue

- pasture is often inferior to that of animals grazing other grass or grass-legume pastures.
- Fescue toxicosis is sometimes referred to as "summer syndrome" and is evidenced by diverse symptoms including:

- Matua Prairie grass (rescuegrass)
  - Adapted to well drained, high fertility soils.
- Orchardgrass
  - Does best on well drained, loam soil. Adapted statewide.
- Reed canarygrass (tolerates wet soils)
  - Tolerates poorly drained soils. More drought tolerant than many other cool-season plants.
- Perennial rye
  - Like Italian rye. Poor persistence as a perennial.
- Timothy
  - Well drained to somewhat poorly drained, fine-textured soils.
  -

Annual Cool Season Grasses

- Annual Rye
  - Any well drained soil. Will do better on poor soils than wheat, oats, or barley.
- Annual Ryegrass (Italian rye)
  - Will grow well on most soils used for crops in Virginia.

Perennial Warm-season Grasses

- Bermudagrass
  - Greatest forage potential in the Southern Piedmont and Coastal Plain. Will grow on all types of soil, but is better suited to sandy and droughty soils than other grasses. Prefers well drained soils.
- Caucasian Bluestem
  - Adapted to wide range of soils. It performs better on the finer textured soils such as loams, clay loams, and silty loams but will also grow well on sandy loam soils. Cauca-sian bluestem does not do well on extremely sandy soils, and wetland soils.
- Eastern Gamagrass
  - Grows in fertile bottomland, swamps, and along stream banks.
- Switchgrass
  - 5.5-6.5
    Deep, well drained to moderately well drained soils.

Annual Warm-season Grasses

- Pearl Millet
  - Any well drained soil

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- Foxtail millet
  - Any well drained soil
- Forage sorghum
  - Well drained to somewhat poorly drained soils
- Sudangrass, sorghum-sudan hybrids
  - Well drained to somewhat poorly drained soils.
- Crabgrass
  - Crabgrass is best adapted to well-drained soils such as sands, sandy loams, loamy fine sand, loams, and silt loams that do not crack extensively. Crabgrass will produce on moist clay loams, but produces only moderately on clays, silts, and silty-clay loams. Optimum growth occurs at a slightly acid pH. In most cases a pH range of 6 to 6.5 should be targeted. It is best when used in rotation with a cool-season annual grass such as rye or annual ryegrass.

Teaching & Learning Tools

Uses of Forage Crops in Virginia

Hay

- Hay may come from fields dedicated to hay production or from grazed pastures producing more forage than cattle can consume.
- Hay may be from "pure" stands or any number of mixed species from either the warm season or cool season group. Since hay is cut and stored, season of maximum growth must work with other operations on the farm, but is not constrained by demand by animals.
  - Alfalfa is used as a high high quality hay for horses, diary, and pelleted feeds.
  - Bermudagrass and tall fescue are important in fields used for manure management.
  - Red clover, alfalfa, orchardgrass, and tall fescue are the most widely grown hay crops in Virginia. However, any forage plant that can be cut, dried, and stored can be utilized for hay.
- Since the entire crop is removed, nutrient inputs for hay fields are much greater for pastures in which grazing animals return nutrients in the form of urine and feces.

Silage

Most crops grown for livestock feed, including forages and grains, can be harvested, processed, and allowed to ferment in storage, for feeding as silage. This process improves palatability. Handling of the crop for silage should always favor proper fermentation.

Grazing

- Pastures are the backbone of Virginia's beef and sheep industries and are

of increasing importance to the dairy industry. The over 2 million acres of pasture in Virginia provide feed for grazing livestock with minimal requirements for labor and equipment. Pasture plants growing in areas inaccessible to machinery and equipment or on soils unsuitable for cropping serve as a feed for livestock in the production of meat and fiber for human use.

- In general, pastures are seeded to either cool-season or warm season species. Mixtures of warm and cool season species, are possible with very careful management, but generally result in one set of species as the dominant type.
- High quality pastures will consist of 25-40% clover. Significant improvement in animal performance is realized when clover is present in a grass-based stand of forage. Because of clover's ability to fix nitrogen into the soil, no supplemental nitrogen is required for grass-clover pastures with significant clover content.
- Inventory the forages currently available, in terms of both area and quality.
- Estimate the demand of you animals, paying special attention to peak demand times of young and lactating animals during the year.
    - An animal unit (AU) is usually defined as a 1000 lb cow and her calf, two 500 lb steers, or five ewes with lambs. Generally, one acre of excellent pasture is required to carry an AU through the grazing season, or 1.5 acres of good pasture per AU, or 3.0 acres of average pasture per AU, or 6.5 acres of poor pasture per AU. An animal unit month (AUM) is defined as the amount of pasture (400 lb total digestible nutrients) required to provide adequate grazing for an AU for one month.
- Year-round grazing should be an objective of most pasture-based livestock systems. Utilizing combinations of plant species which make their growth at different times of the year is key to successful year-round grazing programs (See Figure 1). Otherwise you will need to conserve and store hay or silage, provide feed grains, or reduce animal numbers.
    - Ideally the nutrient needs of the animals you wish to raise can be met by existing forages. Otherwise you plans will need to incorporate new plantings to improve the seasonal distribution.
        - It may be necessary to supplement cool-season pastures with summer grazing crops, such as Caucasian Bluestem, Switchgrass, sorghum-sudangrass hybrids, sudangrass, and pearl millet.
        - Winter annual crops such as rye, or a mixture of rye and barley, can provide additional late-fall and early-spring grazing.
        - Stockpiling : Winter grazing can be obtained by grazing or clipping **tall fescue** stands in August, fertilizing with 70-80 lbs nitrogen per acre, then permitting plant growth to

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accumulate through late fall. One acre of "stockpiled" growth can provide 120 days of winter grazing for a beef cow.

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Climate

Cool Season Adaptations

- Most Virginia forage programs are based on cool season perennials such as tall fescue, orchardgrass and bluegrass. These grasses are most productive at temperatures of 60--80 degreees F and production will decline at temperatures above 80 degrees, even when moisture is adequate. This depression gets worse if accompanied by low rain fall.
- Legumes emerge later in the spring, and begin contributing to the forage mix about a month later than cool season grasses.

Warm Season Adaptations

- Bermudgrass has its highest yield potential in the southern Piedmont and Coastal Plain. Can be damaged by late frosts in the spring.

Soils

slope; drainage class; available water capacity; frequency and duration of flooding and ponding; soil reaction, acidity and alkalinity as measured by pH; salinity; cation exchange capacity (CEC), and organic matter content, describing fertility; frost heaving potential; trafficability as characterized by the Unified Soil Classification; surface rock cover fragments; drainage class; shrink-swell; and depth to restrictive layers.

Other measurable soil properties that help define or modify other soil characteristics have an indirect effect on forage production and management. Soil texture is an example; it influences plant growth by affecting soil aeration, water intake rate, available water capacity, CEC, permeability, erodibility, trafficability and, in the case of surface stones, the amount of surface soil area upon which plants can grow. For forage suitability groups, texture is an important soil property, but not precise enough to be used alone for defining soil capability groups. This is because a soil textural class may have some good as well as some negative features, making it impossible to evaluate it properly; for example, a sandy loam may have great permeability and trafficability, but also low water holding capacity and native fertility.

Infrastructure

- Fencing
- Waterers
- Mowing Equipent
- Hay balers

- Tedders
- Rotary Rakes
- Storgage

Resources

Agronomy Handbook

Controlled Grazing of Virginia's Pastures
http://pubs.ext.vt.edu/418/418-012/418-012.html

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Resources
Agronomy Handbook
Controlled Grazing of Virginia's Pastures
http://pubs.ext.vt.edu/418/418-012/418-012.html

Vegetables

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Overview

A large number of vegetables are adapted to Virginia conditions. Because of the relatively high value of vegetables, farmers use Irrigation, intensive management, mechanization, liming and nutrient inputs to overcome all but the most difficult soil constraints. Climate does not eliminate production of many vegetables in most locations, but it does dictate when they can be planted, and harvest dates can vary significantly across the state.

This does not mean that every place has equal advantage. Large commercial plantings of vegetables occur primarily in the Coastal Plain region. In the rest of the state, plantings tend to be smaller, and often more diversified to appeal to market demands coming arising from direct marketing, regional farmer's markets, or vegetable aggregators/distributors.

A few key factors to consider up front:

- Rotation: You will need adequate growing space to rotate annual crops between different fields. Growing the same annual vegetable, or in most cases, the same family of vegetable in the same field year after year will result in an accumulation of pests, diseases and weeds that will challenge your goal of sustainability.
- Water: Vegetables are expensive to produce, and irrigation is the only way to ensure that you will recoup those costs in most situations. Only crops like asparagus that mature early in the season (before evapotranspiration begins to exceed precipitation) can be consistently grown without supplemental water.
- Don't plant vegetables on land with a history of heavy weed infestation, especially perennial weeds.

Production Systems

Two primary production systems are used for vegetable production in Virginia, with many variants and hybrids of each.

Traditional System

In the traditional system, vegetables are planted in open rows or shaped beds. This system may use conventional tillage methods for soil preparation, weed control and pest management, or more recently, no-till system have been developed. Irrigation is provided either via an overhead (sprinkler) system, or by laying drip irrigation tape or tubing on the soil surface or within the planting rows. Cost and management for

this system are lower than for the plasticulture system, but yields and quality may also be lower, and harvests are often later in the season.

Plasticulture System

Plasticulture combines raised planting beds containing a buried drip irrigation system with a covering of a plastic (sheet) mulch. Commercial systems generally fumigate the soil just prior to or after laying the plastic to help control soilborne diseases, weeds, and pests where rotations cannot effectively deal with these problems. The plastic serves as a barrier for weed invasion and growth, warms the soil allowing more rapid growth, reduces soil-vegetation contact, and reduces leaching of nutrients by heavy rains. The mulch also reduces evaporation from the soil surface. Although some rainfall enters the soil via stem flow, water for plant uptake is supplied primarily by the irrigation system. The irrigation system usually gives producers the capacity to fertigate (inject water soluble nutrients or emulsions into the irrigation water for delivery to the plant root system) for improved nutrient use efficiency. Costs and management for this system are significantly higher than the traditional system, but can greatly increase productivity and improve earliness of the harvest.

In many organic systems, the traditional system is modified to include use of plastic or other forms of mulch as an aid to weed control with or without the other components.

Some general assumptions

- You understand the market or will before planting
- You will have adequate water for irrigation and processing, including hydro-chilling if necessary

You are now ready to consider which vegetables will be suitable and productive for an place, or a hypothetical place that you are considering.

Let's take a quick overview of the types of vegetable products you might consider as you formulate a startup plan on which crops to grow.

Types of Vegetables

We cannot attempt to cover the unique requirements of all vegetables grown. Instead we will focus on the various types of vegetables grown and how "Place" affects your choices.

Extensive information on individual crops, weeds, diseases, and pests are available in the resources listed at the end of this section. The commercial vegetable guides contain exceptional information on a wide range management practices.

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Reference
For more information on plasticulture see: Sanders, D.C., W.P. Cook, and D. Granberry. 1996 Plasticulture for commercial vegetables. North Carolina Cooperative Extension. Publication Ag-489. http://www.ces.ncsu.edu/depts/hort/consumer/agpubs/ag-489.pdf

Perennials

- Perennial crops undergo an annual dormancy period that allows persistence from year to year. The critical factor in selection of cultivars is hardiness at the local minimum low temperature. Most hardy perennials in Virginia can tolerate temperatures of −10 degrees F or lower.
- The most common perennial vegetables in Virginia are asparagus, rhubarb, and some perennial herbs. Like perennial trees and small fruits, these vegetables break dormancy and emerge on their own time table and produce edible stems and leaves. As harvest removes, the plant reacts by producing more. Before plant productive reserves are exhausted, harvest is discontinued and the plants are allowed to complete the annual cycle of in order to build root reserves for the next year.

Cold Tolerant or Cool Season Annuals

- These vegetables are started by direct seeding or transplanted to the field each year, well before the last frost in the spring, sometimes as much as 60 days before.
- Many of these vegetables do not perform well in hot, humid conditions. Some will "bolt" or proceed to the reproductive phase, some will not properly pollinate, and others will produce lower quality harvests. For many cool season vegetables, pest and disease pressure limit productivity as temperature and humidity increase.
- A second crop of many cold tolerant crops can be placed in the field in mid to late summer. The crops will mature under the cool conditions of fall, and some may continue to produce for a few weeks after the first frost. Success of such plantings depends on water supply, disease and pest pressure, and local demand for the products.
- If season extending structures are available, and the local climate is favorable, some cool season crops can even be "overwintered" for late winter or early spring harvests.
- Cold tolerant vegetables include:
  - Allium Crops : Onions, garlic, leeks, shallots, scallions, and chives all belong to the genus Allium. The edible portion of the plant is the leaf in some species (e.g., scallions, chives, leeks), the bulb in others (e.g., onion, garlic), or both. Diseases and insects attack the root, leaf, or the bulb, reducing the yield and marketability of the crop or, if infested at the seedling stage, destroying it entirely. To a greater or lesser extent, all species in the genus generally suffer from the same pests and diseases.
  - Brassica vegetable plants belong to the mustard family, Brassicaceae (=Cruciferae). They are also called crucifers and cole crops. Edible plant parts are diverse and include roots of radish and turnips, stems of kohlrabi, leaves of cabbage and other leafy brassicas, flower heads of

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Reference
See USDA Hardiness zone map for Virginia. Suppliers of perennial vegetable cultivars often include this information

broccoli and cauliflower, and seeds of mustard and rape. Other members of this family include Brussels sprouts, collards, kale, and rutabaga. Many weed species are also in this family and can harbor insect and disease pests.

- Chenopods or Goosefoot family. Spinach, beets, and chard belong to the plant family Chenopodiaceae. There are very few crop plants in this family, but many weeds, including common lambsquarters and oak leaf goosefoot. Beets and chard are cool season crops that can tolerate frosts and light freezes. Spinach is even hardier and tolerates temperatures as low as 15o F. Beets and chard do well in both warm and cool weather, but spinach will bolt under the hot temperatures and long days of summer. There are some varieties of spinach that are somewhat bolt-resistant. While crops in this family are related, the most important diseases are very crop-specific.
- Lettuce: a member of the composite family, a large group that includes sunflowers, artichokes, endive, and chicory, as well as noxious weeds, such as thistles and ragweed. It is commonly grown as a salad crop for its edible leaves. There are three commonly grown types of lettuce: leaf, head, and romaine. All three are popular as baby greens and are used in salad mixes. Cultivated lettuce is closely related to wild lettuce, and both share the same insect pests and diseases.
- Peas: a member of the legume family, most of which are cold intolerant. Green peas can be planted before frost, and yields seeds in pods that are also edible before seeds fully mature.
- White potato: a cold tolerant member of the Solanaceae (most cold intolerant). Unlike other members of the family, the edible portion is the tuber, or underground storage tissue. Can be planted from tubers. Still shares some common pests and diseases with other family members.
- Carrots and parsnips are members of the Umbelliferae family. These are biennial root crops that have a distinctive, umbrella-like flower that is seen only in the second year. Roots are developed in the first year of production and can be harvested or allowed to stay in the ground until the following spring.
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Cold intolerant

- Assuming a 10% probability of temperature of 32 degrees F or less, data from the Southeastern Regional Climate Center indicates that the last killing frost in Virginia in spring ranges from around April 1 to June 5, and the first killing frost of fall ranges from September 12 to about November 19.
- Cold tolerant crops are direct seeded into the field or transplanted only after all danger of frost has past in the spring.
- Most have a long growing season, and allow production of only one crop a year.

In areas with long growing seasons (eastern Virginia) two cold intolerant crops can be produced, or a cold intolerant crop can follow an early season crop to take advantage of plasticulture already in place.

- Production of cold intolerant crops during periods with high probability of freezing temperatures will require season extending structures, and possibly supplemental heat and lighting.
- Many benefit from the use of black plastic mulch which warms the soil
- Cold Intolerant vegetables include:
  - Solanaceae includes several important vegetable crops, such as tomatoes, (potatoes - cold tolerant), eggplants, and peppers. These crops share a number of insect and disease pests, so any crop rotation plan should consider all crops grown from this family.
  - Cucurbitaceae is a large family composed of several major vegetable crops, including cucumber, muskmelon, watermelon, summer squash, winter squash, pumpkin, gourd, and bitter melon. A similar pest and disease complex affects these crops, though individual varieties differ in susceptibility to various pests.
  - Sweet corn is in the grass family (Graminaceae) with other cereal crops. It shares few diseases with other common vegetable crops, so it may be useful in crop rotations. Sweet corn shares pests with field and silage corn, so proximity to these crops is often a problem for sweet corn producers.
  - Legumes: Beans, field peas, and soybeans belong to the Fabaceae. The unifying characteristic of the family is that the fruit, often called a pod, has a single chamber and opens along two edges. Pods typically contain more than one seed. Plants are able to utilize nitrogen from the atmosphere through a symbiotic relationship with soil microbes.

Herbs

Many of our familiar herbs such as lavender, rosemary, thyme, bay laurel, marjoram, dill, and oregano — are originally from the Mediterranean region. These herbs require bright sunlight, excellent drainage, and moderate temperatures.
Otherwise :

- Choose a site that receives at least 6 hours of direct sun each day.
- Avoid soils with high water tables or poor internal drainage.

Cut Flowers - What to Grow?

The following have been recommended by Extension agents in Virginia.

- Perennials: Often yield best in 2nd year, and different species may have vernalization requirements. Proper spacing is important.

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Reference

The following publication lists over 50 annual, biennial and perennial herbs that can be grown in this region.

Evans, E. 1998. Growing Herbs For The Home Gardener. North Carolina Coop. Extension Service. Horticulture Information Leaflet 8110. http://www.ces.ncsu.edu/depts/hort/hil/pdf/hil-8110.pdf

- Lavender, Peony, Veronica, Phlox
- Cool-season Annuals: Well suited to coldframe production
- Larkspur, delphinium, Anemone, Iceland Poppies, Sweet william
- Woody plants:
- Flowers: butterfly bush, hydrangea, old-fashioned roses
- Berries: hollies, callicarpa
- Branches: pussywillow, corkscrew willow, coral bark dogwood
- Bulbs and tubers:
- Manage some as annuals:
- Gladiolus, dahlia and tulips
- Manage some as perennials
- Calla, tuberose, daffodil, crocosmia, lilies
- Annuals: easily grown with succession planting and can be started with direct seeding or plugs
- Sunflowers, Zinnia, Cosmos, Rudbeckia, Basil, Celosia

Climate

The key impact of climate is on planting dates, frost protection, and season ending freezes.

Although many management practices are used to mitigate the impacts of freezing temperatures (use of transplants, black plastic mulch, row covers, frost protecting irrigation, and hoop houses), nature still holds the upper hand.

The wide variety of plants suitable still give many options

- Specialized production of one or two long season crops with larger planting footprint but lower labor demand such melons or pumpkins
- Market favorites
  - Tomatoes
  - Sweet corn
- Highly diversified:
  - Cool season crops, followed by
  - Warm season crops (multiple plantings), followed by
  - Mid-summer plantings of cool season crops, and
  - Fall crops that carry over for several weeks or months
    - Greens
    - Cabbage
    - Leeks

Unlike small fruits and tree fruits which are perennials and essentially break dormancy as dictated by their genetics, there are only a few perennial vegetables. Growers are able to some extent, manipulate the growing season by direct seeding

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Resources

Cut Flower Production. Penn State Ag Alternatives http://extension.psu.edu/business/ag-alternatives/horticulture/cut-flower-production

For an interesting look at the options available in a Piedmont location (Chatham County, North Carolina), see the the Vegetable Planting Guide and Recommended Planting Dates

http://growingsmallfarms.ces.ncsu.edu/growingsmallfarms-plantingguide/

and transplanting. (Some of this is done in response to market demands more so than by seasonal constraints)

Soils

- Vegetables can be grown in most well-drained soils with good internal drainage, and adequate depth for rooting. Organic matter greatly improves almost any soil, and use of cover crops may be important.
- Since irrigation is almost assumed for most vegetable crops, water holding capacity has a lower priority than workability. In many areas, sands or loamy sands are preferred because they drain quickly, provide an aerated root zone, and enable timely tillage, planting, and harvesting soon after rains or irrigation without damaging structure. The single grain structure also is well adapted for bed shaping and insertion of drip irrigation supply lines.
- Loamy sand and sandy loam soils are generally better suited for growing early market crops.
- Loam and silt loam soils are generally better suited for growing crops for later fresh-market use or for processing.
- Deep, well-drained organic soils are ideal for leafy vegetables and bulb and root crops that offer a high return per acre.Primarily physical rather than chemical: no veggies that require low pH, and nutrients are taken care of with good management

Water

- All vegetables will benefit from irrigation at the right time. The expense of vegetable production warrants the extra expense of irrigation to ensure a crop will be produced
- A mandatory part of the system for plasticulture
- A few crops may receive adequate rainfall:
  - Less essential so for crops that mature very early when precipitation is well in excess of evapotranspiration. (Asparagus, etc).
  - Some vegetables with extensive root systems or advanticeous roots (melons will root at multiple nodes) may not require irrigation.
- Frost protection (less a factor with vegetables than fruits since season initiation can be controlled)
- Processing, cooling
- Good agricultural practices

Rotation

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Resources

Straw, A. Vegetable Planting Guide and Recommended Planting Dates. VCE Publication 426-331. http://pubs.ext.vt.edu/426/426-331/426-331_pdf.pdf

Jones, D. And D. Roos. Planting and Harvesting Guide for Piedmont Vegetables and Herbs. North Carolina Cooperative Extension. Chatham County. http://growingsmallfarms.ces.ncsu.edu/growingsmallfarms-plantingguide/

Rotation of vegetable crops is key in breaking the pest cycles that accompany intensive production.

Disease and nematodes are particularly devastating. By planting crops that do not harbor pests, numbers of spores and pests are reduced.

Some Key concepts
Do not follow crops with crops from the same family.

SEE MODULE 2: Sustainable Farming Practices: Farm Biodiversity

Bees for pollination

- Supplemental pollination by bees is desireable for:
  - cantaloupe, cucumber, pumpkin, squash, watermelon (pollination requirements of seedless varieties are generally greater than seeded)
- These vegetables will set fruit without bees, but bee activity has been shown to increase yields:
  - Eggplant, okra, lima bean, pepper
- Honeybees do not assist in the pollination of the following crops, but will collect pollen and/or nectar from them:
  - Pea, sweet corn, snap bean, tomato

Resources

2013 Commercial Vegetable Production Recommendations
Virginia Cooperative Extension Publication 456-420.
http://pubs.ext.vt.edu/456/456-420/456-420.html

Southern Extension Workers Vegetable Guide
Vegetable Pest Management Guide
http://www.thegrower.com/south-east-vegetable-guide/

Penn State Ag Alternatives
http://extension.psu.edu/business/ag-alternatives/horticulture

NC State Horticultural Extension Vegetable Website
http://cals.ncsu.edu/hort_sci/extension/HorticulturePublicationsVegetables.php

Teaching & Learning Tools

SEE MODULE 2: Sustainable Farming Practices: Farm Biodiversity

Small Fruit: Blueberries, Brambles, and Strawberries

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Factors to Consider for all

Small fruit crops are perennials and remain productive for varying lengths of time, from as little as one to two production years for plasticulture strawberries to up more than 50 years for blueberries. Planning and preparation before planting is critical, since mistakes at this stage will be an ongoing concern.

Climate

- Although adapted small fruits can be grown in all but the highest mountains of Virginia, climate and microclimate can affect:
  - the choice of production system, the cultivars selected,
  - the need for irrigation,
  - the need for frost protection, and
  - the susceptibility to diseases and pests.
- More information on these factors are included by plant type below.

Air Drainage

- Good air drainage Reduce the potential for frost damage by selecting sites with good air drainage. This is a serious problem with strawberries and, less frequently, with blueberries.
- Good air drainage promotes drying and lower humidity within the plant canopy, which in turn reduces the potential for foliar and fruit diseases.

Wind Exposure

- Protected sites should be selected, or protection should be provided by windbreaks
  - Winds can desiccate plantings, especially over the winter.
  - During flowering, pollination is aided by wind in small fruit, but in hot dry winds, flowers can be dessicated and unreceptive to pollen.
- In windy areas, straw covers (strawberries) or trellising (cane breakage of brambles) may be needed to provide protection.

Soils

- Gather data and begin preparation <u>at least</u> a year before planting.
- Berry crops generally perform best in sandy soils; however, a high organic matter content (minimum of 2 percent; 5 percent preferred) can do much for improving plant growth, even in a heavy clay soil.
- Soils must be well drained: small fruits are susceptible to a number of root rots.
  - where internal soil drainage is marginal, growing small fruit crops on raised beds can help excess water can drain away from the root zone.

- Tile drainage can improve drainage, but at a cost.
- Wet sites should be avoided.

- Strawberries and brambles - just about any soil meeting the above criteria that has been tested, well prepared, and amended before planting can be suitable. Some production systems such as plasticulture, are better suited to loamy or sandy soils.
- Blueberries have very specific soil chemical demands (specifically, a strongly acidic pH).

Availability of irrigation Water

- An ample water supply may be essential for sustainable small fruit production.
- Small fruits have relatively shallow root systems and affected by moisture stress during dry periods
- Overhead irrigation (not just drip) for frost protection with strawberries and often for blueberries is very desirable for consistent year-to-year production.

Surrounding Fields

- Nearby fields and forests provide habitat for species that are pests and pathogens for small fruit crops:
  - Woodlots and fencerows: strawberry clipper beetles
  - Various forages: plant bugs, spittlebugs, and leafhoppers
  - Sod: Japanese beetles
  - Various fruits and vegetables: sap beetles
  - Wild or abandoned small fruit crops: viruses and orange rust fungus
- Take measures to keep plantings as far from wild plants as possible.

Prior Crops and Their Impact

- Crops • The crops which precede a berry crop can make the difference between having a healthy planting and having a disaster. Certain crops can encourage a buildup of pathogens to which berry crops are susceptible. Other crops have beneficial effects.
- Be aware that annual field crops planted may have residual herbicide carryover the following year which can damage new berry plantings. Know what products were used on the previous crop prior to planting.
- Cover cropping with certain cover crops for 1 to 2 years before planting is also a good way to reduce pest and disease species at a given site.
- In most cases, small fruit crops can be successfully grown without fumigation. Fumigation is not routinely recommended in the Mid-Atlantic region when long crop rotations can be used for disease, insect, and weed management (see next topic).

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When sites previously planted to small fruits are replanted to fruit crops, there is

enhanced risk of nematodes and diseases.

- Nematodes: Plant-parasitic nematodes (microscopic eelworms that parasitize plant roots) feed on many species of plants. Among the most widespread and commonly troublesome of these are dagger and lesion nematodes.
  - These feed on
    - small fruit and tree fruit crops,
    - legumes such as clover, alfalfa, and vetch, and
    - weeds.
  - All sites with a history of growing these crops should be checked for potentially damaging populations of plant-parasitic nematodes 1 to 2 years before planting.
  - If high populations of plant-parasitic nematodes are found, special rotational crops (for dagger nematodes) or soil fumigation are usually required to reduce damaging populations well before planting.
- Diseases
  - Fields previously planted to tomato, potato, tobacco, eggplant, pepper, cucurbits, and some strawberry, black raspberry, and blackberry cultivars may have well-established populations of the verticillium wilt fungus.
  - Fields previously planted to strawberries may have high populations of the soilborne fungus Phytophthora fragaria, which causes red stele or other root-rotting diseases. Fields planted to other fruit may harbor other Phytophthora species.
  - Raspberries are particularly susceptible to crown gall disease. Sites with a history of crown gall are best used for other less-sensitive crops such as strawberries, blueberries, and vegetables.
- Insects
  - Heavy sod frequently harbors high populations of white grubs (large, fleshy, C-shaped larvae of June beetles and other species of beetles) that can severely damage small fruit root systems. If a sod-covered area must be used, plant corn or a small grain for at least 1 year.

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Strawberry

Climate

- Most growers in the cooler and mountainous areas of the region utilize matted-row field production, while plasticulture production is more common in warmer areas. Both ribbon-row production and high tunnel production are also used, but to a lesser extent.
- In general, there appears to be increased interest in day-neutral production as consumers become more accustomed to the availability of “off-season” strawberries.
- Slopes of 5-7% for air drainage are preferred
- Overhead irrigation for frost protection is essentially a requirement for consistent production

- For plasticulture - both drip irrigation (under the plastic) and over-head irrigation for bloom protection are required.

Soils

- Soil must have good internal drainage
- Black rot more common on soils with clayey textures, compacted soils
- Plasticulture is more common on sandier soils which are well suited for this system
  - But possible on any soil with high organic matter (2-6%) or a tilled in cover crop.

Blueberry

Most blueberries are moderately to highly self-fertile. However, most will benefit from cross pollination.

Climate and Location

- This information focuses on the highbush blueberry (V. corymbosum) since it is the most common commercially grown blueberry in the Mid-Atlantic.
- Blueberries generally tolerate minimum temperatures to -20°F (Plant hardiness zone 5a or higher), although some cultivars are more sensitive than others. All areas of Virginia except the highest mountains fall within the adapted is range.
- Most highbush cultivars require 750 to 800 hours of chilling below 45°F as a prerequisite for breaking dormancy. In the Virginia, this requirement is usually met no later than mid- February.
- Choosing a site that is free of frost, or being prepared to provide frost protection, is important. When blueberries are in full bloom, the flowers can be injured by temperatures slightly below freezing (28 F). The earliest flowering varieties are most susceptible to frost injury, so avoid planting these on frost-prone sites.

Soils

- Soil test and begin soil preparation one to two years before you plan to plant.
- The best soils for blueberries are sandy loams that are moist, porous, and acidic. Soil pH should be between 4.5 and 5.0.
  - Blueberries are native to southern New Jersey where they grew on sandy loam soils with shallow water tables, high organic matter, and a soil pH between 4.3 and 5.0.
- Few areas in the Mid-Atlantic region can support blueberries without a considerable amount of soil amending prior to planting.
  - Typically, pH is too HIGH, and organic matter is too low.
  - The entire planting area should be acidified, including the root zone. High pH in the row middles will make it difficult to maintain low pH in the rows. Surface applications of sulfur (or any acidifying materials) after planting

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are not very effective in lowering pH within the root zone.
  - Elemental sulfur is the most economical source, but lowering the soil pH takes time (months).
  - Additions of organic matter to improve soils can be done with cover crops, but also takes at least one growing season.
- Blueberries will grow in a wide range of soil types as long as they have good internal drainage. But the more clay present, the more difficult it will be to lower and maintain pH, and the more essential it will be to increase the organic matter content.
- Blueberries are shallow rooted plants. Whereas they tolerate some seasonally high water tables, the do not do well in saturated conditions, or in tight, compacted soils.
- Because they are shallow and finely rooted, irrigation is highly recommended, especially in areas with strong summer water deficits.

Organic matter

- Green manure crops grown for one or two years before planting are extremely valuable for new blueberry plantings, which require a high organic matter content (5 percent is preferred). Buckwheat is a good cover crop to precede blueberries because of its ability to tolerate a low soil pH.
- Heavy mulching is also recommended for blueberries, to maintain soil moisture, weed control, and resupply of organic matter.

Brambles

All variable, most brambles fruit on the growth from the previous year. In the second year, this primocane becomes a floricane and flowers, producing berries.

Climate and Location

- Once a plant begins to lose its dormancy after 1,200 hours of temperatures between 35 and 50 degrees F (usually in February in Virginia), it can be injured at much higher temperatures.
- Winter injury is frequently the result of fluctuating winter temperatures rather than absolute low temperatures. This fluctuation occurs more toward the late winter to early spring when solar radiation on clear days can raise the internal temperatures of the canes several degrees higher than ambient air temperatures. After sunset when air temperatures drop, the overheated canes can be severely stressed by the rapid change in temperature as well as by a very low temperature.
  - In locations where this type of injury is a problem, summer-fruiting cultivars should be planted on north-facing slopes, if possible, to minimize exposure to the heating effect of direct winter sunlight. South and

southwest-facing slopes are less-optimal locations.

- so choosing a site that is free of frost, or being prepared to provide frost protection, is important. When blueberries are in full bloom, the flowers can be injured by temperatures slightly below freezing (28 F).
- Bees:
  - In the past, abundant, widespread, feral honey bee and native wild bee populations most likely provided adequate pollination of wild and domestic brambles

Soils

- Brambles require full sun and well-drained soil—they never tolerate wet soils. Brambles will use water at the rate of pan evaporation or higher during fruit production (see Appendix E for additional sources of information), especially in high temperatures or winds. Suitable soil can only hold 7 to 14 days of moisture before serious water deficits occur, growth stops, and leaf desiccation or sunscalding occurs.
-

Other Considerations

- The planting site should be isolated from other brambles. Wild or neglected bramble plants are major reservoirs for wind-blown spores of the orange rust fungus and for viruses that are spread into the f!eld by flying or wind-borne aphids, leafhoppers, white flies, and, very commonly, virus-infected pollen.
- Wild brambles also harbor a number of specific bramble insect pests. Monitor a 500-foot border around your fields for any such “weed” brambles and, wherever possible, destroy them
- Crown gall is a particular hazard because once it infects the soil it cannot be eradicated, even with fumigation.
- Avoid planting in poorly drained soils or after any verticillium-susceptible crop (including tomatoes, potatoes, peppers, eggplant, or strawberries)

Resources

- The Mid-Atlantic Berry Guide for Commercial Growers 2013-2014. PSU College of Agricultrural Sciences. Pub AGRS-097
  http://pubs.cas.psu.edu/freepubs/MAberryGuide.htm
- Frost/Freeze Protection in Strawberries, http://pubs.ext.vt.edu/2906/2906-1386/2906-1386_pdf.pdf
- O’Dell. 2009. Ten years’ Experiences with Strawberry Plasticulture in a Colder Area; http://pubs.ext.vt.edu/2906/2906-1320/2906-1320_pdf.pdf
- Highbush Blueberry Production guide, NRAES-55, 1992

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Tree Fruit

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Tree fruit most suited to Virginia

- Apples
- Pears
- Peaches & Nectarines
- Sweet Cherry, Tart Cherry
-

Factors to Consider for all Tree Fruits

General

- These are perennial crops that are generally planted once and last 15 or more years
  - Planting is critical, only one chance to get it right
- Seasonal cycle, including chilling requirements
- Growing perennials requires a bigger commitment of money, time and secure access to land, since these crops take several years to grow before you can start to harvest their fruits.
- Self-fruitfulness (cross pollination requirements)
  - Most apples benefit from or require cross pollination from another cultivar, and even closely related varieties do not pollinate each other
  - Pears require two or more varieties for pollination
  - Commercial sweet cherry varieties generally require two or more varieties for pollination
  - All commercial peach varieties, except J. H. Hale, are considered to be self-fertile.
- The vast majority of commercial orchards in the region are grown under a ground management system of a sod row middle with a vegetation-free zone underneath the trees. Sod between the rows prevents soil erosion, provides traction for equipment, adds organic matter to the soil, improves soil moisture and structure, and can be a site for beneficial predatory insects.
- Ideally, the site to be planted should be either fallow or row cropped for at least two years before planting. Grains such as corn or wheat cannot serve as reservoirs of tomato ringspot virus.
- Orchard sod should be planted the fall before trees are planted.
- The addition of clover or other legumes is not recommended for orchard row middles. While they may provide additional nitrogen to the orchard, the release of that nitrogen is unpredictable. Legumes also can serve as reservoirs for tomato ringspot virus, which causes stem pitting in peaches and apple union necrosis in pome fruit.
- Nematode assays should be conducted prior to planting an orchard in the event that intervention is required. It is most helpful to know preceding crops grown in the location to be planted with small fruit for disease management.

- Most of the herbicides labeled for tree fruit work well against annual weeds, but only a few can control perennial weeds. Therefore, you should clean up any problem perennial weeds before planting.

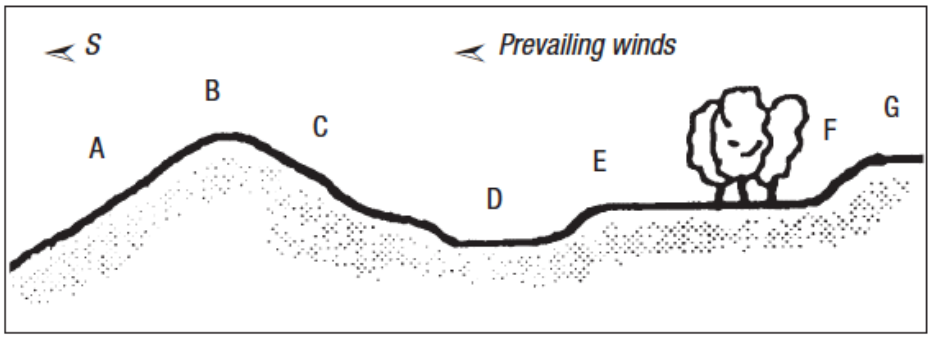
Climate and Position

- Site selection, including climate and influencing factors, such as latitude, altitude, physical configuration, and proximity to large bodies of water

It is easier to amend a site before the trees are planted than it is once they are in the ground.

To build a good orchard, you need a good foundation.

- The ideal site is on rolling or elevated land so that cold air can drain during spring frosts. Figure 1-1 shows typical site arrangements.
- Site A is a warm location that receives more sun. This site is not affected by late spring frosts because cold air drains to lower lying areas.
- Site B also misses late spring frosts, but the top may be too cold in winter because of exposure.



Soils

Since orchards are perennial, land is prepared once, and must be correctly prepared before planting. Soil testing will be used to determine existing nutrition and what fertility and pH management tasks must be implemented for the specific crop.

An old recommendation for a desirable orchard soil is that it be deep and well drained. Soil drainage is probably the most important factor in the longevity of an orchard. This is because of the inherent inability of certain types of fruit trees to survive when planted in imperfectly drained soils. Stone fruits (peaches, cherries, and plums) are the most susceptible to poor drainage. Apples are intermediate, and pears can survive on the more poorly drained soils.

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Comment [Steven Ho1]: This needs to be shortened and explained better

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The best soil is a well-drained loam a minimum of 3 to 4 feet deep. Good drainage, however, should take preference over depth.

In Figure 1-1, soils at site B are most likely to be the shallowest because of erosion, while those at site D tend to be the richest. Soil fertility should be medium to low. Overly fertile soils can lead to excessive tree growth at the expense of fruit production. Adding fertilizer to increase tree vigor is easier than trying to reduce vigor. Fruit trees grow well in soil with a pH of 6.0 to 6.5. Higher or lower levels can cause nutrient deficiencies.

A more detailed site evaluation is probably warranted, and we recommend that a backhoe be used to dig holes 5 to 7 feet deep so that the soil profile can be examined. A test similar to a percolation test used for installing septic systems may also be advisable where internal soil drainage is questionable. Poorly drained soils often have horizontal layers of light-colored material.

- It is best to subsoil as deeply as possible. Running a deep shank in two directions across the
- field will break up any existing hardpans.

- Next, take a soil test to determine soil fertility. If you are replacing an existing orchard or clearing the land for a new one, take the soil sample after removing the trees and as many of the roots as possible. An initial plowing and leveling should also be done before taking the soil sample. In this way, any subsoil that comes to the surface can be thoroughly mixed.

Water

- irrigation or water needs
- identify critical periods and amounts of moisture for each crop and its fruit development timeframe
- discuss methods of water delivery and their impacts on fruit quality, mother plant, and food safety
- irrigation for freeze protection (Sustain Veg Prod Chapter 13, page 137, paragraph 2)
-
- Nematodes and Weeds
-
- If you are replacing an existing orchard, particularly a stone fruit orchard, it is important to take a nematode test before the old trees are removed to determine the need for fumigation.
- If the site has been open pasture or field cropland, be sure to take a nematode sample.

- Examine the field for the presence of perennial weeds before working the ground. If multiflora rose, thistle, poison ivy, or hackberry are in the field, they should be treated in the summer or fall with glyphosate before planting.

Wildlife Problems

Several species of animals may feed on various parts of trees or on the fruit. Below is a brief discussion of the most common problems and possible control measures.

- White tail deer. Bucks can partially debark a tree or break branches by rubbing their antlers against the trees in the fall. Plan on control measures such as repellents if the planting is small or exclusion methods for larger plantings.
- Rabbits – Rabbits may feed on bark just above the ground and, if damage is extensive, the trees may be weakened or killed. Surrounding the trunk with hardware cloth to a height of at least 12 inches above ground usually prevents rabbit damage.
- Voles – Voles are small rodents that feed on plants and are often confused with mice. Voles feed on roots of plants, and they can feed on roots or bark.
- Birds – fruit is a favorite food of several bird species.

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Tree fruit: Wisconsin Pub A 3560, Site Preparation, pp. 11-13;

Resources

High Density Apple Orchard Management, http://www.ces.ncsu.edu/depts/hort/hil/pdf/ag-581.pdf;

Before You Start an Apple Orchard, http://fruit.cfans.umn.edu/apples/beforeyoustart.htm

Site Considerations for Apple Production, http://fruit.cfans.umn.edu/apples/siteconsiderations.htm

Peaches and Nectarines

- Peaches and nectarines are essentially the same, differing only in genes for surface fuzz.

General

- Plant hardy varieties. Many varieties perform well in Virginia, consult extension and catalog information for variety recommendations.

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- Paint trunks white. During winter the low sun angle increases the trunk temperature. The rapid alternating of heating and cooling during the day and night can cause bark splitting, especially on the south side of the tree. White paint on the trunk reflects the light and heat and minimizes such injury. In November, paint trunks and lower branches with white latex paint. Do not use oil-base paint. Using a water-soluble, exterior grade, white latex paint
- All commercial peach varieties, except J. H. Hale, are considered to be self-fertile. Even so, it is advisable to place bees in large blocks of one variety to ensure adequate pollination.
- Choose a location with proximity to markets, nearby transportation systems, agricultural suppliers, equipment dealers, and other commercial orchards.

Climate and Location

- Areas of having winter temperatures of -10 or below should not be considered for growing peaches or other stone fruits. Mid-winter temperatures of -10 to -15 o F often kill peach flower buds, and shoots and branches may be injured or killed at -20 to -25oF.
- Varieties requiring less than 800 hours of chilling often bloom early and are susceptible to early spring frosts. Many varieties developed by Southern breeding programs have short chilling requirements and are adapted to southern growing conditions.
- Peach flowers can be killed by air temperatures of 25 to 28oF. Therefore, peach trees should be planted on the tops or sides of hills at higher elevations than the surrounding area. Sometimes, just 10 feet in elevation can mean the difference between having or not having a crop.

Soils and Site Selection

- The two most important factors for site consideration are air drainage for frost control and soil water drainage.
- Peaches do well on a wide variety of soils. Because soil fertility can be easily adjusted, it is not a major consideration.
- Soils with high fertility should be avoided because trees grow too vigorously, produce low yields at a young age, and produce poor quality fruit.
- Soil providing a rooting depth of about 4 feet is preferable. Shallow soils have poor water holding capacity.
- Soil water drainage properties can be evaluated by digging a hole 2 feet deep. If water drains out of the hole within three days after a heavy rain the soil should be suitable for tree growth.

Water

- The availability of water for irrigation, spraying, and hydro cooling should also be considered.
- Water for older trees is most critical during the final six weeks of fruit growth (final

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swell) before harvest. In Virginia, water is rarely limiting in the spring. Slight water stress is actually beneficial from about 45 days after bloom until six weeks before harvest. Do not water trees until six or seven weeks before anticipated harvest.

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Other considerations

Ring Spot Virus

- Many broadleaf weeds and woody plants contain tomato ring spot virus which can then be spread by dagger nematodes feeding on the roots. This virus causes stem pitting and tree death. Therefore, all broadleaf plants should be destroyed with herbicides and a grass cover crop grown for at least a year to reduce the transmission of the virus.

Nematodes

- If stone fruit is to be followed with stone fruit, a nematode sample be taken before removing the old orchard and that the ground be row-cropped for 1 to 2 years with a suitable grain. Do not use broadleaved crops such as soybeans or alfalfa since they may harbor the stem pitting virus. Corn or small grains are suitable,

Pears
Two varieties needed (not self fruitful)
Pears are considered self-unfruitful under eastern United States conditions. Cross-pollination should be provided to ensure commercial crops.

Fire blight resistant cultivars

Climate

- 1,000 to 1,200 hours below 45 degrees F during the winter to complete their dormant period.
- Although most pear varieties are slightly less winter hardy than apples, most varieties can withstand low winter minimum temperatures common in Virginia. Fully dormant trees can survive temperatures of –20 to –25 degrees F.

Soils:
Most pears are propagated on seedlings collected from open pollinated seeds of Bartlett fruit. Of all tree fruit rootstocks, these are generally the most tolerant of wet, poorly drained soils.

most tolerant of all fruit trees, still several days of wet conditions dan damage roots. , rooting depth and drainage;

Our remarks on site and soil selection for apples (see Orchard Establishment) apply equally to pears. Maintain pear blocks in permanent sod cover. Use herbicides to keep grass and weeds
away from tree trunks.

Cherries

- Site preparation and nursery tree selection are similar to that for apples (
- Both tart and sweet cherries cultivars are grown in Virginia
- All commercial sweet cherries (except Stella and Duke) are considered self-unfruitful. Tart cherry pollen will pollinate sweet cherries, but the bloom periods do not overlap.
- Tart cherries are self-fruitful and will produce commercial crops when set in solid blocks of trees.

Climate

- Most sweet and tart cherry varieties have chilling requirements of about 1,000 hours; about 1,000 hours of temperatures between 35º and 55º F during the winter are required before buds will develop in response to warm spring temperatures. Avoid planting varieties requiring less than 800 hours of chilling because they will bloom too early.
- Cherry trees generally do not thrive where summers are long and hot or where winter temperatures are high for short periods. For these reasons, cherry production is challenging in the Piedmont and Tidewater areas of Virginia.

  The best sites for all tree fruits in Virginia are located on the slopes of the Blue Ridge Mountains or on hills at the northern end of the Shenandoah Valley, at elevations of about 800 to 2,200 feet above sea level.
- Virginia winters are not cold enough to injure cherry trees. However, cold weather events during early spring, before bloom, may kill flower buds. Above average temperatures during late winter and early spring, followed by a sudden drop in temperature (10º to 20º F), may injure flower buds on sweet cherry trees. These injured buds will usually not swell normally and will shrivel and fall from the tree by the normal bloom time. Spring frost is the primary consideration for choosing a site to locate an orchard.
- Plant trees on a site that is higher than the surrounding land, so the cold air can drain into the lower areas. Hillsides and hilltops are usually the preferred locations. The direction of the slope is much less important than the elevation.
- Sweet cherries are more difficult to produce than tart. They are scarcely more hardy than peaches, bloom early, and thus are frequently caught by spring frosts.
- Precipitation, heavy fog, or dew just before harvest may cause cherry fruit to crack if water is allowed to remain on the skin for a few hours before harvest. For some varieties in some years as much as 90% of the fruit may crack. Cracking is caused by absorption of water through the fruit skin.
-

Soils

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- Soils should be well drained, with a pH of 6.2 to 6.8, and have a rooting depth of at least 3 feet.
- Cherry roots are extremely sensitive to excessive moisture, which may stunt tree growth or kill the tree. Tree losses caused by the soil-borne fungus Phytophthora (crown rot or collar rot) tend to be greater in wet or poorly drained soils.

Borders
Bacterial canker

- Remove wild species of Prunus species adjacent to the orchard to reduce inoculum.

Resources

Halbrendt, J.M. (Editor). Pennsylvania 2012-2013 Tree Fruit Production Guide. Penn State University. Publication No. AGRS045. 325 pp.
http://extension.psu.edu/plants/tree-fruit/tfpg

Marani, R. P. Growing Peaches & Nectarines in Virginia. publication 422-019
Marani, R. P. Growing Cherries in Virginia. publication 422-018
Marani, R. P. Growing Cherries in Virginia. publication 422-023.

Vineyards

Factors to Consider

A number of species of grapes are found in Virginia, but many of the most popular varietals not all are suitable for commercial production statewide.

Type of Grapes

- Varietals
- Interspecfic hyrbrids
- Table grapes
- Fox Grapes or Muscadines

Siting of a vineyard in Virginia is complex due to the many combinations of climate and elevation differences across the state. Elevation is often one of the most critical factors to consider.

Physical Factors Affecting Vineyard Site Selection

- Length of Growing Season
- Likelihood of killing frost
- Frequency of extremely low temperatures
- Maximum Daytime and Minimum Nighttime Temperatures during ripening

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- Precipitation Patterns
- Elevation and Topography
- Slope and Aspect

For those interested in vineyard siting two excellent sources on recommended varieties and vineyard siting are recommended.

An on-line web tool is also available for those looking at suitability for a specific location.

Resources

Vineyard Site Selection
http://pubs.ext.vt.edu/463/463-020/463-020.html

Commercial Grape Varieties for Virginia
http://pubs.ext.vt.edu/463/463-019/463-019.html

Web-based Vineyard Site Evaluation Tool - Virginia Cooperative Extension
http://pubs.ext.vt.edu/ANR/ANR-63/ANR-63.html

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2.2 Animal Products

2.21 Factors to Consider for All Animals

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Climate

- Essentially all the animals covered in this section are adapted to the climate of Virginia, and with good management, can be productive. Pastured animals may require temporary shelter in the coldest regions of Virginia. In general, the smaller the animal, the more need for protection from the elements and predators.
- For grazing animals, climate affects type of forage grown, and when it is produced. Forage production should be matched with animal demand, and this can be challenging. Stored feeds (grains and hay) will likely be required.
- Animals without access to pastures (poultry, pigs, and some dairy) may need cooling during the summer.

Soils

- Soils are linked to animal production by their capacity to produce forages and crops used by the animals. Soils capable of producing crops and pastures will be suitable for animal production.
- Soils that are too steep, erodible, or stony should not be used for pasturing or loafing areas.
- Poorly drained soils are generally not suitable for animals or sustainable pastures.
- Where manures are collected, especially where animals are confined (zero grazing systems), there should be sufficient crop land to receive the manure in accordance with the nutrient management guidelines of Virginia.

Water

- Animals require a year-round supply of fresh, clean water in amounts that vary with the temperature and animal characteristics. Waterers should ensure supplies during freezing temperatures.
- If surface water is used as the primary water source, it should be tested if there is any question of its suitability.
- Free animal access to streams is an environmental concern. Managed access should be implemented where ever possible. Consult with NRCS for further information on recommended practices and available cost share programs.

See Unit 1.3 Water for additional considerations and amounts needed

Legal Requirements for Animal Waste

In Virginia, an Animal Feeding Operation (AFO) is defined as a lot or facility where animals are stabled or confined for a total of 45 days or more in any 12-month period, and where a crop or vegetative growth is not maintained in the normal growing season over the lot or facility.

Animal Feeding Operations that confine more than 300 animal units of livestock and handle liquid manure are required to obtain a Virginia Pollution Abatement permit.

Poultry operations that confine more than 20,000 chickens or 11,000 turkeys must register for coverage under the VPA General Permit for Poultry Waste Management. http://www.deq.virginia.gov/Programs/Water/LandApplicationBeneficialReuse/LivestockPoultry.aspx

General Considerations Related to Place

- What type of fencing is needed for my animals, and is it in place?
- Do I need to be concerned with predators?
- Do I need to provide shelter:
  - Sleeping/loafing
  - Pens for kidding, lambing
- Do I have adequate land for pastures and forages for the number of animals I want?
- Do I have storage for feed and tools?
- What work areas are present or might be needed for
  - Animal care
  - Milking
- Will I need additional labor, and is it available?
  - High demand seasonal tasks that must be accomplished in a timely manner
  - Birthing
  - Shearing
  - Dealing with horns, hooves, castration, etc.
  - Harvesting, transporting, or processing for meat
- How long can my animals be safely left without human attention? How will I provide for them if I need to be away for several days?
- Breeding
  - Will I breed my own animals to build the herd/flock or purchase young animals?
  - Are there special considerations for keeping male animals?

Resources
Ag Alternatives Penn State Extension
http://extension.psu.edu/business/ag-alternatives

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See Fencing Materials For Livestock Systems VCE publication 442-131

2.22 Poultry: Meat and Eggs

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Poultry can be produce both eggs and meat, although the production systems are generally very different. There are few limitations on where poultry can be produced in Virginia. The major concerns are adequate feed, water, shelter, light, protection from predators, and any legal restrictions that may apply.

Feeding habits

- Poultry can be produced in many ways, including cages, coops, chicken tractors, or pastured. All poultry require supplemental feeding of grains for good growth and production, whether for meat or eggs.

Fencing - Special Considerations

- For poultry, fencing limits wandering of birds and is essential for protection of the birds and eggs from predators, rodents, and snakes. Chicken wire, with small holes is recommended.

Predators

- Predators of poultry can be numerous. In Virginia, these may include birds of prey, coyotes, foxes,, racoons, skunks, dogs, weasels, and minks.

Water

- A constant water supply is necessary.

Shelter

- Poultry require a dry, relatively draft free house. A house with windows and/or doors which can be opened for ventilation may be necessary. For larger shelters, fans may be needed to regulate temperature and ammonia build up in the litter.
- Shelters should be built on high, well-drained areas. Litter must be kept dry. Facing a coop, the windows and outside run to the south will allows the sun to warm and dry the coop and soil.
- Keeping poultry totally confined together with a fence and covered runs is your best protection from predators. Be aware that predators are capable of digging under fences and walls.
- Windows and doors should be covered with heavy-gauge mesh wire or screening when open. If outside areas not predator-proof, securely enclose poultry before dark.
- For Meat birds: floor Space: At least 1.5 square feet per bird, however, 2 square feet recommended.
- Yards for either type bird: Not necessary, but if desired, confine the birds to an exercise area which provides between 5 and 10 sq. feet per bird.

Light

- Laying birds require at least 14 to 16 hours of light each day for maximum year round production. Be sure to provide several hours of darkness for roosting.

- For floor-reared layers, provide at least 6 inches of roost space per bird. Roosts should be 24 inches above the floor. Provide one 10- by 10-inch nest for every 4 or 5 hens, at least 24 inches above the floor and away from the roosts.
  - At least 23 hours of light per day is recommended for meat birds.
-
- Biosecurity
- Biosecurity and sanitation are necessary to prevent disease outbreaks. This involves isolating birds by age group, restricting human access to buildings, keeping the buildings clean, and properly disposing of dead birds.
- Isolate new birds for one month before contact with other birds to prevent the introduction of diseases.

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Resources

Clauer, P.J. Management Requirements for Meat Bird Flocks. VCE Extension publication

2.23 Small Ruminants: Milk, Meat, Fiber

Goats, Sheep, (Alpacas, Llamas)

Products:

- Milk
  - Drinking
  - Cheeses
    - Requires breeding to keep the milk flowing
    - Milking is an every day event
- Meat
  - Markets may be some distance away
  - Organic production can be particularly challenging due to worms
- Fiber (Wool or Hair)
  - Look closely at costs and prices; profitability is typically low in this region
  - Fiber products generally must be harvested for the health of the animals

Feeding habits

- Goats can learn to graze a pasture, but are natural browsers, like deer. This means they prefer trees, bushes, and woody weeds rather than close cropping of grasses. They are able to select a high-quality diet from lower-quality forages, especially when consuming weeds and shrubs.
- Sheep are close croppers.
- For milking and efficient weight gain, supplement grains for small ruminants will be required. Be aware, however, that high-grain diets with low fiber intake can lead to rumen health problems and lower milk fat content.

Fencing - Special Considerations

- Keeping contained goats contained can be challenging. Fencing must prevent kids and lambs from going through the fence, and adults (especially goats) from going over Barbed wire is not recommended, since animals tend to rub against wire and posts, and can be injured. Woven wire and two strands (low and high) of electric wire are probably the best option. In some cases several strands of electrified high tensile fencing may be adequate.
- Goats can be destructive to trees, shrubs, and crops if allowed to roam where they are not wanted. Some of the common plants that homeowners use for landscaping can poison goats. You may also want to protect the trees that you can't or don't want to remove within the containment areas by protecting with wire enclosures around their trunks.
- Predators may determine boundary fencing needs for other animals. Two to three strands of electrified wire is the minimum.

Predators

- Predators can become a significant threat for goats and sheep. Fencing may be effective, but guard animals (dogs, donkeys, or even llamas) may be required in areas of heavy predator pressure.

Disease:

- Worms (internal parasites) are the biggest health problem faced by goat and sheep producers. This is a significant problem in Virginia. Rotational grazing helps, but rest periods in excess of 30 days are required for affected pastures. Be prepared to diagnose and treat as necessary.
- An increasing problem with parasite control in goats is parasite resistance to dewormers.

Water

- A general rule is to give a goat between a half-gallon to four gallons each day per goat.

Shelter

- Goats need some kind of shelter from the elements and a safe place to rest. They are not fond of mud.
- Sheep may need shelter in inclement weather. During lambing season, pens for are needed for pregnant ewes.
- Sheep and goats should not be confined together.
- Dairy
- First, the building should be adequately ventilated and the walls and ceiling should be free from condensation. Second, the bedded area should be dry and clean. Third, feeders and watering devices must be well built and located so that feed and water are not contaminated with animal wastes or inefficiently wasted. Ready access to good-quality water is essential for milk production and herd

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health. Fourth, housing should be arranged to minimize the amount of labor and time required for maintaining a clean facility.

- Milk must be cooled immediately after milking

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2.24 Dairy Cows

Comment [Steven Ho2]: Essentially empty' SUITABILITY PRODUCTIVITY PROFITABILITY

Production Systems - Confinement or Grazing?

Traditional dairy operations are capital and management intensive with little profit margin. As a result, there are very few small operations (<100 cows) remaining. In this system, dairy animals are confined in a roofed stall barn or shed, sometimes with occasional access to pasture. This system emphasizes efficiency, and production, and profitability depends on economies of scale. Operations depend heavily on grain concentrates, silage, and hay, and frequently qualify as "Animal Feeding Operation" that must be permitted for liquid manure handling systems.

Grazing dairies derive most of their nutrition from forage, and milking is stopped when forage growth declines (2-3 months), and cows are calving. Most grazing dairies utilize cool season forages, so are located primarily in the western part of the state. These operations are land intensive since paddocks must be rotated during the grazing season, and summer annuals are usually needed to supplement cool season forage production during the hotter parts of the summer. But the animals do most of the harvesting, and manure management is limited to the milking parlor. Supplemental grains are usually required, but feed costs are greatly reduced compared to traditional systems. The key is timely management of forages to provide high quality feed as needed. This system is more about cost reduction than intensive production.

Fencing - Special Considerations

Fencing should allow easy movement of cows from barns or pasture to and around the milking area. Grazing dairy cows can be trained to pay attention to fences. Over time, single strand, moveable electric fencing can be used for implementing rotational grazing.

Climate

High temperatures can affect milk production, and must be managed in warmer areas and periods. Most of the dairies in the state are in the western part of Virginia, where cooler temperatures prevail. These locations also favor cool season grasses which produce earlier in spring and later in the fall than warm season grasses. Summer annuals or perhaps warm season pastures can be grown to supplement production when cool season growth slows during mid-summer.

Resources

Dairy Grazing Manual. 2012. Univ. of Missouri Extension Publication M168. (Many of the chapters in this manual are available online at http://extension.missouri.edu/p/M168

Pasture-based Dairy Program Web Pages
http://dairy.missouri.edu/grazing/publications/

Horner, J. And R. Milhollin. 2012. Keys to Building a Profitable Pasture-Based Dairy. Univ. Mo. Extension Publication m191.
http://extension.missouri.edu/explorepdf/manuals/m00191.pdf

Articles on Pasture and Grazing - Penn State Extension
http://extension.psu.edu/animals/dairy/health/nutrition/forages/pasture/articles-on-pasture-and-grazing

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2.24 Beef

Types of Beef Operations

- Seedstock: these are purebred operations, selling primarily young bulls, and perhaps young breeding females for the purpose of improving herd genetics. In general, extensive knowledge of the cattle business is required unless you can develop a niche market for an unusual breed.
- Commercial cow/calf : breeding females and bulls produce an annual crop of feeder calves. The calves are typically weaned at 7 to 9 months of age, weighing 400 to 650 pounds. At weaning, these feeder calves may be sold to backgrounders or cattle feeders. The calves may also be retained on the farm or ranch on which they were raised and marketed later as heavier feeder cattle or may be sold as finished cattle.
    - is a forage based enterprise typically makes use of land that is of no use or marginal value to row crop production. Approximately two-thirds of the forage requirements for a cow-calf herd should come from pasture and the other third from stored feed (hay or silage). Many of the state's cow/calf herds operate at 2 to 2 1/2 acres of pasture per cow/calf unit with an additional 1/2 to 3/4 of an acre for hay production.
    - One of the most important facilities in a cow-calf enterprise is a corral and chute. These are essential for normal management and health maintenance practices (e.g., vaccination and deworming), as well as for pregnancy testing or assisting a cow at calving.
    - Economic returns to the cow/calf operator are variable and generally cyclic in nature.
- Backgrounder : weaned calves are backgrounded or "conditioned" for one to six months before being sending them on to a stocker or feed yards at a higher weight. The purpose of backgrounding is to manage light-weight cattle through the stressful adjustment period of weaning, shipment, and diet change. Small groups of animals are purchased, grown primarily on high

quality forages, and sold as larger more uniform lots to stockers and feeder operations.

- Stocker: after weaning or backgrounding, cattle are fed on primarily on high quality forages to add size and weight generally until the animals are ready to enter a feed-lot. While higher quality forages are needed than a cow/calf system, stocker producers have lower demands for facilities and labor than other cattle enterprises. When receiving young cattle, the operator must have handling facilities and labor to process the animals and be available to identify and treat sick cattle. Some stocker cattle operations are able to maintain one yearling stocker per acre of pasture.
- Cattle feeding: cattle enter at any stage from weaning to stockers stage, and are fed a high grain diet until they are ready for slaughter at around 1000 to 1350 pounds (14 months to 30 months). Cattle feeders need a source of relatively low priced grain and other concentrate feeds, extensive feeding and handling facilities, and capital for purchasing cattle and feed (usually in large numbers). Many of these operations may also be required to manage manure under a permitted system.
    - The high rainfall results in frequent deep mud conditions when cattle are confined to a typical feed-lot for a normal finishing period. The high humidity during the warmer months also depresses feed intake. This leads to higher costs of weight gain when feeding cattle in Virginia. Most Virginia producers sell to feeding operations outside the state.

Climate Considerations

Given the topography, elevation, rainfall patterns, and forage species, grazing cattle enterprises tend to predominate in the western half of the state.
The rolling topography, climate, and soils of Virginia lend themselves to producing an abundance of lush forages.

- Most Virginia forage programs are based on cool season perennials such as tall fescue, orchardgrass and bluegrass. These grasses are most productive at temperatures of 60--80 degrees F and production will decline at temperatures above 80 F, even when moisture is adequate. This depression gets worse if accompanied by low rain fall.
- Legumes such as ladino clover, red clover and alfalfa improve forage quality and reduce fertilizer requirements. They are also more tolerant of warm temperatures and can contribute to the forage on offer if they are present in the pasture mix.
- Controlling the calving season makes it possible to match the cow's nutritional needs to your peak forage supply.
- Producers need to be prepared to feed hay or other supplements during winter when heavy snow or ice covers forage for more than a day or two.
- Cow herds on pasture perform best and economically with shelter and shade

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provided by hills or windbreaks. As long as there is adequate "natural" shelter, cold temperatures are not as detrimental to cow or calf health as muddy conditions with extreme variation between night and day temperatures

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Fencing - Special Considerations

- Fencing for operations with bulls must be more substantial than for cows or calves. Even five strands of high tensile electrified wire may not always be adequate.

Predators

- The majority of livestock damage in Virginia is caused by dogs and coyotes. Isolated cases of damage by vultures, foxes, and bears also have been reported.

Water

- Where possible, pastures should be located so that the maximum distance cattle must travel to water is 800 feet, 500 more preferable.

Shelter

- A herd calving in late winter or early spring requires little or no housing. However, some provision for maternity pens or sheltered lots should be provided when calving in very cold, wet, and windy conditions.
- For feeder operations. Housing does not have to extensive - open-sided sheds and more completely enclosed structures are equally effective. Younger cattle require more shelter than older cattle, especially for protection from winter winds. All facilities should be designed for the number of cattle fed and include a good manure management program.
- To reduce mud, use concrete pads for areas around waterers and feed bunks.

Resources

McKinnon, B.R. Getting Started in the Cattle Business in Virginia. VCE publication 400-790.

McCann, M.A. Understanding and Coping with Summer Slump

McCann, M.A. Managing Pastures for the Stocker Operation. Livestock update. Sept. 2010.
pubs.ext.vt.edu/news/livestock/2010/09/LU_09-01-10-3.html

2.26 Pigs

Commercial production of pigs is typically managed by contract. We assume here you are interested in producing a small herd (<100 head) of pigs.

Types of swine operations in the region

- Farrow-to-Finish: sows are breed and farrowed, offspring feed to market weight in a 10-11 mo production cycle. Farrow-to-finish operations demand the most capital and labor, and require a long-term commitment to the swine business.
- Farrow-to-Feeder: sows are breed and farrowed, with piglets sold to finishing operations at 30 to 60 pounds. Fewer facilities are needed and less operating capital, but producers are at the mercy of a volatile feeder pig market.
- Feeder-to-Finish: feeder pigs weighing 30 to 60 pounds are purchased and fed to market weight. This system requires the least overhead, low labor requirements, and no long-term commitment. It is also an opportunity for a grain farmer to use homegrown feeds to fatten pigs without having to manage breeding stock.

Confined or pastured?

- Pastured Pigs
- Pigs are ominvores and while a portion of their nutrition can be obtained by grazing (perhaps as much as 20%) , pigs on pasture still need a high energy feed.
- Pastures can be damaged if pigs are left on them on them too long, so careful management is required. It is probably a good idea to keep pigs off a pasture for a year.
- Some sources recommend no more than 10 head per ac during the feeder stage.
- Pigs on pasture will need water and shade, and preferably a simple shelter.

Confined

- Shade, shelter, bedding
- If confined, 20 square feet per pig in minimal, 50 better.

Fencing - Special Considerations

- Sturdy fencing
- Woven wire, hog panels, or minimum two strand high voltage electric fencing,
- Smaller mesh for piglets

Predators

- Predators are few, but coyotes, dogs, and occasionally bears have preyed on small pigs.

Disease:

- These are most important in confined, high density operations. Biosecurity in these areas must be maintained or the entire operation could be at risk. For small herds, diseases are possible and warrant attention, but most producers report few problems.

Water

Good quality, cool water is essential. Pigs cannot sweat to cool themselves and need a

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constant supply of water. Water should be placed away from the shelter and feed.

Size	Intake (quarts/day/head
12-30 lb	1
30-75 lb	2
75-100 lb	5
100-240 lb	6
Sow & Boar	8
Lactating Sow	10

Shelter

- Minimal, pen with outdoor access, concrete pad for feeding drinking shade in summer, shed or barn in winter
- Dig under fences

Resources
Swine Production
http://extension.psu.edu/business/ag-alternatives/animals/swine-production

2.27 Bees

- Bees pollinate fruits and vegetables. Without the honey bee, our food supply could be in serious jeopardy.
- The economic value of bees include honey, wax and other hive products
-

Factors to Consider

- A beekeeper will occasionally be stung. Stinging is the way bees defend their colony, and stings usually indicate that the beekeeper is doing something wrong. Use protective equipment and acquire experience in gentle handling of frames containing live bees.
-

Essential elements of an apiary include:

- Abundant sources of nectar and pollen located within a mile of the apiary. A variety of plants will increase the availability of nectar and pollen year-round. Bees need pollen for brood rearing and surplus honey made from nectar for successful over-wintering.
- A good source of clean water within one-quarter of a mile.

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- Good air circulation with no stagnant air pockets. A location with a gentle slope is suitable, but avoid placing colonies in low areas with poor air circulation.
- Good water drainage and above flood level.
- Provide morning sun and afternoon shade for colonies, if possible. Eastern entrance exposure for morning sun is great. Be careful not to place colonies in locations that are shaded most of the time. Total sun exposure would be better for colonies than total shade.
- Protection from direct winds, especially in winter. Trees or shrubs are good wind breaks.
- Orient multiple colonies in a "U" or "S" shape rather then in a straight line. When colonies are placed in a straight line, bees tend to drift to colonies at the ends of the line, which weakens colonies in the middle.
- Ready access – The apiary must be easy to get to with a vehicle. Bee colonies are heavy. The apiary should be near a hard-surface road. It will be necessary to visit your apiary in all kinds of weather.
- Maintain colonies with honey bee races certified as European honey bees (EHB).
- Reduce interactions between your bees and your neighbors as well as with pets or livestock.
    - Maintain all colonies at least 10 feet away from property lines.
    - Place all colonies less than 40 feet from property lines behind a barrier no less than 6 feet in height. Barriers should be of sufficient density to establish bee flyways above head height.
    - Remove or relocate an apiary that is within 50 feet of any animal that is tethered, penned, kenneled, or otherwise prevented from escaping a stinging incident.
    - Avoid opening or disturbing colonies when neighbors or the general public are participating in outside activities or using machinery within 150 feet of an apiary.
- Comply with all homeowner association, local, state, and federal ordinances, regulations, and laws pertaining to beekeeping
-

Special Consideration = Laws

- The Virginia Bee Law regulates the movement of honey bees into the state, the sale of bees, queens, used bee equipment; and provides a means for dispatching bee disease reservoirs. Virginia utilizes a Uniform Inspection Certificate approved by the Apiary Inspectors of America for interstate movement of colonies. Virginia also participates in the Mid-Atlantic States Agreement which specifies inspection requirements for bee diseases and pests and allows for partial (random) inspection of apiaries that meet certain disease-free criteria.

http://leg1.state.va.us/cgi-bin/legp504.exe?000+cod+TOC03020000044000000000000

Resources on Beekeeping

- Beekeeping in Tennessee.
  https://utextension.tennessee.edu/publications/Documents/PB1745.pdf

- http://pubs.cas.psu.edu/FreePubs/pdfs/agrs93.pdf

Virginia Department of Agriculture and Consumer Services
Office of Plant and Pest Services
P.O. Box 1163
Richmond, VA 23218
Telephone: 804.786.3515
FAX: 804.371.7793
Email: VABees@vdacs.virginia.gov
Website: http://www.vdacs.virginia.gov/plant&pest/apiary.shtml

Resources for Getting Started with Animal Agriculture

New England Beginning Farmers Project
http://nebeginningfarmers.org/publications/farming-guide/

http://growingsmallfarms.ces.ncsu.edu/growingsmallfarms-animallinks/

Penn State Ag-Alternatives
http://extension.psu.edu/business/ag-alternatives/livestock

Nelson, Melissa. 2010. The Complete Guide to Small-Scale Farming: Everything you need to know about raising beef and dairy cattle, rabbits, ducks, and other small animals. Atlantic Pub. Group, Inc. Ocala , FL. 288 pp.

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