NorthEast Organic Network — Shining the Light on Organic

NEON

Guide to the Expert Farmers' DACUM Chart for

"Manage Crop Rotation System"

DACUM Farmer Panel -- Winter 2002

Panelists:

Polly Armour
Four Winds Farm
Gardiner, NY

Paul Arnold
Pleasant Valley Farm
Argyle, NY

David Blyn
Riverbank Farm
Roxbury, CT

Roy Brubaker
Village Acres Farm
Mifflintown, PA

Jean-Paul Courtens
Roxbury Farm
Kinderhook, NY

Jim Gerritsen
Wood Prairie Farm
Bridgewater, ME

Brett Grohsgal
Even Star Organic Farm
Lexington Park, MD

Jack Gurley
Calvert's Gift Farm
Sparks, MD

Don Kretschmann
Kretschmann Farm
Rochester, PA

Drew Norman
One Straw Farm
White Hall, MD

Eero Ruuttila
Nesenkeag Farm
Litchfield, NH

Will Stevens
Golden Russet Farm
Shoreham, VT

Guide and DACUM Chart for

"Manage Crop Rotation System"

Project Coordination
Sue Ellen Johnson
Eric Toensmeier
New England Small Farm Institute
PO Box 937, Belchertown MA 01007
413-323-4531

DACUM Facilitator
Tina Overtoom
CETE, The Ohio State University

DACUM process has been developed by:

The Center on Education and Training for Employment
1900 Kenny Rd; Columbus, Ohio 43210-1090 www.cete.org

Funded by
USDA Initiative for Future Agriculture & Food Systems

Through a grant to
NEON (The NorthEast Organic Network)

The North East Organic Network (NEON) is a consortium of farmers, researchers, extension educators and private, grassroots nonprofits working together to improve organic farmers' access to research and technical support. Funded with a $1.2 million grant from the US Department of Agriculture's Initiative for Future Agriculture and Food Systems, this multi-state, multidisciplinary team is conducting research, extension and education programs on organic agriculture throughout the Northeast.

The DACUM effort and this publication were supported by a grant (#2001-04320) from the United States Department of Agriculture Initiative for Future Agriculture and Food Systems program to Cornell University. The views expressed here are those of the authors and do not necessarily represent the views of the USDA or Cornell University.

This publication is available from the New England Small Farm Institute at (413) 323-4531 or at www.smallfarm.org . It is also available as a pdf file at www.NEON.cornell.edu .

About the NEON DACUM "Manage Crop Rotation System" Chart

In January 2002, the New England Small Farm Institute convened a panel of twelve experienced organic vegetable farmers to discuss crop rotation. The goal was to give the NorthEast Organic Network a better understanding of how successful farmers really manage crop rotations, as background for the development of a crop rotation planning manual. Using a structured, facilitated process called DACUM, the panel developed a chart detailing the actions and decisions related to rotations on their farms. This booklet presents and summarizes the chart (pages 13-24). It also contains a description of the background of the project and findings, farmers' comments about the process (pages 4-6), and sample five-year rotations for real fields on each of the panelists' farms (pages 7-12). A summary of comments from additional farmers based on a verification process can be found on page 26. Brief biographies of the expert panelists and descriptions of their operations is on page 27.

Introduction

The NorthEast Organic Network (NEON) is a group of scientists, grassroots activists, and farmers dedicated to researching and improving organic farming techniques for the Northeast. One of NEON's first areas of interest is crop rotation on organic vegetable farms. To set off on the right foot, NEON convened a panel of experienced growers to help NEON scientists understand how expert farmers manage their rotations. This document is a summary of the panel process and what NEON has learned from the experts. The results of the panel are helping to guide NEON's research, as well as forming the basis for a rotation planning manual (available in 2005). We hope it will be valuable to farm advisors, scientists, and farmers.

Background

The New England Small Farm Institute (NESFI), a NEON project partner, began adapting a vocational curriculum development tool known as "DACUM" (see sidebar) in 1999. The DACUM model relies on skilled workers, in this case experienced farmers, who are consulted as the experts to develop an "occupational profile", outlining the general duties and tasks of a particular job or responsibility. Thus, the training materials or information and research developed reflect what experienced farmers actually do. NESFI adapted the DACUM process to capture farmers' thought processes in planning and implementing their organic vegetable rotations.

In late 2001, sixteen Northeast organic farming organizations nominated successful, respected organic growers who have been farming for eight years or more and produce vegetables as their primary crop. From these nominees a panel of twelve farmers was selected who hailed from southern Maryland to northern Maine. Their operations range from two hundred to three acres, with a wide array of marketing strategies.

The panel met from January 30 to February 1, 2002, at the farm of Paul and Sandy Arnold in Argyle, New York. The results were formulated into a "Manage Crop Rotation System" chart.

The DACUM Process

DACUM is an abbreviation of "Design a Curriculum." The DACUM process is an analysis of a given occupation (or part of one), originally developed for training skilled workers in a variety of jobs. The initial product is a chart that profiles the job and breaks it down into duties and tasks for which training materials can be developed.

DACUM philosophy holds that skilled people who are currently performing the job are better able than anyone else to describe their occupation. DACUM materials are developed by a trained facilitator working with skilled workers in the field being analyzed.

For more information visit **www.dacum.com/ohio**.

Since the workshop, the chart has gone through several revisions, including verification by an additional eighteen growers. The chart is included in this booklet. Comments of the panelists and the eighteen grower-reviewers have been integrated into this text.

The DACUM Experience

For many seasoned growers, rotation management is an intuitive activity. Many of the farmers on the panel had never put their rotation management systems into words before. The strictly facilitated process assisted the farmers to create an outline of the factors they consider and the decisions they make in planning rotations; allowing for differences in farm scale, region, and management systems.

The panel was enthusiastic about their work being used in the development of the NEON Rotation Planning Manual (see box). This booklet describes the DACUM process and its immediate results.

The panel was required to step back and examine how and why they make decisions – an experience that was sometimes grueling. Participants described themselves as having a love-hate relationship with the DACUM process. But afterward, they felt they had expressed their intuitive understanding of their rotations, which enabled them to communicate more effectively with their workers and others. All appreciated the opportunity to spend time with such an experienced group of growers. They learned from each other. Polly Armour, for example, said she would like the group to reconvene to “beat more topics into submission”. The panelists continue to serve as advisors for NEON.

Summary of Findings

Many of the panelists indicated that they work within the parameters of a flexible rotation. Rotations are constantly evolving; adapting to new knowledge, opportunities and farm conditions

Year-to-year farmers tend to manage short crop sequences, rotating crop families as much as specific crops, and responding to field situations season by season.

The lack of “strict", fixed, cyclical rotations is one of the key findings of this NEON activity.

Another key finding is that expert organic growers do more than rotate cash crops from field to field around the farm; they also rotate cover crops, the application of mulches and composts, and tillage practices.

Yet another finding is that many non-crop factors determine rotation management - including weather, markets, equipment, and labor. In many situations, business is a more influential driver of the rotation than biology.

However, expert farmers’ decisions are always made in the context of the longer term cropping history and health of a field. Decisions are consistent with each grower’s personal guidelines, farm goals and limits.

Farmers do follow numerous “rules” - and their intuition - as they choose crops, and plan and implement rotations on an annual, seasonal, or even last minute opportunistic basis. Consequently, they are interested in knowing more about the guidelines for rotations and what particular crop sequences can do for the system.

NEON Crop Rotation Planning Manual

In addition to this booklet, NEON is developing a crop rotation planning manual based on the farmer input embedded in this chart and other information from farmers. The farmer planning manual:

- summarizes expert farmers' approaches to crop rotation planning,
- presents example rotations
- provides tables and worksheets biological and physical processes that assist with crop rotation planning

This manual, to be published by NRAES, will be available in early 2005. Check **www.neon.cornell.edu** for details.

Crop Rotation Defined

NEON's experts did not formally define the term, but panelists provided the following working definitions:

Roy Brubaker: "A planned succession of crops (cash and cover) chosen to sustain a farm's economic and environmental health."

*Jean-Paul Courtens: "*Rotations balance soil building crops (soil improvement crops) and cash crops, and can allow for bare fallow periods to break weed cycles and incorporate plant matter into the soil."

Don Kretschmann: "Rotation is the practice of using the natural biological and physical properties of crops to benefit the growth, health, and competitive advantage of other crops. In this process the soil and its life are also benefited. The desired result is a farm which is more productive and to a greater extent self-reliant in resources."

Brett Grohsgahl cautions that "smaller and more intensively managed farms don't have nearly the cover crop dependence that [larger farms] do, and that Grubinger's definition (see below) defines as critical, yet these smaller systems can be extremely efficient, vigorous, and profitable." Many of these smaller, intensive farms rely on mulching, compost, and/or short-term winter covers in place of longer-season cover crops and hay rotations.

Will Stevens: "I've come to view crop rotation practices as a way to help me use Nature's ecological principles in the inherently non-natural world of agriculture. Striving to have as much 'green' on the ground as possible throughout the year is one step in that direction. I view crop rotation as a series of 'rapid succession' cycles, (ideally) minimally managed. Through this approach, the power and sustainability of natural systems can be expressed through the health and prosperity of the farm system."

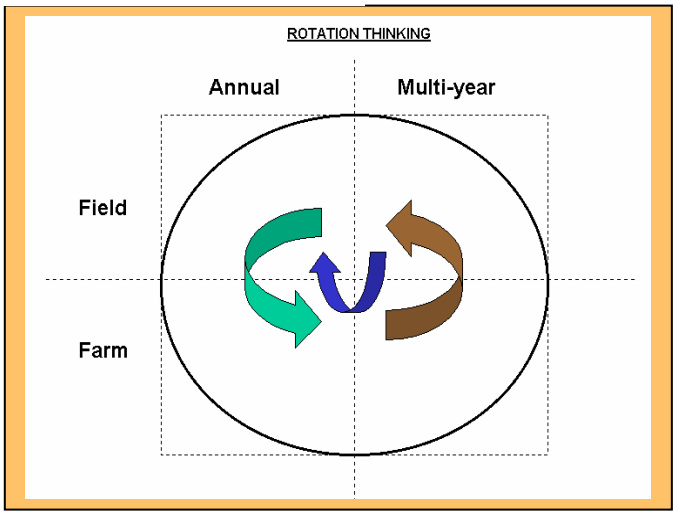
There are many published definitions of "Crop Rotation", Grubinger's captures the panel's concepts:

"Crop Rotation is a fundamental practice of sustainable agriculture. Crop rotation is a planned system of growing different kinds of crops in recurrent succession on the same land. Rotation, or lack of it, can have a profound effect on the marketable yield of vegetables because location of crops around the farm over time influences insect, weed, and disease pressure as well as soil nutrient status and physical condition. To achieve an effective crop rotation, it is critical to have a systematic plan for the arrangement of cash crops and cover crops that looks ahead three or more years." -Vern Grubinger, Sustainable Vegetable Production; 1999; NRAES

Rotation Planning is Multi-dimensional

Rotation decisions integrate time and space. Rotation management requires understanding the needs of the whole farm and each individual field or bed on both an annual and multi-year basis (see diagram).

This booklet attempts to distinguish rotation activities that occur on the whole farm level (such as balancing overall acreage of cash crops, cover crops, livestock, and fallows) from field- or bed-scale activities (such as assessing weed, disease, and pest control).



Five-Year Crop Sequences from Panelists' Fields

In addition to creating the chart of how to manage crop rotations, each DACUM panelist described a cropping sequence (or rotation) for ***one particular field*** on their farms. At the suggestion of Drew Norman, a farmer panelist from Maryland, each expert farmer provided an example of a "five year rotation" for one of their fields to illustrate the rotation decision process for NEON scientists.

The panelists' examples on the following pages describe multi-year single-field rotations. The panelists emphasized that these sample rotations were from one field and were not necessarily replicable or transferable to other farms or other fields.

The farmers offered many specific reasons why these specific crop sequences work for them. For example:

- *Jack Gurley believes he needs to maximize use of cover crops without losing growing space. Consequently, he looks for opportunities to interseed cover crops with saleable crops (e.g., broccoli with hairy vetch; tomatoes with white clover).*
- *Polly Armour follows potatoes, which often have weed problems in her bed system, with winter squash. The squash works as a smother crop that, together with heavy mulching, controls the weeds.*
- *Several farmers plan for winter-killed cover crops where early spring crops will be planted. Panelists stressed the importance of matching the cover crop to the following crop (for example, crops differ in their ability to tolerate cover crop residues). Fertility and weed-control benefits also can be matched to specific crops.*

Some growers indicated that the four- or five-year rotation for the particular field they were describing was tried and true. In other words, the rotation for that field is consistently effective and rarely needs modification. Other panelists stated that their plans accommodate any of several possible contingencies, and that they build alternative plans and options into their primary plan. And since the panel convened, several farmers have reported that the sequences for these fields have been adapted to deal with changing conditions or opportunities.

The five-year cycle was an arbitrary choice by the panel. Some panelists farms and fields rely on less than a 5-year rotation cycle, while others have sequences that cover periods of more than 10 years.

These sample rotations provide insights into farmers' priorities for crop rotation management. In principle, rotations address the biophysical needs of each field: fertility, tilth, diseases, and weeds. But in reality, the year-by-year, field-by-field decisions are conditioned by weather, market, and logistical factors that must be balanced against biophysical management criteria.

One Rotation Question

This exercise generated several interesting discussions about specific challenges faced by organic farmers. For example, established organic vegetable farms often develop weed problems with galinsoga, chickweed, and purslane. These weeds out compete profitable small-seeded crops like salad greens and spinach. The growers speculated that this weed problem is the direct result of many years of intensive cropping. These weeds, which have very short life cycles, are ideally suited to such conditions. To break this cycle, several growers are cycling large portions of their acreage into continuous cover, hay and managed fallows. The growers asked NEON to initiate research to test the efficacy of this practice and see if it is effective at controlling these troublesome weeds. Panelist Eero Ruuttila suggests that flame weeding should also be evaluated as a technique for controlling these weed species.

While overall whole farm requirements of cash flow, market options, equipment, and labor strategy set the broad parameters of the rotations, the rationale behind each of these particular sequences is field based. As Don Kretschmann points out, “many rotations are very possible in flat, relatively homogeneous soil type situations. With the vagaries oftentimes present on farms in hilly or non-homogeneous soil, rotation becomes a real scramble and an art." Thus, rotations evolve and deviate from a plan because of variables such as weather, weed pressure, labor, market conditions, and numerous other factors.

Panelists agreed that many final field decisions are based on avoiding known negative or adverse actions, with deliberate screening for crop sequences that “don’t work”. The farmers emphasized the importance of knowing “what not to do”.

Panelists also indicated many reasons why their plans may **not** work out, and what they do when that happens (see page 23 for examples).

On the following pages field specific rotations are presented. The sample rotations and crops differ for each of the twelve farms. A major element influencing these rotations is the total land area that a farm has available for cropping. When the farm size is small, cropping is more intensive and hay or cover crops are less likely to be central to the rotation. A few of the sequences include mulches, but most do not indicate the other aspects of production, such as compost applications or seedbed preparation, which many panelists indicated are as important to their rotation decisions as their crops and cover crops.

In contrast to these example rotations, the DACUM chart (page 13-14) presents the general steps the farmers agreed are necessary to design and implement the rotations for each field over the entire farm.

A note on the look of things: the presentation of farmers’ information.

Summarizing complex systems on a flat page is never easy. On the pages that follow complex processes are presented in oversimplified, but easy-to-read formats.

The columnar lists of each farm’s 5-year rotation do not illustrate the cyclical aspect of crop rotations, (which although not strictly cyclical are a succession of plantings of recurrent crops, sometimes on the same ground).

Similarly, the standard format of the DACUM chart (a binary matrix) suggests that farmer decision-making is a linear process. As described by the panel, the farmer decision process is rarely linear. It is a dynamic iterative process, with farm and field and a multitude of factors being juggled. Feedback loops, revisiting of decisions, and the iteration between rotation tasks and duties are not fully depicted in the following pages. The panel acknowledged that there is a progression through a series of steps to final implementation of a decision and consequent re-examination of the decision and this is what is displayed in the DACUM chart. A flow chart summarizing the DACUM chart is provided in the crop rotation manual.

Real Farms Real Fields
Sample Four and Five-Year Rotations

		Calvert's Gift Farm Jack Gurley, MD	Even Star Organic Farm Brett Grohsgal, MD	Four Winds Farm Polly & Jay Armour, NY
Y1	Winter	Garlic	Crimson Clover	Oats
	Spring	Winter Squash	Tomatoes **OR** Peppers	Potatoes **OR** Tomatoes*
	Summer			
	Fall	Spinach	Red Clover / Winter Brassicas / **&** Lettuce (strip crop)	Straw Mulch / Garlic (in alternate beds**)
Y2	Winter		Red Clover	
	Spring			
	Summer	Soybeans	Okra-Flowers-Basil	Winter Squash (in alternate beds) / Straw Mulch
	Fall		Vetch / Winter Brassicas / **&**, Lettuce (strip crop)	
Y3	Winter		Vetch	Straw Mulch
	Spring	Oats	Cucurbits	Beans
	Summer	Fava Beans		
	Fall	Brassicas	Crimson Clover / Winter Brassicas / **&** Lettuce (strip crop)	Compost
Y4	Winter	Vetch	Red clover	Direct-seeded Quick Crops/ Small-Seeded Greens/Radishes
	Spring	Tomatoes		
	Summer			Cukes (mulched with straw) / Lettuces
	Fall	Garlic	Red Clover / Winter Brassicas / **&** Lettuce (strip crop)	
Y5	Winter	*Return to Year One*	*Return to Year One*	*Return to Year One*
	Spring			
	Summer			
	Fall			

**This rotation switches between potatoes and tomatoes in alternate cycles.*
***This rotation is designed around alternate beds.*

KEY

- Cash crops are indicated by black text, and cover crops and fallows by white text.
- "Fallow" indicates a deliberate period of bare soil with frequent cultivation to kill weed (also called a stale bed).
- Split boxes indicate strip crops or split beds.
- Intercrops with more than one crop family are represented by a dark grey background.

Grasses - Poaceae	Legumes – Fabaceae	Brassicas – Brassicaceae	Solanaceous –Solanaceae	Cucurbits – Cucurbitaceae	Chenopods – Chenopodiaceae	Mulch	Cash Crop
Lettuces – Asteraceae	Alliums – Alliaceae	Carrot Family – Apiaceae	Miscellaneous	Fallow	Grass/Legume Mix	**Intercrop**	Cover Crop

Real Farms Real Fields
Sample Four and Five-Year Rotations

		Golden Russet Farm Will Stevens, VT	Kretschmann Farm Don Kretschmann, PA	Nesenkeag Farm Eero Ruuttila, NH
Y1	Winter	Wheat **OR** Oats	Alfalfa	Rye and Vetch
	Spring	Brassicas	Tomatoes	Winter Squash
	Summer		Rye and Vetch	Rye and Vetch
	Fall		Lettuce (triple crop)	Potato
Y2	Winter	Oats	Spinach / Turnips	Rye and Vetch
	Spring	Potatoes	Rye and Vetch	Sudan Grass
	Summer		Beets	Field Peas and Oats
	Fall		Late Brassicas with underseeded Rye **OR** Oats	Lettuce / Spinach - Chard - Beet Greens
Y3	Winter	Wheat (overseed)	Alfalfa	Arugula – Mustard – Brassicas / Lettuce
	Spring			Rye and Vetch
	Summer	Winter Squash and Summer Vetch		*Return to Year One*
	Fall			
Y4	Winter	Wheat (overseed)		
	Spring			
	Summer	Sweet Corn / Summer "Smalls"*		
	Fall			
Y5	Winter	Oats (and compost)		
	Spring	Spring "Smalls"*		
	Summer	Summer Fallow		
	Fall	Wheat **OR** Oats		

** "Smalls" indicates any crop grown in small quantities, such as scallions, green beans, and other "oddballs".*

KEY

- Cash crops are indicated by black text, and cover crops and fallows by white text.
- "Fallow" indicates a deliberate period of bare soil with frequent cultivation to kill weed (also called a stale bed).
- Split boxes indicate strip crops or split beds.
- Intercrops with more than one crop family are represented by a dark grey background.

Grasses - Poaceae	Legumes – Fabaceae	Brassicas – Brassicaceae	Solanaceous –Solanaceae	Cucurbits – Cucurbitaceae	Chenopods – Chenopodiaceae	Mulch	Cash Crop
Lettuces – Asteraceae	Alliums – Alliaceae	Carrot Family – Apiaceae	Miscellaneous	Fallow	Grass/Legume Mix	**Intercrop**	Cover Crop

Real Farms Real Fields
Sample Four and Five-Year Rotations

		One Straw Farm Drew Norman, MD	**Pleasant Valley Farm** Paul & Sandy Arnold, NY	**Riverbank Farm** David Blyn, CT
Y1	Winter	Orchardgrass/ Alfalfa Hay	Mulch	Hay
	Spring		Lettuce	
	Summer	Plow down - Fallow	Beans	Buckwheat
	Fall	Crimson Clover-Vetch	Radish	Oats and Peas
Y2	Winter		Winter Rye	
	Spring	Tomatoes	Carrots	Multiple Crops in Strips: Onions, Spinach, Beets, Radish, Salad Mix, Lettuce, Peas
	Summer		Beans **OR** / Turnips	
	Fall	Rye and Vetch		Carrots, Beets & Lettuce
Y3	Winter		Winter Rye	Winter Rye
	Spring	Plow down - Fallow	Lettuce	
	Summer	Brassicas	Winter Squash (with hay mulch)	Tomato / Pepper / Eggplant on plastic / **OR** Cucumber/ Zucchini / Melon on plastic
	Fall		Mulch	
Y4	Winter			Winter Rye
	Spring	Lettuce	Beets	Oats and Peas
	Summer	Buckwheat	Radishes	Brassica Greens **and** / Lettuce
	Fall	Spinach **and** / Arugula **and** Radish	Winter Rye	Garlic / Rye
Y5	Winter	*		Flowers
	Spring		Tomatoes (with hay mulch)	Lettuce
	Summer	Summer squash		
	Fall	Hay	Mulch	Rye

**Brassica and fall cool season crop harvest extend in to winter. Clovers may be interseeded at the last cultivation.*

KEY

- Cash crops are indicated by black text, and cover crops and fallows by white text.
- "Fallow" indicates a deliberate period of bare soil with frequent cultivation to kill weed (also called a stale bed).
- Split boxes indicate strip crops or split beds.
- Intercrops with more than one crop family are represented by a dark grey background.

Grasses - Poaceae	Legumes – Fabaceae	Brassicas – Brassicaceae	Solanaceous –Solanaceae	Cucurbits – Cucurbitaceae	Chenopods – Chenopodiaceae	Mulch	Cash Crop
Lettuces – Asteraceae	Alliums – Alliaceae	Carrot Family – Apiaceae	Miscellaneous	Fallow	Grass/Legume Mix	**Intercrop**	Cover Crop

Real Farms Real Fields
Sample Four and Five-Year Rotations

		Roxbury Farm Jean-Paul Courtens, NY	**Village Acres Farm** Roy Brubaker, PA	**Wood Prairie Farm** Jim Gerritsen, ME
Y1	Winter	Clover	Rye	Plow down - fallow
	Spring			
	Summer	Fallow-July	Strawberries 1st harvest	Seed Potatoes
	Fall	Oats and Peas		
Y2	Winter	White Clover between crop rows / Pepper-Eggplant on Plastic		Fallow
	Spring			
	Summer		Strawberries 2nd harvest	Wheat **OR** Oats (undersown with clover)
	Fall	Interseeded Rye		
Y3	Winter	Broccoli		Clover
	Spring		Buckwheat	
	Summer			
	Fall		Wheat (frost seed grass and clover into wheat in spring)	Timothy with Clover
Y4	Winter	Fallow		
	Spring	Sweet Corn (Overseeded with Clover)		Spring Mustard plowdown
	Summer			
	Fall			Buckwheat plowdown
Y5	Winter	Clover (mowed two or three times)	Forage Millet and Soybeans **OR** Grass/Clover mix grazed by poultry	*Return to Year One*
	Spring			
	Summer			
	Fall		Rye	

This strawberry rotation is followed by cycling into a 5-year vegetable rotation sequence.

KEY

- Cash crops are indicated by black text, and cover crops and fallows by white text.
- "Fallow" indicates a deliberate period of bare soil with frequent cultivation to kill weed (also called a stale bed).
- Split boxes indicate strip crops or split beds.
- Intercrops with more than one crop family are represented by a dark grey background.

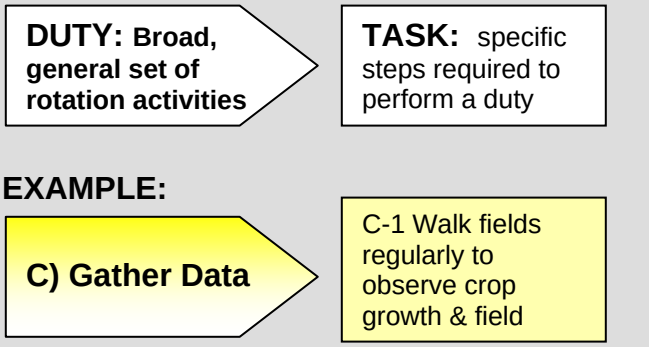
Grasses - Poaceae	Legumes – Fabaceae	Brassicas – Brassicaceae	Solanaceous –Solanaceae	Cucurbits – Cucurbitaceae	Chenopods – Chenopodiaceae	Mulch	Cash Crop
Lettuces – Asteraceae	Alliums – Alliaceae	Carrot Family – Apiaceae	Miscellaneous	Fallow	Grass/Legume Mix	**Intercrop**	Cover Crop

The NEON "Manage Crop Rotation System" Chart

About this chart
The DACUM process is designed to describe and distinguish the broad duties and explicit step-by-step tasks associated with any kind of job. The resulting charts are generally used as templates for curriculum development.
The primary purpose of this NEON "Manage Crop Rotation" chart was to provide a real world basis for an organic crop rotation planning manual (forthcoming from NRAES in 2005). The chart outlines the thinking and management processes of experienced growers, specifically organic farmers' approach to planning and implementing crop rotations. The chart is a checklist for managing their own rotations. By examining the duties and tasks associated with the crop rotation, farmers or their advisors can identify actions and tasks they need to do or skills they need to develop to successfully manage their rotations.

How to read the chart (see box below)
The arrows on the left side of the chart represent eight broad "duties" or sets of activities necessary to manage crop rotations. Each of the duties (labeled A through H) is associated with a number of "tasks" described in the boxes that run across the page. These tasks must be done to fulfill the duty (such as "Review annual production plan").

How to read the chart:



Assumptions of the NEON "Manage Crop Rotation" Chart

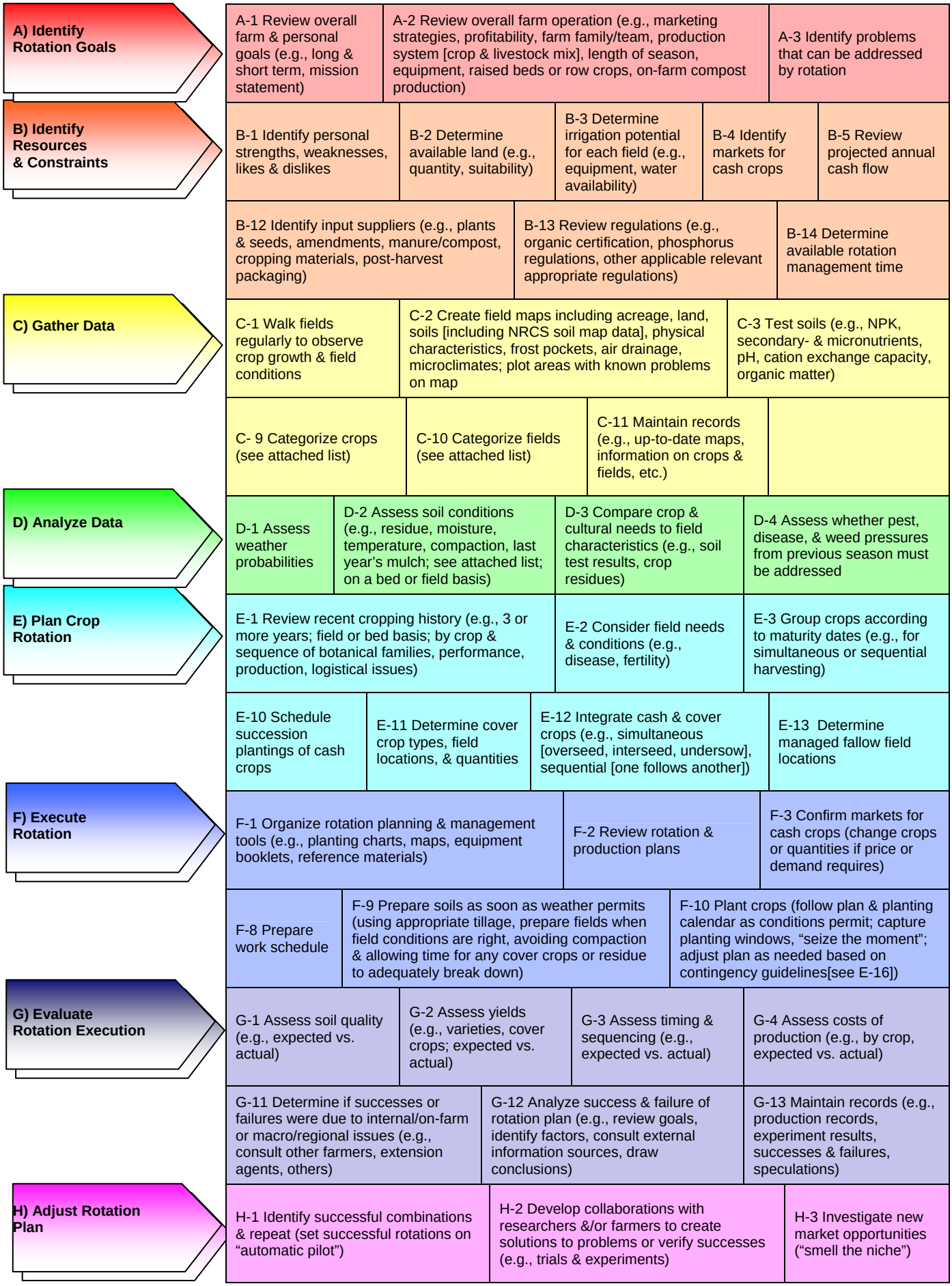
The farmer panel agreed on the following assumptions as it developed the "Manage Crop Rotation System" chart. Bear them in mind when consulting the chart!

- The word "crop" refers to both cash and cover crops unless otherwise specified.
- All duties and tasks refer to actions performed at both the whole farm level and the level of individual fields or beds, unless otherwise specified.
- Many of the farmers on our panel do extensive planning on paper. A few keep all details in their heads. Most agreed that farmers should make an effort to write things down.
- The chart does not cover all aspects of production planning – only those which the farmers thought were most important in setting parameters for the rotation and those which are most inextricably linked to rotation system management.

The panel listed the duties in a seasonal sequence. Rotation management is an iterative activity. Most rotation *planning* activities take place during the winter months.

Duties A through E primarily take place during this relatively quiet time on the farm, when production and marketing pressures are less intense and there is time catch one's breath, take stock, and look to the growing seasons ahead.
Duty F (the actual implementation of the rotation) begins in early spring and continues throughout the growing season.
Duties G and H intensify in fall and winter, following the most hectic periods of the field season. Ultimately, Duty H "wraps around" and leads the readers back to Duty A, where the process starts anew.

The tasks associated with each duty are arranged by their relative importance (as determined by the panel and verifiers) and by the order in which they should be performed. Note that the tasks associated with a duty sometimes take up more than one line.


A) Identify Rotation Goals
A-1 Review overall farm & personal goals (e.g., long & short term, mission statement)
A-2 Review overall farm operation (e.g., marketing strategies, profitability, farm family/team, production system [crop & livestock mix], length of season, equipment, raised beds or row crops, on-farm compost production)
A-3 Identify problems that can be addressed by rotation
B) Identify Resources & Constraints
B-1 Identify personal strengths, weaknesses, likes & dislikes
B-2 Determine available land (e.g., quantity, suitability)
B-3 Determine irrigation potential for each field (e.g., equipment, water availability)
B-4 Identify markets for cash crops
B-5 Review projected annual cash flow
B-12 Identify input suppliers (e.g., plants & seeds, amendments, manure/compost, cropping materials, post-harvest packaging)
B-13 Review regulations (e.g., organic certification, phosphorus regulations, other applicable relevant appropriate regulations)
B-14 Determine available rotation management time
C) Gather Data
C-1 Walk fields regularly to observe crop growth & field conditions
C-2 Create field maps including acreage, land, soils [including NRCS soil map data], physical characteristics, frost pockets, air drainage, microclimates; plot areas with known problems on map
C-3 Test soils (e.g., NPK, secondary- & micronutrients, pH, cation exchange capacity, organic matter)
C- 9 Categorize crops (see attached list)
C-10 Categorize fields (see attached list)
C-11 Maintain records (e.g., up-to-date maps, information on crops & fields, etc.)
D) Analyze Data
D-1 Assess weather probabilities
D-2 Assess soil conditions (e.g., residue, moisture, temperature, compaction, last year's mulch; see attached list; on a bed or field basis)
D-3 Compare crop & cultural needs to field characteristics (e.g., soil test results, crop residues)
D-4 Assess whether pest, disease, & weed pressures from previous season must be addressed
E) Plan Crop Rotation
E-1 Review recent cropping history (e.g., 3 or more years; field or bed basis; by crop & sequence of botanical families, performance, production, logistical issues)
E-2 Consider field needs & conditions (e.g., disease, fertility)
E-3 Group crops according to maturity dates (e.g., for simultaneous or sequential harvesting)
E-10 Schedule succession plantings of cash crops
E-11 Determine cover crop types, field locations, & quantities
E-12 Integrate cash & cover crops (e.g., simultaneous [overseed, interseed, undersow], sequential [one follows another])
E-13 Determine managed fallow field locations
F) Execute Rotation
F-1 Organize rotation planning & management tools (e.g., planting charts, maps, equipment booklets, reference materials)
F-2 Review rotation & production plans
F-3 Confirm markets for cash crops (change crops or quantities if price or demand requires)
F-8 Prepare work schedule
F-9 Prepare soils as soon as weather permits (using appropriate tillage, prepare fields when field conditions are right, avoiding compaction & allowing time for any cover crops or residue to adequately break down)
F-10 Plant crops (follow plan & planting calendar as conditions permit; capture planting windows, "seize the moment"; adjust plan as needed based on contingency guidelines[see E-16])
G) Evaluate Rotation Execution
G-1 Assess soil quality (e.g., expected vs. actual)
G-2 Assess yields (e.g., varieties, cover crops; expected vs. actual)
G-3 Assess timing & sequencing (e.g., expected vs. actual)
G-4 Assess costs of production (e.g., by crop, expected vs. actual)
G-11 Determine if successes or failures were due to internal/on-farm or macro/regional issues (e.g., consult other farmers, extension agents, others)
G-12 Analyze success & failure of rotation plan (e.g., review goals, identify factors, consult external information sources, draw conclusions)
G-13 Maintain records (e.g., production records, experiment results, successes & failures, speculations)
H) Adjust Rotation Plan
H-1 Identify successful combinations & repeat (set successful rotations on "automatic pilot")
H-2 Develop collaborations with researchers &/or farmers to create solutions to problems or verify successes (e.g., trials & experiments)
H-3 Investigate new market opportunities ("smell the niche")

A-4 Set rotation goals (e.g., insects, disease, weeds, soil, field logistics, profitability; see attached goals, set custom goals)	A-5 Review annual production plan (e.g., crop & cover crop species & varieties, desired quantities)	A-6 Balance acreage, at whole farm level, between cash crops, cover crops, livestock, and "fallow" (e.g., bare soil, stale seed bed, sod/hay, permanent pasture, or woodlot)(consider role of livestock in fertility and weed control)	A-7 Update records (e.g., whole farm plan & farm mission, record annual production plan)

B-6 Identify neighbor issues (e.g., compost pile location, spraying, chemical drift, pollination, genetic pollution)	B-7 Inventory farm equipment & facilities (e.g., tractors, greenhouses, post harvest handling areas)	B-8 Assess crop cultural needs (e.g., spacing, trellising, crop height, microclimates, irrigation)	B-9 Identify cultural constraints based on equipment (e.g., row width, irrigation)	B-10 Inventory labor availability	B-11 Assess labor strengths, weaknesses, likes & dislikes

B-15 Establish and/or maintain relationships with off-farm experts (e.g., extension, scouts, land grants, others; talk to laborers)	

C-4 Network with farmers & others (e.g., helpers, extension, others; site-specific & practice-related)	C-5 Study existing research data (e.g., cover crops, insects, diseases, fertility, weeds)	C-6 Consult field records (e.g., what was actually planted where in previous years, successes & failures)	C-7 Consult meteorological data (e.g., frost free dates, rainfall)	C-8 Consult sales data & market trends

D-5 Determine applicability of research data, advice, & other farmers' experience	D-6 Assess crop mix (e.g., market data, soil tests; over whole farm)	D-7 Maintain records (e.g., record data analysis results & decisions made)	

E-4 Consider harvest logistics (e.g., access to crops; field & row length; minimum walking & box-carrying distance; use of harvest equipment; plan for ease of loading onto trucks)	E-5 Consider companion planting options	E-6 Group crops according to botanical families	E-7 Determine crop quantities (e.g., 500 row feet, 2 acres; add 10% for contingencies)	E-8 Determine field locations of most profitable, beneficial, &/or "at-risk" crops	E-9 Determine field locations of lower-priority crops

E-14 Plan crop/rotation experiments (e.g., new crop trials, "new to this farm" rotations)	E-15 Draft annual plans (e.g., rotation plan, production plan, soil fertility plan)	E-16 Develop guidelines for contingencies in case rotation does not go as planned (e.g., guidelines for improvisation, principles, priorities, to use to make on-the-spot decisions; written or mental)	E-17 Use senses & imagination to review plan (e.g., field plans and logistics; walk fields and visualize rotation, "farm it in your head")	E-18 Maintain records (e.g., write down plan, draw maps)

F-4 Implement production plan (e.g., secure labor & train labor, prepare equipment [including irrigation], order seeds & supplies)	F-5 Monitor weather (e.g., short term [best day for planting]; long term [need to change plan due to drought])	F-6 Monitor soil & crop conditions (e.g., field readiness for planting; cover crop maturity; residue incorporation)	F-7 Monitor greenhouse conditions (e.g., observe condition of transplants relative to soil conditions; slow or accelerate growth if necessary to produce appropriate-sized transplants)

F-11 Keep unused soil covered (e.g., cover crop, mulch, trap crops)	F-12 Maintain crops (e.g., cultivate, spray, trellis, irrigate, harvest)	F-13 Adjust actions according to field & crop conditions (e.g., weather, soils, weed pressure; assign crops to different fields or beds to adjust for wetness or other problems; replant if necessary, abandon crop or replace with a cover crop to cut losses)	F-14 Maintain records (e.g., what was actually planted where, successes & failures, planting & harvest dates, compliance with regulations & organic certification)

G-5 Assess profitability on a whole farm & crop-by-crop basis (e.g., expected vs. actual)	G-6 Assess disease control (e.g., expected vs. actual)	G-7 Assess weed control (e.g., expected vs. actual)	G-8 Assess insect & pest control (e.g., expected vs. actual)	G-9 Interview work crew to determine likes, dislikes, & suggestions	G-10 Measure performance against rotation goals (positive or negative outcomes)

H-4 Tweak crop mix (e.g., based on market data & field performance; consider adding or abandoning crops or elements of rotation as necessary)	H-5 Tweak field management (e.g., change planting or plowdown dates, crop locations; shift crop families to different fields; put poorly performing fields into hay ahead of schedule)	H-6 Upgrade or improve equipment as necessary	H-7 Start process over (return to Duty A)	H-8 Maintain records (e.g., keep notes of actual changes implemented)

HOW SUCCESSFUL FARMERS MANAGE THEIR CROP ROTATION SYSTEMS

The following pages present a discussion of each of the duties and its associated tasks, with examples from the farm operations of the panelists.

A) Identify Rotation Goals

Rotations are only one, albeit critical, dimension of the art and science of farm management. Expert farmers manage their field rotations in the context of their whole farm systems, including mission and management strategies. Certain "givens" like available cropland, production system (bed or field), equipment, crop mix, cash flow requirements, and marketing strategies all define the parameters within which the rotation must be designed. Of particular importance is the annual (whole farm) production plan, which lists the mix of crops, livestock, cover crops, and fallows that the rotation must allocate to specific beds and fields for the coming year. The mix of cash and cover crops is based on market demands, labor availability, and the needs and capabilities of the soils on the farm – the rotation simply arranges where these crops are planted.

Crop Rotation Goals

These are the common crop rotation goals identified by the farmer panel. They are listed in order from most to least popular based on the verification process.

- Maintain healthy soil (e.g., chemical balance, drainage, humus, vitality, biological health, fertility management, erosion, nutrient cycling, tilth, organic matter)
- Produce nutritious food
- Control diseases, especially soil-borne diseases
- Reduce weed pressure
- Increase profitability
- Approach holistically; good rotation leads to healthy crops
- Manage farm as a whole system
- Create a diverse line of products to market
- Stabilize farm economically
- Control insects
- Add N & other nutrients in a way that is environmentally safe and conforms with regulations
- Maintain biotic diversity
- Unlock living potential of soil
- Reduce labor costs
- Balance economic viability and soil fertility
- Diversify tasks to keep labor happy and busy all season
- Balance the needs of the farm with the needs of the farmer
- Minimize off-farm inputs
- Capture solar energy
- Refine aesthetic quality of field or farm
- Bring the farmer to life;
- Develop spiritual relationship to land

Although they may not consciously review them, the farmers each have a set of farming goals that guide their rotation planning for each field and for their whole farm. Some goals are general and some are unique to certain farms. The table at left lists some of the panel's Crop Rotation Goals.

Examples of farm-specific goals include:

- *Maximizing 100% of acreage without sacrificing soil health and tilth (Jack Gurley)*
- *Managing the rotation to "confuse the weeds"*
- *Conserving and building organic matter in a light sandy soil*
- *Rotating to break the wilt cycle in solanaceous crops*
- *Keeping brassicas out of fields with clubroot (Will Stevens)*
- *Producing certified seed potatoes that must be disease-free. Therefore the entire rotation is designed to control potato diseases and increase organic matter. (Jim Gerritsen)*

B) Identify Resources and Constraints

This is the farmers' review of factors influencing the rotation and overall farm production plans. Included are field-specific issues like available land; the irrigation potential of each field or bed; crop cultural needs, such as spacing and trellising; constraints imposed by equipment (such as row width), the personal preferences of farmers and crew, the availability of field supplies (including seed), market demand and access, projected labor availability and regulatory issues. There may also be constraints on specific fields related to a particular year. For instance, heavy weed pressure the previous season may preclude small seeded salad crops being planted in that field that year.

This duty also encompasses a number of "communication" tasks such as establishing market relationships, assuring land access, making labor arrangements, and accessing expertise and suppliers.

- *The growers on the panel have different production systems. Most, but not all, use cover crops, while some use rotations with fields in hay or full season cover crops. Those with smaller acreages are less able to put extensive areas into cover crops or hay and are required to develop diversified systems to keep production going while maintaining healthy crops and soils. Some farmers with less land rely primarily on a winter cover cropping strategy.*
- *Some panelists do not cover crop. Polly Armour uses an intensive raised-bed system on a few acres with mulching. Hay and straw mulches, used on full-season crops, are rotated throughout the farm to build organic matter and control weeds. Composted livestock manure also provides for fertility needs. Rotation decisions are made to control perennial weeds.*
- *In contrast, Drew Norman's operation, with two hundred acres under cultivation, has half the farm in hay at any given time. Farm operations use farm machinery. The equipment used by this farm dictates the layout of fields and rows, and the allocation of crops to fields.*
- *Many growers plan for ease of irrigation based on irrigation block size and similar irrigation needs. Crops with similar fertility, labor, spraying, and cultivation regimes are managed "by block" when possible.*
- *Jean-Paul Courtens' rotations are based, in part, on access to the field. Some crops must be located in areas with minimal distance to packing sheds. Long rides on bumpy roads can bruise delicate produce, like tomatoes. The logistics of harvesting affect rotations in other ways as well – for example, high-traffic crops with frequent harvest or care needs must be in easily accessible areas. Salad greens and braising greens are located in the same field due to the time of day they are harvested. Crops are grouped based on when they are harvested.*

C) Gather Data

Rotation decisions, for each field and for the whole farm, are based on an impressive array of information. Some information is collected on the farm and some is gathered from off-farm sources. For example, Jim Gerritsen (who specializes in potatoes), reviews the research on potato disease and pest vectors, and uses his rotation to interrupt their life cycles. Will Stevens interviews his workers throughout the season, because they are able to observe many things he does not have time to see.

A baseline of information about both crops and fields is necessary to effectively match up crops and fields in a given year. Two crucial tasks in rotation planning relate to gathering and organizing crop and field data. The first is to "categorize" each of the cash and cover crops to be planted, noting a range of important characteristics about each. The variety of characteristics that are considered indicates the complexity of the issues which are balanced in crop rotation decisions. See the box below.

Similarly, farmers also “categorize” their fields, on the basis of both long-term characteristics and shorter-term conditions. See the boxes below at left and on page 21.

- *All the farmers agreed that regularly walking the fields throughout the season is a best way to gather data and monitor up-to-the-minute and ongoing conditions. In winter, this sometimes takes the form of cross-country skiing or walking the dog. This helps them think about field conditions and logistics in previous seasons.*

Crop Categories

The table below lists the crop characteristics ranked by panel and verification farmers in order from most to least important.

- Botanical family
- Market demand
- Early, mid, and late season (planting & harvest, labor and land use)
- Susceptibility to pests & diseases
- Cash vs. cover crops
- Ability to compete with weeds
- Annual, biennial, perennial, overwintering annual
- Direct seed vs. transplant
- “Givers” vs. “takers”
- Cultural practices [e.g., spraying; cultivation, irrigation]
- Heavy vs. light feeders
- Preferred seed bed conditions
- Spacing needs
- Income per acre
- Harvest group
- Cash flow generated
- Costs per acre
- Tolerance of mechanical cultivation
- Ability to trap nutrients
- Root vs. leaf & fruit crops
- Drought tolerance
- Row vs. block planted crops
- Large vs. small seeded
- Deep vs. shallow rooted
- Tolerance of “wet feet”
- Shade tolerant vs. intolerant
- Pollination needs

Field Characteristics

These are the relatively immutable, fixed characteristics of a field, which are more difficult to change.

- Recent planting history (1-5 years)
- Wet or dry tendencies
- Proximity to water source
- Erosion potential
- Drainage
- Sun and shade
- Known problems (such as deer pressure)
- Slope
- Moisture holding capacity
- pH
- NRCS soil type
- Aspect (direction facing e.g., north)
- Air drainage
- Frost pockets
- Size
- Cation exchange capacity
- Proximity to barn or access roads
- Stoniness
- Shape

See the box on page 21 for a list of field conditions that can change rapidly.

D) Analyze Data

All of the tasks related to gathering data merge at the key phase of analyzing data, when the information gathered in the previous steps is cross-referenced and integrated and, when necessary, weighted. Respecting the previously defined market and labor parameters and overall farm and rotation goals, the critical task of this analysis is to compare the crop cultural needs to the current field characteristics and conditions. At this point the farmer-panelists assess their soil conditions (see tables on facing page), and determine whether and how pest, weed, and disease pressures from the previous season need to be addressed in this year's rotation plan. This preliminary matching of all possible crops to all possible fields is the foundation of the rotation plan.

- *After harvesting late snap beans, wet weather prevented Roy Brubaker from seeding a rye cover crop. Therefore oats and field peas will be scheduled for early spring planting. This cover crop will be plowed down prior to planting late fall brassicas.*
- *Sometimes bad autumn weather leads to non-uniform cover crop growth. This does not change Brett Grohsgal's overall rotation but does change details and sometimes his crop mix. Heavy feeders are planted where the cover crop was most successful. For example, beefsteak tomatoes, which are heavy feeders, would get that part of Solanaceae acreage that saw good cover crop growth, whereas thrifty cherry tomatoes would get the remainder. In Cucurbit acreage, heavy-feeding and high-value watermelons would receive the choice areas, while lower-value and resilient winter squash would be assigned to the less fertile areas. All of these decisions are based on careful observation and analysis.*

E) Plan Crop Rotation

This duty is the ultimate synthesis of information. It is the stage where farmers allocate fields to crops and crops to fields. This planning happens annually on a "rolling basis". First, they review the cropping history of each field or bed for the last three (or more) years. This includes: what crops or crop families were grown; how well they performed; and any successes or failures as far as logistics of equipment use, irrigation, harvesting, and labor. This allocation of crops to fields includes consideration of future cropping plans as well as past cropping history for each field. Thus rotation plans are both reactive, by responding to weed pressures or other legacies, and proactive, in attempting to provide the following crop with its favored conditions.

- *Panelists spoke repeatedly about the importance of managing for proper seedbeds. If the residue of previous cash or cover crop is not fully broken down or incorporated, small seeded crops will not be successful. In spring, growers pay close attention to the levels of residue in each field and allocate crops and cover crops with the following crop in mind to ensure the necessary seed bed. In the event of unanticipated residue, small seeded crops are replaced with larger-seeded crops or transplants.*

This duty is intricately intertwined with the production plan – information such as what crops to grow, in what quantities, labor flow, required equipment, and the desired harvest dates all influence rotation in any particular field. The farmers distinguished planning the rotation from the production plan. The production plan determines what needs to be grown, while the rotation plan determines where each crop will be planted among the farm's fields and beds.

Farmers' "Rotation Rules of Thumb"

One particularly important observation is that none of the panelists think of themselves as having rigid multi-year rotation plans for their farms. Instead, they have deeply internalized knowledge of their fields and crops along with a set of principles and "rules of thumb" which they use to determine the rotation for each individual field. In the earlier years of their farms they created long term plans, which rarely worked out. While many of them have rotations for certain fields which they put on "automatic pilot" to repeat year after year, none of them do this at the whole farm level. Many of the farmers have formal or informal contingency plans to fall back on in case the rotation plan cannot be followed as planned due to wet soils, cover crops breaking down more slowly than anticipated, or other reasons. In fact it is precisely because they know from experience that weather and other factors will be unpredictable that these farmers do not have multi-year plans or even annual plans. Their improvisational guidelines rely on principles and a clear sense of priorities, and build flexibility, and the ability to respond to opportunities into the plan. Many panelists' contingency guidelines focus on what ***not*** to do – for example, at minimum, never plant solanaceous crops where other solanaceae have been grown in the past three years.

With every crop and field in mind, farmers begin the annual assignment of their highest-priority crops to fields (or beds). High priority crops include the most profitable crops, cover crops with the greatest benefits, and "at-risk" crops particularly vulnerable to pests, diseases, weather, or other issues. Farmers also base decisions on high-priority fields – for example, those with the highest fertility, prime locations, or serious problems that need to be aggressively addressed. Fields are then determined for the remaining crops, cover crops, fallow areas, (or livestock, if any). The plan is built

around the fields assigned to the highest priority crops. This "building" is based on logistical as much as biological considerations.

Once all the crops and fields are preliminarily matched on paper (most farmer panelists plot their information on farm maps and notebooks creating an annual crop plan), each farmer takes the initial plan and in the words of one panelist “farm it in your head” – that is, they use their imagination and memory to review the plan. Several actually walk the fields and use their senses to visualize how the plan would look, working through the sequence of crops and cropping operations, field to field, over the course of the season. They review any possible logistical or biological conflicts (for instance timing of operations) and adjust the plan as necessary. Most expert farmers work through their plans on paper and keep careful records. Others keep very few written records or maps and do most of their planning in their heads. Either way, the basic planning process is the same.

F) Execute Rotation

The next step in rotation management is actually implementing the annual field plan. In early spring farmers are paying daily attention to outside factors that affect how their rotation plan will be implemented or altered. Weather is monitored to find the best times for tillage or other field operations. Excessive drought or wetness effects field conditions and consequently may change the field plan. Farmers also monitor soils to see how well crop and cover crop residues have been incorporated. Cover crops are monitored to determine maturity, thickness of stands, and optimal time for incorporation. Actual planting of any crop on any field is opportunistic and depends on moisture, soil, and cover crop conditions in any given year. See the box on Field Conditions (below) for examples. Problems related to weather, soils, cover crop maturity, and weeds may cause farmers to alter their original plan. Crops may be reassigned or reallocated to different fields or beds to adjust for wetness or other factors or even to accommodate equipment situations. In the event of crop failure, crops may be replanted, abandoned or replaced with a cover crop or other cash crop. Drew Norman described this process as trying to find a "profitable punt".

Finding the right windows to prepare each field and synchronize soil preparation and planting operations across the whole farm is the common challenge for the panelists. While they want to have the soil tilled as early as possible to allow a long enough window for soil warming and sufficient residue breakdown, they must wait for workable soil moisture and temperature conditions. Growers attempt to follow their plans as closely as possible in planting in the priority fields or beds and on the schedule specified in their plan. If they have to adapt the plan they still prioritize high value or sensitive crops and fields.

While a change necessitated by weather or field conditions in one field may cause the reassignment of priority crops to other fields, general and farm-specific rotation principles remain the basis of every decision (for example, cucurbit crops will never be planted in the same field two years in a row). Often expert farmers anticipate problems that might occur (or have occurred in the past) and already have contingency plans worked out. Paul Arnold suggested that this ability to make effective "on-the-fly" adjustments is an important factor in the success of his farm.

As the season progresses, crops are harvested, succession crops are planted, and cover crops are seeded or plowed under; and the process of prioritization and allocation continues. The expert panel emphasized the importance of recording actual cropping and other events as they happen (particularly deviations from the plan) for later comparison with the initial annual crop plan.

For examples, see "Where the Rubber Hits the Road" on page 23.

Field Conditions

Conditions, listed by panel farmers, that change relatively quickly due to weather management, or mistakes and need continual monitoring**.**

- Weed pressure
- Fertility
- Known problems
- Previous cover crop benefits (e.g., weed suppression, nitrogen fixation)
- Tilth
- Biological health
- Moisture
- Soil test results
- Vitality
- Organic matter
- Nutrient cycles
- Humus
- Residue
- Chemical balance (NPK, secondary- and micronutrients)
- Aggregation
- Temperature
- Compaction
- Porosity

Where the Rubber Hits the Road: What Growers Do When Their Plans Are Derailed

Expert farmers have enough experience to know that their best plans will sometimes be derailed. They have acquired and developed many techniques to help them to adapt to all the circumstances that typically effect their rotations.

Wet Fields Delay Planting

- *A common cause of diverging from the rotation plan is wet fields in spring. This can delay plow down and residue incorporation, and consequently, residue decomposition, field preparation, and transplanting schedules. Many of the panelists switch fields when this happens, causing a cascading shift in the allocation of many crops. Priority crops are allocated to a suitable field or bed first.*
- *The condition of transplants in greenhouses is monitored to determine whether transplants are on schedule for planting out relative to soil and weather conditions. Greenhouse environments are managed to make transplant maturity conform to outside conditions.*

Poor Germination

- *David Blyn replants crop failures with fast-growing, short-season crops like radishes. He stocks extra seed for crops that can be replanted on multiple occasions such as corn and carrots. Blyn finds that often the reason for failed germination was a poor seedbed, and on the second try the seedbed is usually better.*
- *Blyn also uses cover crops to "paint" in gaps caused by failed crops or early harvests.*

Weed Problems

- *Growers sometimes have to be able to decide if a cover crop stand that has a lot of weeds is worth keeping for the fertility benefits or should be plowed under early. These judgment calls occur frequently and include consideration of multiple factors, but often must be made on the fly. Growers draw on their bank of experience and knowledge of their fields and crops to help them make decisions field by field.*
- *Brett Grohsgal responds to excess weed pressure by sowing cover crops at heavier rates.*
- *Crops with bad weed problems can be plowed down and planted to cover crops. Eero Ruuttila uses a cover crop of oats and field peas for this purpose - which also produce a marketable crop of pea shoots. Field peas alone are often outcompeted by broadleaf weeds like amaranth and lambsquarters, but growing the peas with oats overcomes this problem.*
- *One farmer uses intensively-cultivated crops to control bad weed infestations. For example, infestations of bindweed and Canada thistle are followed by a triple crop of lettuce, which is high-value enough to justify heavy and frequent cultivation. This is followed by a late allelopathic cover crop of rye.*

Other Weather Problems

- *In the event of summer drought, Don Kretschmann irrigates only the portion of the crop destined for retail markets, allowing the wholesale portion of his crops to perish.*
- *Drought can affect the germination of direct-seeded crops and shallow-rooted crops like garlic. Preventive strategies to have in place include irrigation, mulching, and maintaining good organic matter levels in the soil.*
- *Roy Brubaker found his oat and pea cover crop had not winterkilled due to mild temperatures. Planting of strawberries was delayed due to the time needed for the cover crop to break down. He planted the strawberries at closer spacings so their runners would fill in the rows more quickly for good weed control.*

Other Weed and Fertility Problems

- *Brett Grohsgal occasionally finds that a whole field needs to be temporarily removed from his rotation to rebuild fertility or manage weed infestations. Sequences of cover crops are chosen based on ability to add organic matter, fix nitrogen, survive drought, and compete with weeds. Livestock are often pastured on these fields to control weeds and add fertility.*

G) Evaluate Rotation Execution

Throughout the season, growers keep records on paper or in their heads about how their plans have been working out or evolved. At the end of the season they deliberately assess what was expected versus what actually happened. The factors they consider include: soil quality; yields; timing and sequencing; costs of crop production; profitability (both by crop and on a whole-farm basis); disease, weed, and pest control; and labor satisfaction and efficiency. Either at a desk, table or walking the farm, they more or less formally review the success of the production year on a field-by-field basis and for the whole farm.

Their rotation goals, plans, and principles are used as benchmarks against which they measure the success of the cropping season and the rotation. Successes and failures are assessed, analyzed, and evaluated, with the results recorded to assist in planning for future seasons.

- *When attempting to analyze the success or failure of various elements of the rotation, growers often talk to other growers and extension agents to make sure the issues were the result of their rotation on their farm, rather than, for example, a bad disease year for all farms in the region regardless of rotations.*
- *Several panelists interviewed their work crews at the end of the season. Workers often have suggestions for improving layout that will enhance the synchronization and efficiency of planting, weed control, harvesting, and equipment and labor use.*

H) Adjust Rotation Plan

These are the steps where farmers begin to re-plan and modify their rotation for the coming year. Of course, managing an organic cropping system is a rolling, ongoing venture. As the cropping season slows in late fall and early winter, farmers begin the planning process for another year. In Northeast organic farms there is usually something growing in most fields every season, but the important cash cropping period and most field operations occur between March and November. (Although in the southern reaches of the region, such as Maryland, hardy crops, greens and brassicas may be harvested year round). Farmers reflect on the productivity and problems of each of their fields and of the farm as a whole. They first consider slight changes or "tweaks" in their rotation management or crop plan. For example, they may alter their crop mix by adding or removing crops or changing quantities or area planted to a crop. These decisions are often conditioned by the market as well as field and crop performance. Growers may also change their field management strategies by changing dates of planting or plow down of cover crops, shifting crops to different fields, or managing the fertility of poorly producing fields by putting them into cover crops or hay ahead of schedule. Notes for next year's rotation plan, new guidelines for contingencies, and results of experiments are recorded.

- *For Paul and Sandy Arnold, high quality disease-free beets are very important for farmers' market sales. In order to maintain beet production, they decided to open up new, additional acreage to break the life cycle of soil-borne beet diseases. This also allowed adjustment of their rotation so that their fields spend a longer time in cover crops.*
- *Each of the expert farmers have identified rotations for particular fields or crops which worked well for them. These fields are set on "automatic pilot", and, in the absence of bad weather or other factors, the rotation is expected to run on those farms indefinitely. Fields with particularly characteristic soils, locations, or sizes are most likely to have an explicit rotation (see the five-crop rotations on pages 8-11 for some examples).*

Verification

Following the DACUM workshop, the chart created by the twelve-farmer panel was sent to 18 additional expert farmers for verification. Their comments validated the chart and provide further information. As the next step in the DACUM process, responding farmers reviewed each task in the chart, and indicated:

- Whether or not they perform the task on their farm
- How important the task is to managing their crop rotation system
- How difficult the task is to perform
- Whether they thought training tools for farmers should be developed for that task
- Whether they thought the task was a good subject for further research by NEON

Verification farmers also reviewed other information generated by the panel, including the crop rotation goals (page 15), the lists of crop and field characteristics (page 17), and a list of research ideas.

The boxes below list the tasks rated most important and most difficult by respondents. In addition, many of the other tables in this publication are presented in order of verification farmer responses.

Most Important Rotation Management Tasks	Most Difficult Rotation Management Tasks
• Maintain crops (F-12) • Implement production plan (F-4) • Prepare soils as soon as weather permits (F-9) • Plant crops (F-10) • Walk fields regularly to observe crops & fields (C-1) • Review overall farm operation (A-2) • Draft annual [rotation] plans (E-15) • Monitor soil & crop conditions (F-6) • Adjust actions according to field & crop conditions (F-13) • Identify problems that can be addressed through rotation (A-3) *Codes in parentheses correspond to task boxes in the chart, see pages 13-14.	• Assess profitability on a whole farm & crop-by-crop basis (G-5) • Maintain crops (F-12) • Assess whether pest, disease, & weed pressures must be addressed (D-4) • Investigate new market opportunities (H-3) • Review overall farm operation (A-2) • Review regulations (B-13) • Assess weather probabilities (D-1) • Determine if successes or failures are due to internal or regional factors (G-11) • Develop collaborations to verify successes & solve problems (H-2) • Tweak crop mix (H-4)

Research recommendation

Verification farmers also reviewed a list of research topics generated by the panel. The most popular topic recommended for research was the identification of problems that can be addressed through rotation. Twice as many farmers indicated this research was needed as compared with any other research topic recommended by the panel.

“Farmer Practices” for Managing Successful Rotations

Over the course of the three-day workshop, the farmer panel discussed the personal behaviors, attitudes and attributes they felt are important for successfully planning and implementing rotations. It isn't clear how these attributes differ from the overall suite of skills and attributes of successful farmers. However, it is clear that a solid method for managing rotations is essential for a successful organic farm. Detailed knowledge of one’s farm, an understanding of the crops and cover crops used, and broad farming experience were listed as important knowledge and skills. Other farmer practices listed by the panel are presented in the box below.

Farmer "Practices" for Successful Rotations

- Fit the crop to the site with humility; don’t try to make a poor site grow the wrong crop
- Observe and record
- Make decisions with “head, heart, and grit”
- Remember markets change rapidly; look ahead, look back, adapt to this flux
- Visualize rotation continually
- Be honest
- Remember to value personal/family time as much (or more than) business time
- Remember that *organics* = health & community, not industry
- See entire process as bringing the earth to life
- See your role as transferring the sun’s energy to human (or animal) energy as efficiently as possible

Concluding Thoughts

Growers stressed the importance of experimentation, play, and a sense of adventure in managing rotations. The art of “tweaking” every aspect of the rotation was discussed as the core of successfully managing rotations. While the chart makes rotation planning seem linear and quantifiable, all of the panelists felt that managing rotations is an integrated and intuitive cyclical process only developed through extensive experience and intensive information gathering.

Farmers and scientists found the workshop process a rewarding experience. A practitioner-based, participatory process was an appropriate starting point for developing a farmer manual for decision-making. A structured, strictly facilitated process enabled farmers’ ideas and input to be captured and used by NEON to generate a better understanding of, and respect for, the complex art of rotation management.

It was the hope of the panel that the results of their time together, and the resulting booklet (and forthcoming manual), will provide other growers a comprehensive approach to managing rotations. They hope their effort and information will allow other farmers to “make new and interesting mistakes” rather than those the panelists have made many times.

The NEON Expert Farmer Panel - January 2002

- On Four Winds Farm in Gardiner, NY, **Polly Armour** has been farming with her husband Jay on 3 acres for 15 years. They run a small CSA and also market their vegetables to restaurants, wholesalers, and at farmers' markets.

- In Argyle, NY, **Paul Arnold** owns Pleasant Valley Farm. For 14 years, he and his wife Sandy have raised vegetable crops on 5 acres, and they market almost exclusively through local farmers' markets.

- **David Blyn** farms on 12 acres in Roxbury, CT. For 13 years, his operation has sold vegetables at farmers' markets, wholesale outlets, and through a CSA.

- Village Acres Farm in Mifflintown, PA is a 30-acre farm owned by **Roy Brubaker**. He has marketed vegetables, berries, and flowers through farmers' markets, the Tuscarora Organic Growers Cooperative for 20 years, and more recently through a CSA.

- **Jean-Paul Courtens** farms 150 acres with 30 acres in cash crops on Roxbury Farm in Kinderhook, NY. He runs a 650-member CSA and has been in business for 13 years.

- In Bridgewater, ME, **Jim Gerritsen** has been raising seed potatoes that are available by mail order and through wholesale markets. Wood Prairie Farm spans 45 acres and has been in business for 26 years.

- Even Star Organic Farm in Lexington, MD is farmed by **Brett Grohsgal**, who cultivates 10 acres and manages 100. Brett, a former chef, sells to 10 restaurants, 4 grocery stores, a university, and two farmers' markets.

- **Jack Gurley** has been farming on 5 acres in Sparks, MD, for 9 years. His farm, Calvert's Gift Farm, sells vegetables through its CSA, as well as to restaurants, farmers' markets, on-farm, and with other organic growers through a cooperative.

- In Rochester, PA, Kretschmann Farm is a 650-member CSA. **Don Kretschmann** has been farming for 28 years and also sells his produce wholesale.

- On One Straw Farm, **Drew Norman** has been growing vegetables for 18 years. One hundred acres are in vegetables with another hundred in hay at any given time. One Straw Farm supplies vegetables for a CSA, farmers' markets, and wholesale outlets.

- **Eero Ruuttila** of Nesenkeag Farm in Litchfield, NH has been growing vegetables on 40 acres for 16 years. He markets to restaurants, restaurant wholesalers, food banks, and a newly formed CSA growers cooperative.

- Golden Russet Farm in Shoreham, VT spans 12 acres. **Will Stevens** has been farming for 21 years and sells his crops through a CSA, on-farm sales, farmers' markets, and to local restaurants.