Cornell

CropWare 1.0

A cuNMPS SOFTWARE PROGRAM

(Original Release Date: September 21, 2001)

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PROGRAM DEVELOPERS

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Cornell CropWare is a planning tool for the spatial and temporal allocation of manure and fertilizer. It is a computer program that integrates information on soils, crop nutrient requirements for each field, hydrological sensitivity, environmental risk factors including the New York P runoff and N leaching indices, crop rotations, and volume and nutrient content of manure. CropWare contains equations and coefficients needed to implement Cornell guidelines for meeting crop requirements with manure and fertilizer nutrients and was developed to assist New York nutrient management planners and livestock producers in generating nutrient management plans that meet NRCS standards.

This paper was presented at the workshop on ”Developing and Applying Next Generation Tools for Farm and Watershed Nutrient Management to Protect Water Quality” organized by the College of Agriculture and Life Sciences Integrated Nutrient Management Program Work Team. The workshop was held on December 19 and 20, 2001, in Ithaca NY. The correct reference is:

Rasmussen, C., Q.M. Ketterings, and G. Albrecht (2002). Cornell CropWare Version 1.0, a *cu*NMPS Software Program. In: Developing and Applying Next Generation Tools for Farm and Watershed Nutrient Management to Protect Water Quality. Cornell Animal Science Department Mimeo 220 and Crop and Soil Science Research Series E-02-1. pp 13-29.

PROGRAM DESCRIPTION

Cornell CropWare is the agronomic component of the Cornell University Nutrient Management Planning System (*cu*NMPS) that was developed for use in designing whole farm nutrient management plans for New York. The other major component is Cornell Net Carbohydrate and Protein System (CNCPS). CropWare is a tool that facilitates: 1) balancing farm manure nutrient supply throughout the year with crop nutrient demand; 2) allocating manure nutrients using best management practices to sites that are least hydrologically sensitive; and 3) determining the need for additional fertilizers to balance crop requirements with nutrient supply for optimum economic yields.

CROPWARE PLANNING PROCESS

The basic CropWare planning flow consists of several steps (see Figure 1):

1. Establish a library of farm information.
2. Determine nutrient supply from manure.
3. Determine crop nutrient requirements (N, P, K and lime).
4. Allocate manure and fertilizer to balance nutrient supply and demand.
5. Allocate annual manure and fertilizer applications over the 12 months in a year.
6. Evaluate the New York Phosphorus Run-off and Nitrogen Leaching Risk Indices and adjust manure allocations (rate, timing, and/or application method) if the risk indices are not acceptable.
7. Produce reports that will facilitate the nutrient management plan's tactical implementation.

Each of the seven steps will be described in the following sections.

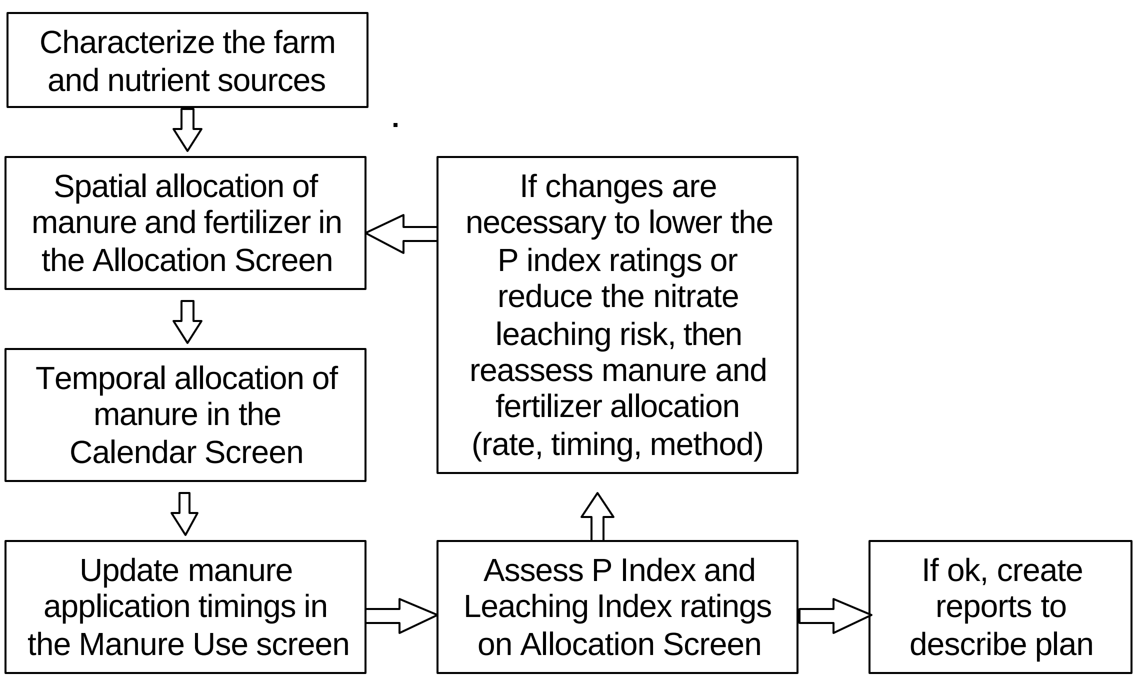


Figure 1: Cornell CropWare planning process flow diagram.

1. Establish a library of farm information

CropWare produces Nutrient Management Plan (NMP) plan for the use of farm nutrients for one up to 12 plan years (Figure 2). Global information such as the farm and planner contact information that does not change from year to year is held at the "Plan level".

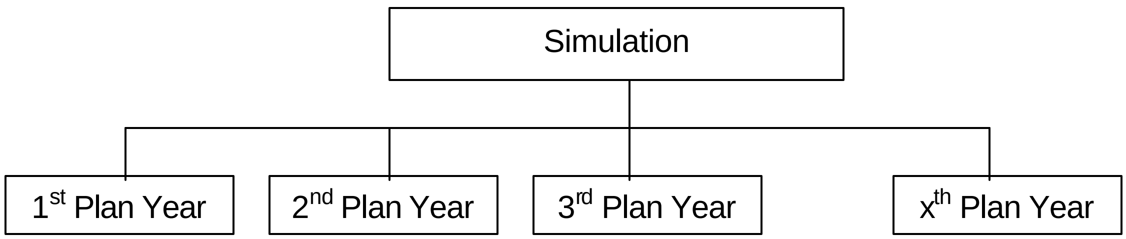


Figure 2: Plan object chart.

Plan data are organized into the following classes corresponding to different data entry screens: Contact Information, Options, Fertilizers Available, and Crop Rotations. The plan level data provide the planner with a library of data to use when creating the plan. This information is constant across plan years.

Each plan year may have unique field and manure source data sets (Figure 3). Information about total manure available for allocation and manure storage capacity are associated with each manure source. Multiple manure nutrient analyses can used to describe the manure composition from each source (see Figure 3).

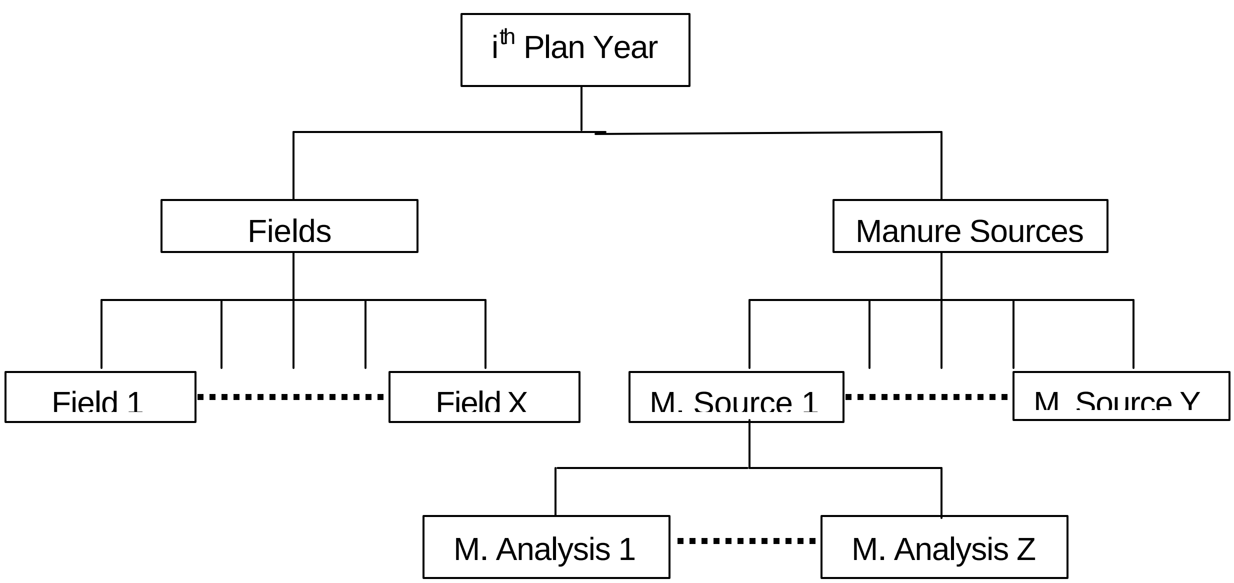


Figure 3: Plan year object chart.

2. Characterize nutrient sources - determine nutrient supply from manure

Essential to developing a nutrient management plan is an accurate estimate of the quantity of manure to be distributed to farm fields or exported off of the farm. The manure quantity must be entered or calculated for each manure source. In this context, a "manure source" is defined as a discrete manure handling system. The total annual manure quantity is the amount in the system at the start of the plan year (for storage systems) plus the amount added to the system annually less the amount exported from system annually.

There may be a significant difference between the total quantity of manure produced from livestock and the manure considered in the nutrient management plan. The quantity of manure to be handled may be increased by additions of wastewater, clean water (to facilitate pumping), silage leachate, lot runoff and precipitation. A reduction can take place as a result of animals being on pasture, manure treatment such as solids separation and composting and manure or compost exports off the farm. In CropWare, the user has the option of choosing one of three ways to estimate the total quantity of manure that needs to be allocated from each source:

1. Estimate amount added using farm records.
2. Estimate using animal parameters.
3. Estimate using number and average weight of manure applications.

The "Estimate amount added using farm records" is a single quantity value entered by the user. The "Estimate using number and average weight of manure applications" is a simple counting of manure loads hauled multiplied by the capacity of the manure spreader. The "Estimate using animal parameters" is the estimated quantity from the total manure excreted plus water, bedding and/or other wastewater added to the manure produced by the animals. The daily manure for dairy cattle is calculated based on the animal's body weight, average daily milk production and percent milk fat. The estimated daily manure excretion for all other species is based on the animal's weight as presented in table 2-1 of the second edition (1985) of the Livestock Waste Facilities Handbook (MWPS-18). Additions from precipitation include precipitation directly into uncovered storage plus run-off into storage from adjacent lots calculated as outlined in the Agricultural Waste Management Field Handbook (Part 651a, July 1996).

The total amount of manure nutrients is calculated by multiplying the quantity of manure and manure nutrient content. Manure nutrient content is extremely variable. Periodic lab analysis of representative waste samples is critical to developing an accurate nutrient management plan. In CropWare, the total amount of N in the manure, ammonia N, organic N, P_2O5 equivalent, K_2O equivalent and total solids are entered as percents. Multiple manure analysis can be entered for each manure source.

For each waste source, if there is storage, the storage capacity can be entered or calculated. This is not a required input but is necessary if the user wants to compare manure storage capacity to storage requirements and project months of storage duration. Solids accumulation and 25 year 24 hour storm precipitation and runoff are calculated following procedures outlined in the Liquid Manure Application Systems Design Manual (NRAES 89, page 46-47) and used to estimate the total waste volume required for 12 months of storage.

3. Determine crop nutrient requirements (N, P, K and lime)

The second part of CropWare's balancing act is to determine the crop demand for nutrients. CropWare calculates N, P, K and lime requirements for each field and each crop in the rotation based on equations derived from decades of field research conducted in New York by members of the Department of Crop and Soil Sciences at Cornell University. The basis for these equations is formed by soil test results obtained using the Morgan extraction solution and method (sodium acetate buffered at pH 4.8). Compliance with Code 590 (Nutrient Management Standard) developed by US Department of Agriculture's Natural Resources Conservation Service (USDA-NRCS) requires that comprehensive nutrient management plans be based on land grant recommendations. In New York, this implies that Bray-1 (HCl and NH_4F), Mehlich-III (an unbuffered solution of acetate, ammonium nitrate, ammonium fluoride, and ethylenediaminetetraacetic acid) and modified Morgan (ammonium acetate buffered at pH 4.8) soil test results for P and K need to be converted to Morgan equivalents prior to calculating the soil P contribution to the NY P index and P fertilizer recommendations. Conversion equations were developed for a number of commercial laboratories that serve New York producers. See Ketterings et al. (2001d) for conversion equations and a discussion on their use.

A. Nitrogen

There is no reliable soil test for N other than the Pre-Sidedress Nitrogen Test. Nitrogen requirements for specific crops are detailed in Ketterings et al. (2001a). Corn nitrogen requirements depend on the corn yield potential, nitrogen content of the soil and nitrogen content of sod crops on the field in the past three years adjusted for the soil's specific nitrogen uptake efficiency (ability of that soil to actually deliver N to the crop). Sunflowers, grain sorghum, sorghum forage, sudangrass, sorghum sudan hybrid, and millet are all calculated using a similar methodology. For corn the equation is:

NetRequiredN = (YP_corngrain*1.2 – SoilN - SodN)/(N_eff/100)

Where:

NetRequiredN is the total amount of N (lbs N/acre) from any source required for optimum crop production. The N requirement is increased by 20 lbs/acre for a no till crop production system due to slower soil warming in the spring.

YP_corngr is the yield potential of corn grain in bushels (85% dry matter) per acre given field soil type and artificial drainage.

SoilN is the soil's nitrogen supplying capacity. SoilN in lbs N/acre is a function of soil type and artificial drainage class.

SodN is the amount of N (lbs N/acre) released from a plowed-down sod available to subsequent crop(s) through mineralization. The amount of N available from these crop residues is a function of the sod density and quality, the percent legume and time since the sod crop was plowed or killed.

N_eff is the soil type and drainage dependent uptake efficiency (see Ketterings et al. 2001a). Plants are not able to take up 100% of the inorganic N supplied to the soil, although 100% efficiency for fertilizer additions and inorganic N from manure can be approached when small quantities are directly delivered to the growing crop (e.g. as sidedress). The percentage of applied fertilizer that does become part of the plant is called the uptake efficiency. The estimates for New York State soils range from 50 to 75 percent. In general, N uptake efficiencies (N_eff) are soil type and artificial drainage class specific.

To establish a legume or legume-grass sod, no N is required. Nitrogen requirements for established legume and legume-grass stands (i.e. topdressing) depend on management intensity and on the percentage legume in the sod. Grass and pasture nitrogen requirements are constant values based on stand management classification as "intensively" or non-intensively managed. The nitrogen recommendations for wheat, wheat seeded with legume, barley-winter barley-winter with legume, oats, oats with legume, barley-spring, barley-spring with legume, and rye production depend on the number of years since sod was grown on the field and the soil management group. For further details on the N requirements for field crops, see Ketterings et al. (2001a).

B. Phosphorus

CropWare's P recommendations (expressed in lbs P_2O_5/acre) are based on soil P level extracted with the Morgan solution. P recommendations for grain corn and corn silage on soils with STP's <50 lbs P/acre are presented in Figure 4. The solid line is the "average" recommended fertilizer P application. The dashed lines imply that recommendations are ranges rather than absolute values. Thus, optimum economic recommendations fall with the dashed line for each soil test P level. P recommendations for other field crops are given in Ketterings et al. (2001b).

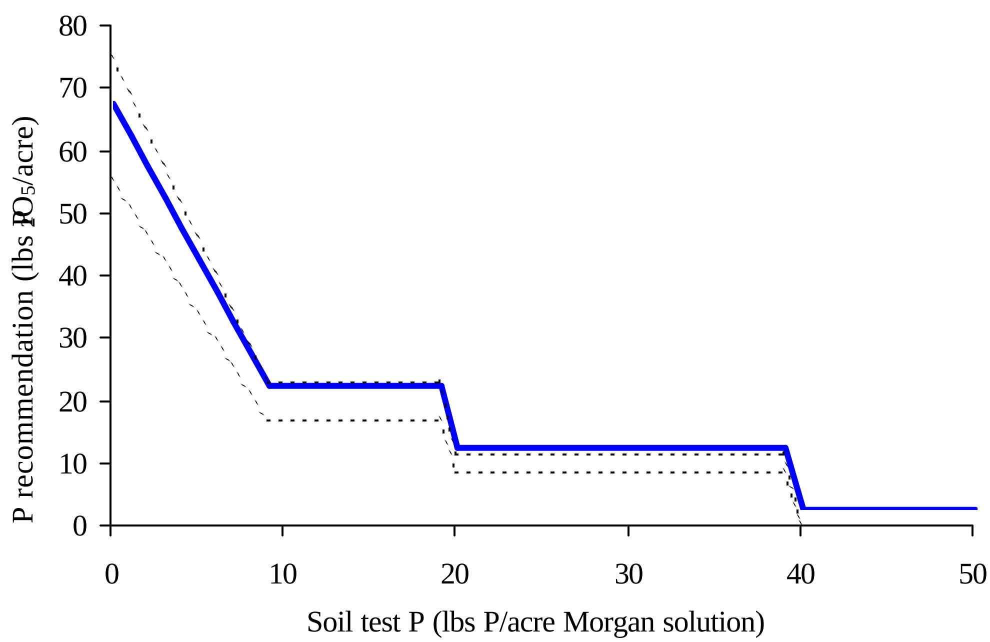


Figure 4. Cornell recommendations for P application to silage and grain corn.

C. Potassium

Potassium requirements are expressed in lbs of K_2O. The K recommendations for sod crops depend on yield potential, soil test K level and constants associated with the soil type. Non-sod crop K requirements depend on soil test K level and constants associated with the soil type. Potassium recommendation equations and constants are shown in Ketterings et al. (2001c).

D. Lime

For optimal crop production and to obtain expected yield potential, soil pH must be adjusted with lime to fit crop needs. The soil test lime requirement is determined for the crop requiring the highest pH within the rotation. Lime requirement are based on the difference between the greatest desired pH and the current soil test pH, the exchange acidity of the soil and adjustments are made depending on tillage depth and ENV (effective neutralizing value) of the liming material being used.

4. Allocate manure and fertilizer to balance nutrient supply and demand

The Allocation Screen is a grid showing each farm field as a row and nutrient requirements (N, P_2O_5, K_2O in lbs/acre), manure source, manure and fertilizer application rates, nutrient balances (N, P_2O_5, K_2O in lbs/acre) and additional user selected data items in columns (Figure 5). A second grid, at the top of the screen, dynamically displays the manure inventory balance as manure is allocated to each field.

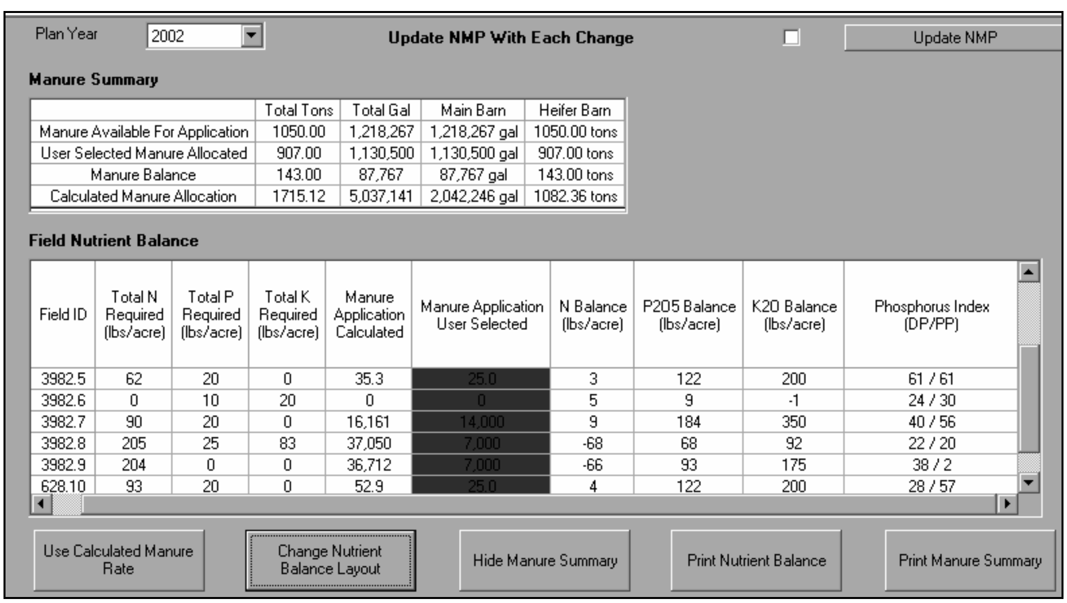


Figure 5. CropWare Allocation Screen (example).

The basic goals in the Allocation Screen are to optimally:

1. Meet crop nutrient requirements on a field-by-field basis by allocating manure and/or fertilizer at achievable rates on the farm.
2. Allocate all of the farm's manure across the land base.
3. Minimize the risk of nutrient losses via runoff, erosion, and leaching, as indicated by the Dissolved Phosphorus Index, the Particulate Phosphorus Index, and the Nitrogen Leaching Index, respectively.

The three "Balance" columns show the nutrients required less nutrients available to the plants in lbs per acre. Nitrogen available to the plant from manure is the sum of the inorganic fraction of the nitrogen multiplied by the ammonia N utilized by the crop (Table 1) and the organic fraction of the current year manure applied multiplied by the first year decay rate (Table 2).

Table 1. Estimated ammonia-N losses as affected by application method.

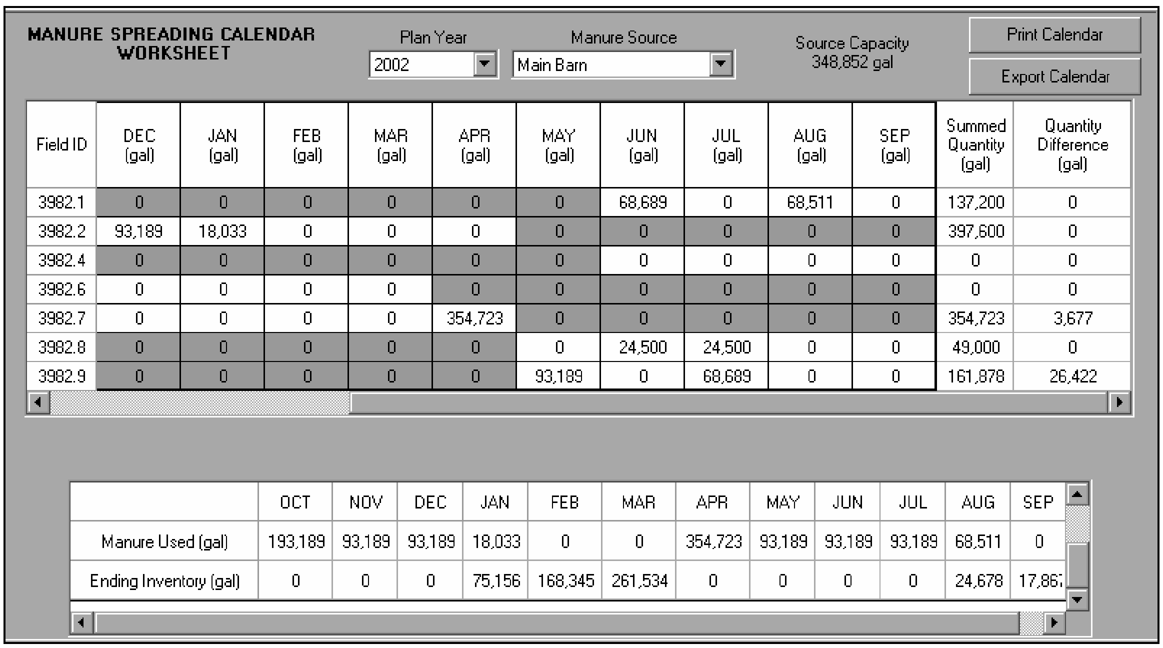
Manure Application Method	Ammonia N Utilized by the Crop (%)
Injected during growing season	100
Incorporated within 1 day	65
Incorporated within 2 days	53
Incorporated within 3 days	41
Incorporated within 4 days	29
Incorporated within 5 days	17
No conservation/Injected in fall	0

Table 2. Decay series for stable organic N in manure by animal type. A "last year release rate" of 12% indicates that an estimated 12% of the organic N applied in the manure is expected to be utilized by the crop a year after application.

		Release rate for organic N in manure (%)		
Source	Dry Matter Content	Present Year "Decay_current"	Last Year "Decay_lastyr"	Two Years Ago "Decay_2yrs"
Cows	<18	35	12	5
Cows	≥18	25	12	5
Poultry	<18	55	12	5
Poultry	≥18	55	12	5
Swine	<18	35	12	5
Swine	≥18	25	12	5
Horses	<18	30	12	5
Horses	≥18	25	12	5
Sheep	<18	35	12	5
Sheep	≥18	25	12	5

5. Temporal Nutrient Allocation

An important consideration in the development of a nutrient management plan is determining whether the applications of manure planned on the Allocation Screen are feasible given temporal constraints. For example, the plan may call for the bulk of the manure to be spread on corn fields. But, it may not be possible to carry out the plan because there is not enough labor and machinery available to spread all the manure between corn harvest and planting. Or, the quantity of manure required by the plan may not be available when the field is accessible. To plan for these contingencies, CropWare provides a Calendar Screen with a running manure inventory to plan the timing of manure applications for each month of the year (see Figure 6).



Field ID	DEC (gal)	JAN (gal)	FEB (gal)	MAR (gal)	APR (gal)	MAY (gal)	JUN (gal)	JUL (gal)	AUG (gal)	SEP (gal)	Summed Quantity (gal)	Quantity Difference (gal)
3982.1	0	0	0	0	0	0	68,689	0	68,511	0	137,200	0
3982.2	93,189	18,033	0	0	0	0	0	0	0	0	397,600	0
3982.4	0	0	0	0	0	0	0	0	0	0	0	0
3982.6	0	0	0	0	0	0	0	0	0	0	0	0
3982.7	0	0	0	0	354,723	0	0	0	0	0	354,723	3,677
3982.8	0	0	0	0	0	0	24,500	24,500	0	0	49,000	0
3982.9	0	0	0	0	0	93,189	0	68,689	0	0	161,878	26,422

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Manure Used (gal)	193,189	93,189	93,189	18,033	0	0	354,723	93,189	93,189	93,189	68,511	0
Ending Inventory (gal)	0	0	0	75,156	168,345	261,534	0	0	0	0	24,678	17,86

Figure 6. Cornell CropWare Manure Spreading Calendar Screen (example).

6. Evaluate The New York Phosphorus Run-off and Nitrogen Leaching Risk Indices

After the initial manure and fertilizer allocation, the planner must consider the risk of water quality degradation from nutrient leaching and runoff. CropWare calculates three values that act as indicators of relative risk: Nitrogen Leaching Index (LI), Dissolved P Index (DP) and Particulate P Index (PP). Best management practices associated with varying index ranges are described in the CropWare Help. Additional environmental factors include inputs for Highly Erodible Land (HEL), soil erosion estimates (RUSLE), buffer widths and other hydrologic sensitivity comments.

A. NY Nitrogen Leaching Index

The New York Nitrate Leaching Index (LI) is an estimate of the average annual percolation expressed in inches for a particular location. The LI is based on the concept that a soil's leaching potential increases as rainfall increases. The extent of the increase depends on soil drainage characteristics. For a given annual rainfall amount, well drained and excessively well-drained soils have a significantly greater leaching potential than poorly drained soils. The current LI rates leaching potential based on soil hydrologic group and seasonal (October though March) and annual average county rainfall data. The Leaching Index equations used in CropWare are those derived by Williams and Kissel (1991). Leaching Index equations and county rainfall data for each county in New York are described in Czymmek et al. (2001a). The hydrologic codes for each soil type are detailed in Ketterings et al. (2001a).

B. NY Phosphorus Run-off Index

The NY-Phosphorus Index (NY-PI) is a rating system designed to assist producers and planners in identifying fields or portions of fields that are at highest risk of contributing phosphorus (P) to lakes and streams. The New York PI includes transport (soil drainage class, flooding frequency, distance to the stream and stream type, and concentrated flow presence) and source factors (soil test P, fertilizer and manure P application rate, timing and method). A full description of the NY-PI can be found in an article in What's Cropping Up? by Czymmek et al. (2001b). This article as well as a P index calculator (Excel file) can be downloaded from the Nutrient Management Spear Program website at http://www.css.cornell.edu/nutmgmt/index.html.

The NY-PI assigns two scores to each field based upon its characteristics and the producer's intended management practices. Dissolved P Index (DP), addresses the risk of loss of water-soluble P from a field (flow across the field or through the soil profile) while Particulate P Index (PP) estimates the risk of loss of P attached to soil particles and manure.

The NY-PI scores will rank a field to determine its susceptibility to P losses. Fields with high or very high site vulnerability should be managed with minimizing P losses in mind. A low or medium ranking implies management can be nitrogen based. The NY-PI score will also indicate whether other management changes such as winter spreading must be addressed. It is, however, important to note that the PI is not a measure of actual P loss, but rather an indicator of potential loss. A high or very high PI score is a warning to further examine the causes, and a low PI score means the risk of phosphorus loss is reduced, but perhaps not eliminated.

7. Produce reports that will facilitate the nutrient management plan's tactical implementation

Finally, after the plan has been adjusted to satisfy feasibility constraints and environmental concerns, the user creates reports to describe and implement the plan. In CropWare, users can construct, print and save customized reports that can be exported to word processing, spreadsheet and mapping/GIS software. The Work Order component of CropWare allows creation of a tactical plan, for the person(s) applying manure, of how many loads to apply per field per month per spreader. CropWare also provides a framework to collect and store manure application records.

Appendix A shows all program inputs and outputs. An example of a summary report on crop, livestock and nutrient indices is shown in Appendix B. Appendix C shows an example of a detailed field report while an example of a nutrient management plan for a farm with 10 fields is given in Appendix D.

PROGRAM APPLICATIONS

Cornell CropWare is as a decision aid for farmers and consultants to create a site-specific nutrient management plan which will promote nutrient recycling and limit environmental degradation and meets NRCS standards for nutrient management. Cornell CropWare can be used to generate supporting documentation for development of CAFO compliant Comprehensive Nutrient Management Plans in the following areas:

- General information
  - Farm and producers name and address, planner name and address, county, livestock enterprise, number of animal units and age classes.
- Field specific information
  - Field number, acreage, land use, RUSLE, and HSA.
- Soil Management/Erosion Control
  - Soil type, crop rotation, type timing, and depth of tillage.
- Fertility program information and environmental risk
  - N leaching index, P runoff index, soil tests results including the soil lab and extraction method, soil pH maintenance recommendations, fertilizer recommendations considering manure applications, and nutrients in sod.
- Manure/Waste Utilization
  - Bedding material and quantity, estimate of annual waste production, waste spreading schedule based on the priority nutrient, template available to record manure analysis and applications.
- Manure Transfer and Storage Existing Facilities
  - Capacity calculated and reported in terms of volume and time.

The Cornell CropWare is currently being used to train extension agents, NRCS and SWCD employees, consultants and other CNMP planners. The system is being used in a capstone course in Animal Science (Livestock and the Environment) at Cornell University. In this course, senior dairy fellows and graduate students learn the principles of improving dairy farm sustainability and apply the knowledge using Cornell CropWare to develop a nutrient management plan for farm case studies.

FOR MORE INFORMATION

A CD with the software, tutorials, extensive help section and documentation can be obtained from Michelle Cole (e-mail: mlc44@cornell.edu; phone: (607) 255-7712; mailing address: 130 Morrison Hall, Cornell University, Ithaca NY 14853) or downloaded it directly from http://www.css.cornell.edu/nutmgmt.html. The software is available at no cost to New York users. Registered users are automatically subscribed to the CropWare listserve and will be kept updated on new releases through this listserve.

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APPENDIX A: LIST OF INPUTS REQUIRED, AND OUTPUTS OBTAINED

Input Simulation (Global) Data:

Producer Name	Farm Name	Farm Address	Farm CityStateZip
Farm Phone	FarmFAX	Farm_email	Planner Name
Planner Company	Planner Address	Planner CityStateZip	PlannerPhone
Planner FAX	FarmWatershed	Farm County	First_NMP_year
Annual Precipitation	Winter precipitation	25 yr rainfull	RunOffValuePaved
RunOffValueUnpaved			

Input Data associated with Fields

Field Name	Acres	Date Sampled	SampleLab
RotationName	Crop array[1..20] of string	StandingYear	SoilName
SoilTest_pH	SoilTest_P	SoilTest_K	SoilTest_Zn
SoilTest_Mg	SoilTest_B	SoilTest_Fe	SoilTest_Mn
TillageDepth	Exchange_acidity	ArtificialDrainage	PSNT
PercentLegumeInSod	FieldCounty	FieldAccess	ManureRate
ManureApplicationSource	ManureSource	ManureTest	ManureTiming
HydroSenComment	User_ypc	FertilizerName(1..4)	FertilizerRate(1..4)
FertilizerIncorp(4)	FertilizerTiming(4)	NutrientPriority	AmmoniaConservation
ManureTiming	Flooding Frequency	WaterbodyType	Distance to Waterbody
RUSLE	Comments	HEL	

Input Data Associated with Manure Analysis

ManureAnalysis_N	ManureAnalysis_NH_4N	ManureAnalysis_OrganicN	ManureAnalysis_P_2O_5
ManureAnalysis_K_2O	ManureAnalysis_DM	ManureAnalysis_Date	

Input Data Associated with Manure Source

ManureSystemIDName	AnimalSpecies	AnnualProduction	Units
Density	AnimalUnits	ManureSourceCapacity	StorageDimensions
Freeboard	SolidsAccumulation	25yrStorm	ManureProductionPlus
ManureExportedOffFarm	MilkHouse Waste	SilageLeachate	BedAnnual
PercentManureToStore	SourceArea	SourceDrainage	PavedLot

Constant Data associated with Soils

SoilName	Soil_Group	Lime_Index	N_EFF_UD
N_EFF_DR	N_SUP_UD	N_SUP_DR	CORN_UD
CORN_DR	Flooding Frequency	ALF_UD	DrainageClass
ALF_DR	HydrologicGroup		

<u>Constant Data associated with Crop</u>

Crop code	Seeding_year	Crop_Description	Sodcrops
A_P	B_P	C_P	MIN_P
MAX_P	A_K	B_K(1..5)	C_K(1..5)
MIN_K(1..5)	MAX_K(1..5)		

<u>Input Data associated with Fertilizers</u>

FertilizerName	FertilizerDry or Liquid	FertilizerDensity	FertilizerCost
FertilizerUnits	FertilizerN	FertilizerP_2O_5	FertilizerK_2O
FertilizerB	FertilizerFe	FertilizerMg	FertilizerMn
FertilizerZn	FertilizerS		

<u>Output Data associated with each plan year:</u>

Total_Annual_Manure	ManureCollected_TotalN	ManureCollected_NH4N	ManureCollected_OrganicN
ManureCollected_P2O5	ManureCollected_K2O	NH4N_supply	OrganicN_supply
CommercialFertCost	FertilizerN	PI_DP_Farm	PI_PP_Farm
FertilizerP2O5	FertilizerK2O	ManureN	ManureP2O5
ManureK2O	NutrientBalanceN	NutrientBalanceP	NutrientBalanceK
LI_Farm	FarmCropAcres	CornPercent	HayPercent
PasturePercent	OtherPercent	IdlePercent	CornSilageAcres
CornGrainAcres	CornAcres	Hay50+LegumeAcres	Hay25-50LegumeAcres
Hay1-25LegumeAcres	Hay0LegumeAcres	PastureAcres	OtherCropAcres
IdleCropAcres	FarmAnimalUnits	FarmAU_dairy	FarmAU_beef
FarmAU_poultry	FarmAU_swine	FarmAU_sheep	FarmAU_horses

<u>Output Data Associated with Field</u>

LoadsPerField	Nreq	Preq	Kreq
ResidNlastyr	ResidN2yrsago	legumeN	Man_Recommend
TotalLime	yp_alfalfa#	yp_corn#	Soil_n#
N_eff#	ysp%	SodN	ResidualN_manure
SodN	NetRequired_N	FieldNBal	FieldPBal
FieldKBal	PI_DP_Field	PI_PP_Field	LI_Field

APPENDIX B: CROP, LIVESTOCK AND NUTRIENT INDEX SUMMARY (EXAMPLE)

Crop, Livestock, and Nutrient Index Summary

Crop Plan

	2002		2003	
	Acres	Percent	Acres	Percent
CORN				
1st Year Corn	19.6	10%	24.7	13%
2nd Year Corn	17.9	9%	0.0	-
3rd+ Year Corn	34.1	18%	54.8	28%
Total Corn Silage	71.6	37%	79.5	41%
Total Corn Grain	0.0	-	0.0	-
HAY				
1st Year Hay	44.9	23%	45.2	23%
2nd Year Hay	18.2	9%	16.5	9%
3rd Year Hay	0.0	-	18.2	9%
4th+ Year Hay	58.6	30%	33.9	18%
Total Hay	121.7	63%	113.8	59%
PASTURE	0.0	-	0.0	-
BEANS	0.0	-	0.0	-
SMALL GRAINS	0.0	-	0.0	-
SOYBEANS	0.0	-	0.0	-
SORGHUM	0.0	-	0.0	-
Idle & Other	0.0	-	0.0	-

Livestock

Animal Type	Animal Units	
	2002	2003
Cattle	256	206
Poultry	0	0
Swine	0	0
Sheep	0	0
Horses	0	0
Total Animal Units	256	206
Animal Units/Crop Acre	1.3	1.1

Nutrient Index Summary
Farm Weighted Phosphorus Index (DP/PP): 18.12 / 11.83
Farm Weighted Leaching Index: 12.54

APPENDIX C: FIELD DETAIL REPORT (EXAMPLE)

Field Detail Report - 3982.5 (5), 17.9 acres

Crop Rotation

Plan Year	1999	2000	2001	2002	2003	2004
Crop/Standing Year	AGT3	AGT4	COS1	COS2	COS3	AGE1

Soil

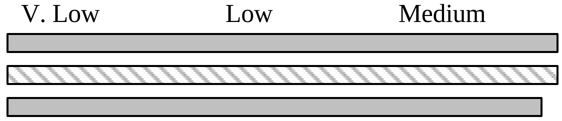
Soil Name: BATH	Artificial Drainage: Adequate	Soil Group: 3
Tillage Depth: 7-9 Inches	Percent Sod: 1-25% Legume	

Risk Factor

Highly Erodable: True
Hydrologic Group: C

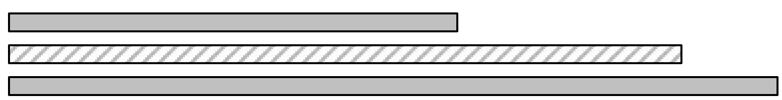
Hydrologic Sensitivity: KEEP MANURE 100 FT FROM STREAM EDGE

	Value	V. Low	Low	Medium	High	V. High
PI-DP	66.9					
PI-PP	66.9					
LI	7.4					



Soil Test Results (Lab: CNAL - Extraction Method: Morgan - Sample Date: 4/11/01)

	Value	V. Low	Low	Medium	High	V. High
pH	7.0					
Phosphorus (lbs/acre)	11.0					
Potassium (lbs/acre)	245.0					
Magnesium (lbs/acre)	0.0					
Calcium (lbs/acre)	0.0					
Ex. Acidity (ME/100g)	0.0					



Nutrient and Lime Requirements For 2002 Plan Year

Lime: 0.0 (tons 100% ENV Lime/acre)
Nitrogen: 62 (lbs N/acre)

Phosphate: 20 (lbs P2O5/acre)
Potash: 0 (lbs K2O/acre)

Nutrient Management Plan (2002)

Manure Source	Test	Rate	Application Method	Timing
Heifer Barn	Heifer 2002	25.0 tons/acre	Surface App on Frozen or Saturated Ground	Feb-Apr

Fertilizer Name	Rate
21-17-0	9 gal/acre

APPENDIX D: NUTRIENT MANAGEMENT PLAN REPORT (EXAMPLE)

Nutrient Management Plan

Manure Available For Application: 1,218,267 gal & 900.00 tons
Calculated Manure Application: 1,716,248 gal & 632.76 tons
Manure Allocated: 1,130,500 gal & 694.50 tons

Field ID	Field Name	Acres	2002 Crop	Residual Sod N	Gross N Req.	Residual Manure N	Total Nutrients Required (lb/a)			Nutrients From Applied Manure (lb/a)			Nutrients From Fertilizer (lb/a)			Nutrient Balance (lb/a)			PI (DP/PP)	LI
							N	P2O5	K2O	N	P2O5	K2O	N	P2O5	K2O	N	P2O5	K2O		
3982.1	1	19.6	COS1	138	30	14	16	0	0	39	93	175	0	0	0	23	93	175	36 / 13	18
3982.2	2	28.4	ALE1	0	0	10	0	83	20	78	187	350	21	0	0	99	104	330	38 / 9	18
3982.3	3	24.7	ALT4	0	0	14	0	0	0	18	50	80	0	0	0	18	50	80	52 / 45	18
3982.4	4	18.2	ALT2	0	0	22	0	10	0	0	0	0	0	0	0	0	-10	0	6 / 7	18
3982.5	5	17.9	COS2	24	78	16	62	20	0	44	125	200	21	17	0	3	122	200	67 / 67	7
3982.6	6	16.5	AGE1	0	0	22	0	10	20	0	0	0	5	19	19	5	9	-1	24 / 30	7
3982.7	7	25.6	COS4	0	109	19	90	20	0	78	187	350	21	17	0	9	184	350	40 / 56	7
3982.8	8	7	GIT19	0	225	20	205	25	83	39	93	175	99	0	0	-68	68	92	22 / 20	12
3982.9	9	26.9	GIT19	0	225	21	204	0	0	39	93	175	99	0	0	-66	93	175	38 / 2	7
628.10	10	8.5	COS3	13	117	25	93	20	0	0	0	0	0	0	0	-93	-20	0	5 / 10	12

Nutrient Management Spear Program: http://www.css.cornell.edu/nutmgmt/index.html

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