Integrated Water Management

Rudy Garcia, Linda Scheffe, and Kenneth Scheffe, USDA-NRCS, Albuquerque, NM

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Rudy Garcia[1], Linda Scheffe, Ph.D.[2*], and Kenneth Scheffe[3]

Irrigation water management is an integral part of a complete farming system of soil, water, air, plant, animal, and human resources. The New Mexico Integrated Water Management Handbook, http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html, is intended to be user friendly for use by planners with producers. NRCS provided training for planners, partners and producers on "how-to" evaluate and understand site-specific field conditions, including chemical, biological and physical. This enables us to evaluate and implement best management practices/approaches for cropland management within an integrated farming system. Considering how the farm fits into broader watershed management (e.g. off-site effects and resource opportunities) is also essential to problem-posing and problem-solving resource management success and development of sustainable communities.

The Handbook provides guidance on understanding and improving soil quality, water quantity/quality, air quality, nutrient and salinity management, crop yield and quality, irrigation water management, integrated pest management. It also provides guidance on reducing overall on-farm energy use, inputs, production costs, pest incidences, pumping costs, as well as soil and water losses. The end result targets becoming a more economical, sustainable farming enterprise, including resource efficient and resource conserving.

The key approach to achieving integrated sustainable management is to think system (ecosystem, whole farm, and watershed), think critically (connect the dots), actively seek resource opportunities, emphasize technology "exchange" vs. "transfer" with other producers and partners, plan creatively and flexibly, and focus on keeping energy flow through the integrated system. A reemphasis on biological factors is also necessary since recent agriculture has essentially forgotten biological, but rather focused on chemical and physical factors. Improving soil quality is key to improving soil, water, air, plant, and animal resources. Case studies, field trials, demonstrations are all important approaches for technology exchange. Interdisciplinary teams including producers and partners are essential in developing integrated sustainable farming systems.

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[1] State Agronomist, USDA-NRCS, Albuquerque, NM.

[2*] Lead Presenter, State Water Quality Specialist, USDA-NRCS, Albuquerque, NM.

[3] Assistant State Conservationist for Resource Inventory and Assessment, USDA-NRCS, Albuquerque, NM.

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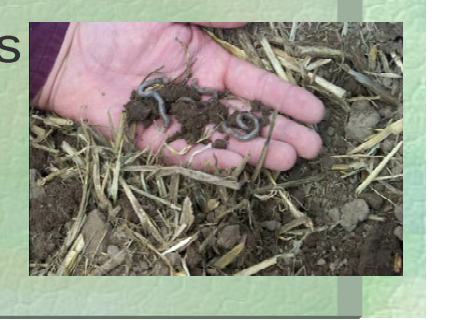
Build Soil Quality

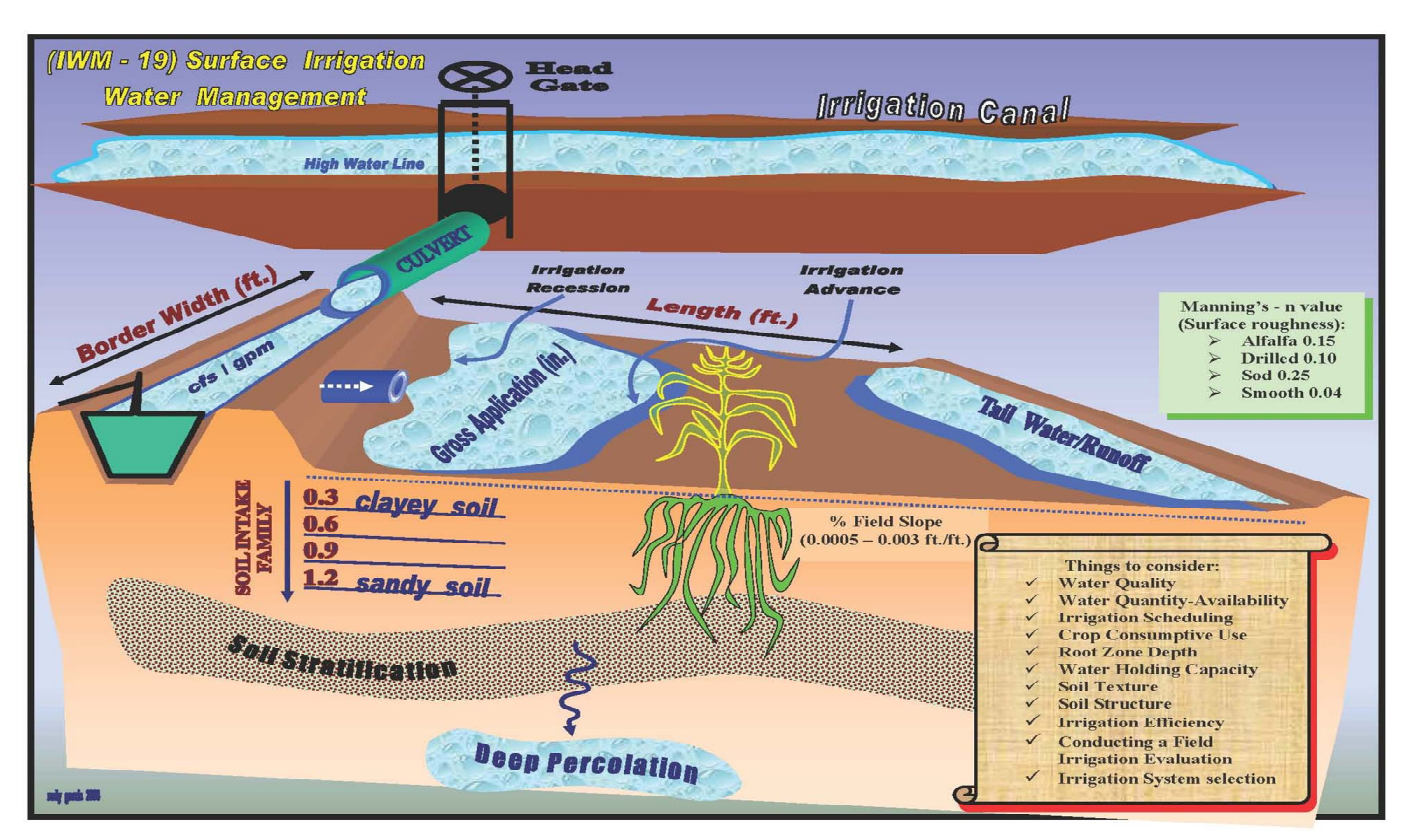
- Minimize or eliminate tillage
- Apply nutrients according to soil, plant, tissue tests and nutrient budget
- Increase on-farm nutrient cycling, plant species diversity
- Maintain ground cover year round by using cover crops and mulches and by leaving crop residues in field
- Manage/protect soil organisms preserve biodiversity
- Rotational grazing, prescribed grazing



Sustainable Farming – Maximize Biodiversity

- Integrate crop and livestock production
- Use hedgerows, insectary plants, cover crops, etc. to attract beneficial insects, bats, and birds
- Plant trees and perennial crops
- Abandon monocropping in favor of crop rotations, intercropping and polycultures
- Manage pastures to support diverse selection of forage plants
- Plant cover crops

A basic field inventory is needed to assess the parameters of an Irrigation System design & IWM



Soil Quality Test Kit (for Field Demonstrations)

Tests/Measurements:

- Soil Respiration
- Infiltration
- Bulk Density
- Electrical Conductivity
- pH
- Soil Nitrate Test
- Aggregate Stability
- Slake test
- Other (Soil Temp., Earthworms, etc.)

Each NM NRCS field office and soil survey office has a soil quality test kit for field demonstrations. Dr. Susan Andrews, USDA-NRCS, Soil Quality Team and Ray Archuleta, Manure Management Team, are assisting NM in application for NM farmers.

Integrated Irrigation/Nutrient/Residue/Salinity Management/Soil Quality Field Trials/Demos

CONSERVATION Showcase

Role of Soil Health Promoted

Continued success of agricultural systems in our world is dependent upon the ability to maintain soil health and manage water resources through conservation planning, according to New Mexico NRCS agronomists, water quality specialist, and soil scientists. And, they are out to increase understanding of the role conservation planning plays in the maintenance and improvement of soil health.

"Conservation planning seeks to take soil health and productivity from its current level and manage it to achieve its full potential," said Ken Scheffe, state soil scientist. "One of the most powerful tools to deliver soils information to farmers, ranchers, conservationists, and homeowners is the Web Soil Survey which is on the Internet."

The Web Soil Survey puts local soil maps, descriptions, data, and suitability ratings into the hands of users.

Another source of information NRCS New Mexico is making available to land and water users, in its efforts to continually provide more and better information, is the Integrated Water Management Handbook. This handbook incorporates materials that emphasize the effects of tillage, irrigation, and nutrient and pest management upon long term soil productivity. This information was used this past summer for training session for conservation planners and NRCS partners.

In addition, NRCS New Mexico has acquired soil quality test kits so its local field and soil survey offices can assess soil conditions for farmers and ranchers, and offer options and recommendations for improving soil health. Because recognizing soil health indicators is so important, NRCS New Mexico is also scheduling workshops for farmers and ranchers this year to provide hands-on demonstrations of soil sampling, testing, and evaluation of soil conditions.

"Global reduction in agricultural productivity due to soil erosion and degradation, depletion of irrigation water supplies, and competing land uses is putting a squeeze on capacity to meet increasing world-wide demand for food and fiber," said Scheffe. "Even when looking at the local picture, to continually succeed as producers we must maintain soil health and manage water resources through conservation planning."

Integration of needed conservation practices and management assures water quality, soil quality, and overall ecosystem health is maintained.

For more information about the Web Soil Survey and Integrated Water Management Handbook go to www.nm.nrcs.usda.gov

NRCS Natural Resources Conservation Service

NM Integrated Water Management Handbook

http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html, July 2008

Major NRCS Contributors:

Rudy Garcia
R. David Fischer
Linda Oyer Scheffe
Santiago Misquez
Michael Standefer
Dean Pritchett
Tom Marshall
Jean Foster
Art Ariaz (retired)
Brian Schwebke
Robert Minton
Carmella Irwin
Ray Archuleta
George Chavez
Clarence Chavez
Kenneth Scheffe
Kelley Mullen
Cindy Nycz
Luis Garcia
Mauro Herrera
Roman Jacquez

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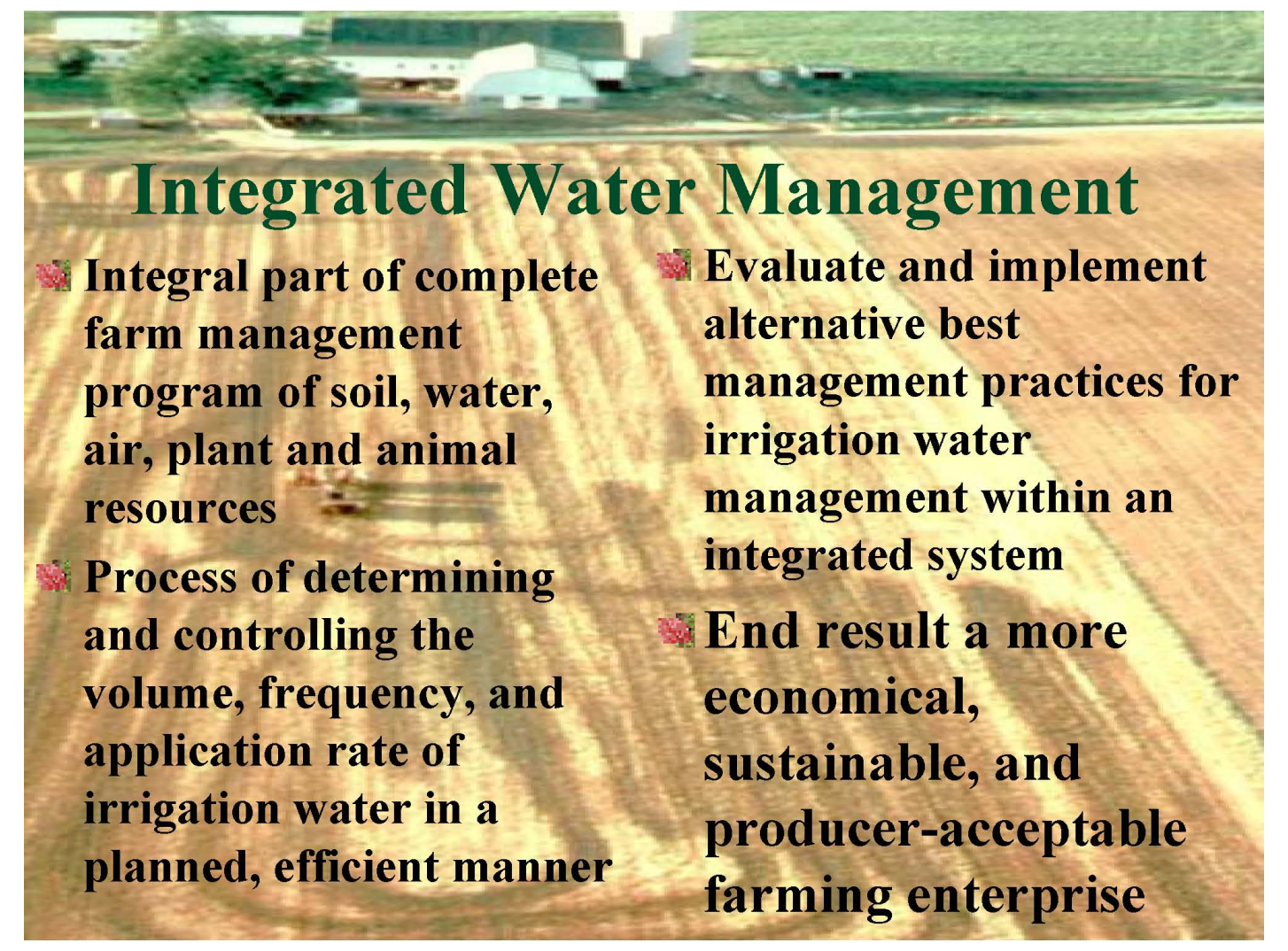
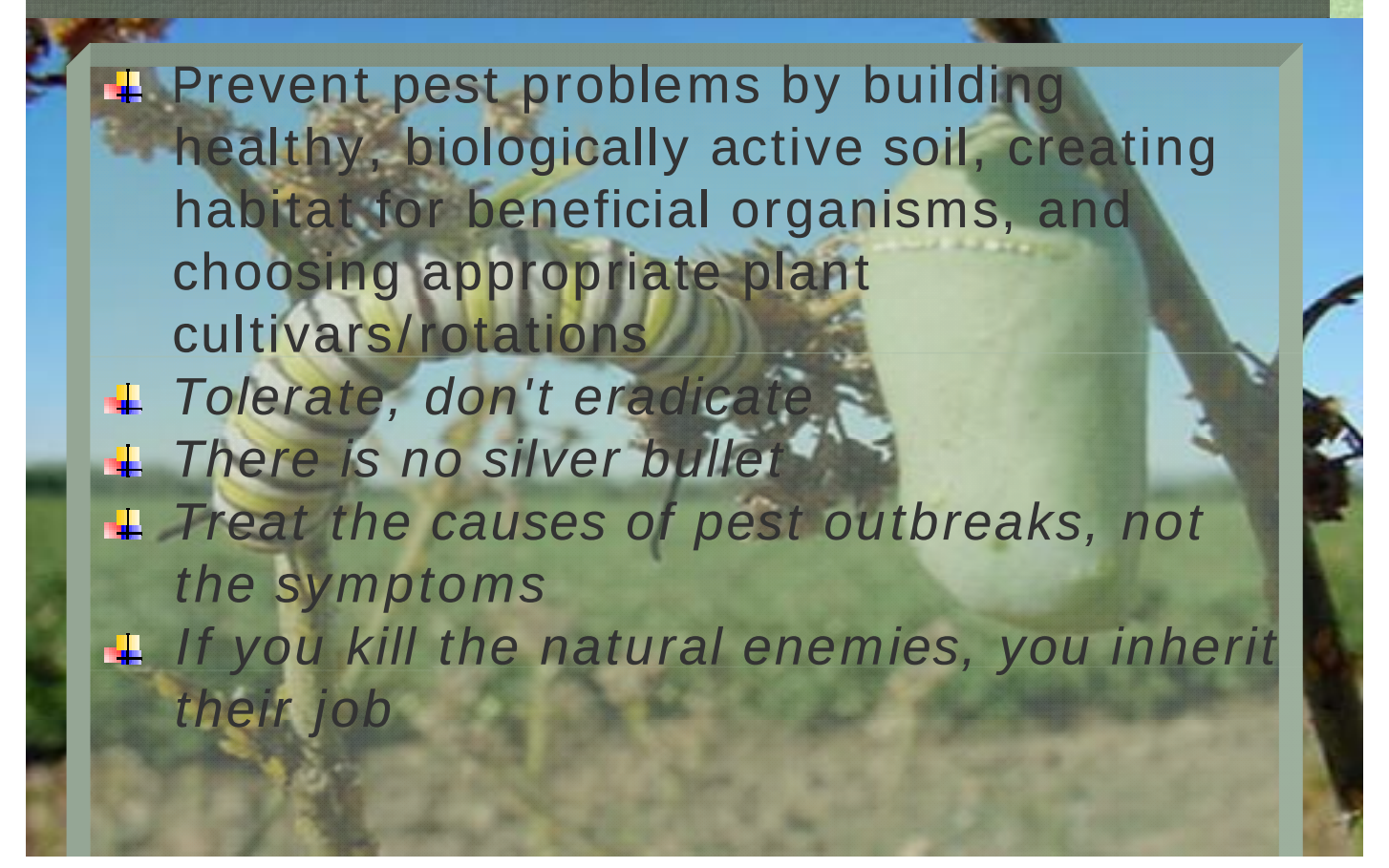


- Integral part of complete farm management program of soil, water, air, plant and animal resources
- Process of determining and controlling the volume, frequency, and application rate of irrigation water in a planned, efficient manner
- Evaluate and implement alternative best management practices for irrigation water management within an integrated system
- End result a more economical, sustainable, and producer-acceptable farming enterprise

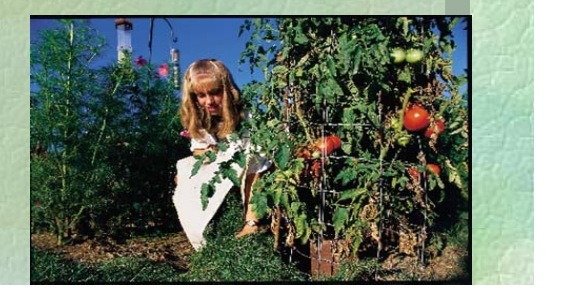
Manage Pests Ecologically

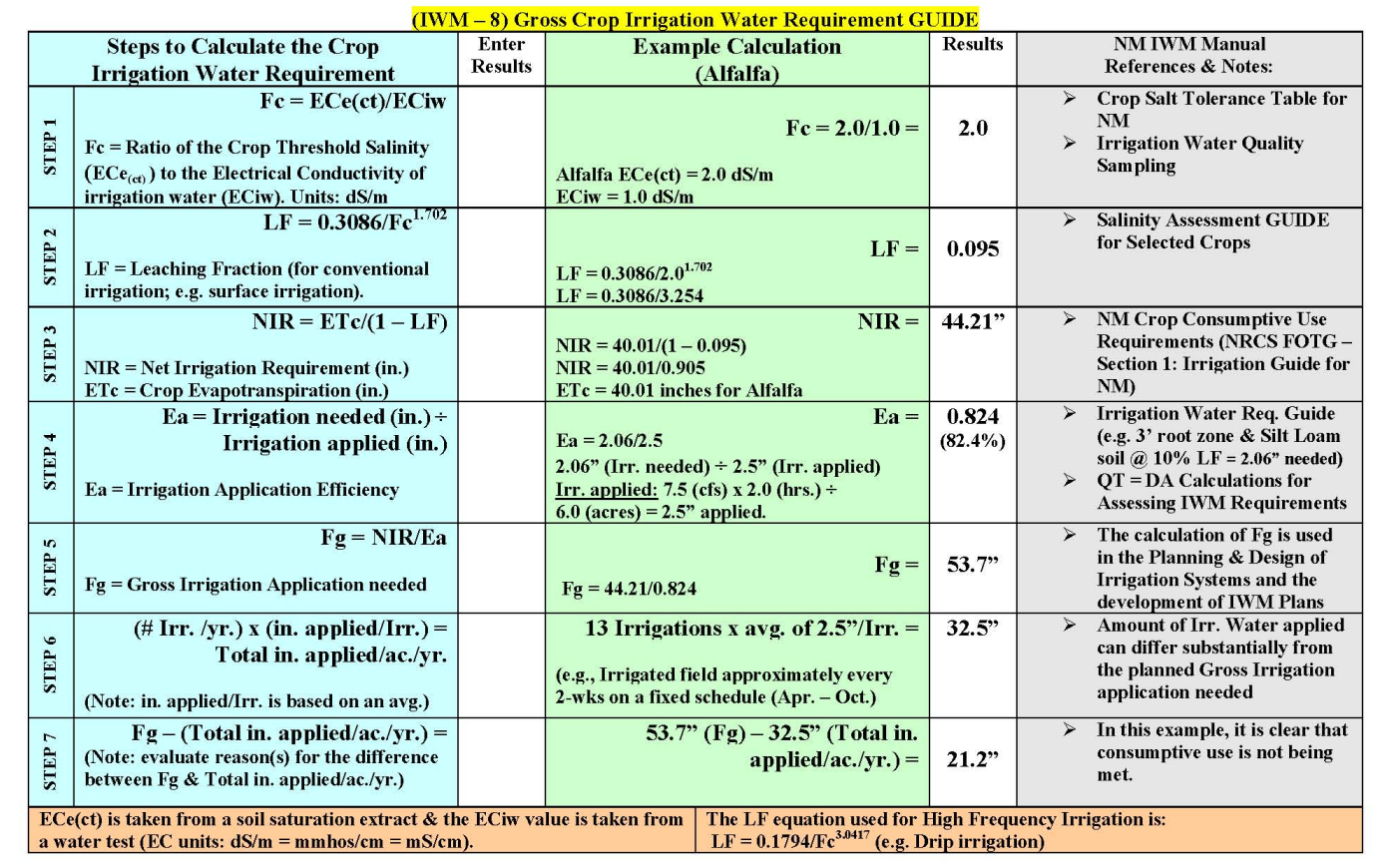


- Prevent pest problems by building healthy, biologically active soil, creating habitat for beneficial organisms, and choosing appropriate plant cultivars/rotations
- *Tolerate, don't eradicate*
- *There is no silver bullet*
- *Treat the causes of pest outbreaks, not the symptoms*
- *If you kill the natural enemies, you inherit their job*

Develop Conservation Plan

- Use integrated approach to inventory resources and develop conservation plan for whole farm
- Choose and apply conservation practices, technologies, approaches to address identified resource concerns and take advantage of opportunities
- Not only think outside the box, but step outside the box



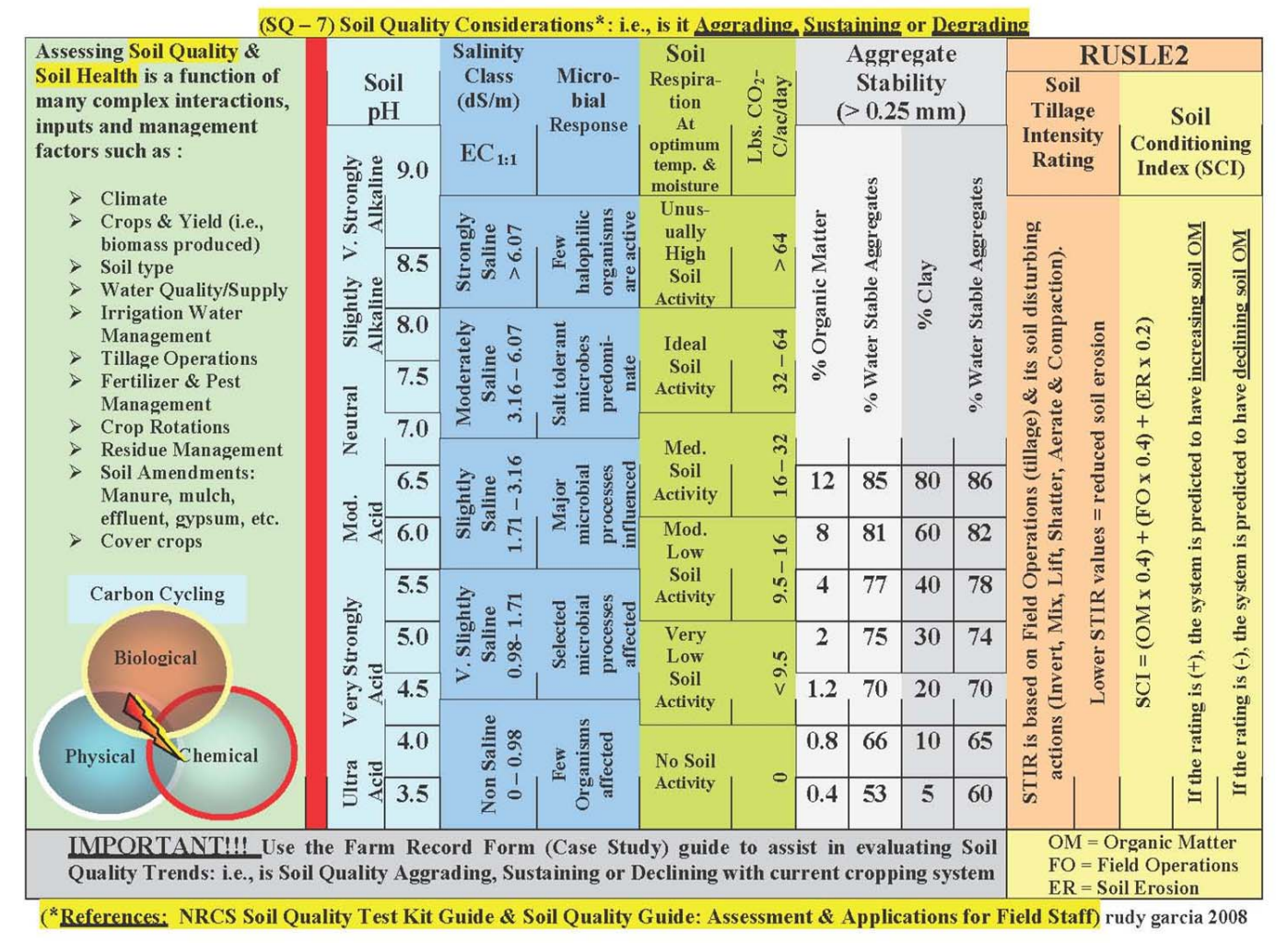


(IWM – 8) Gross Crop Irrigation Water Requirement GUIDE

	Steps to Calculate the Crop Irrigation Water Requirement	Enter Results	Example Calculation (Alfalfa)	Results	NM IWM Manual References & Notes:
STEP 1	Fc = ECe(ct)/ECiw Fc = Ratio of the Crop Threshold Salinity ($ECe_{(ct)}$) to the Electrical Conductivity of irrigation water (ECiw). Units: dS/m		Fc = 2.0/1.0 = Alfalfa ECe(ct) = 2.0 dS/m ECiw = 1.0 dS/m	2.0	➢ Crop Salt Tolerance Table for NM ➢ Irrigation Water Quality Sampling
STEP 2	$LF = 0.3086/Fc^{1.702}$ LF = Leaching Fraction (for conventional irrigation; e.g. surface irrigation).		LF = $LF = 0.3086/2.0^{1.702}$ LF = 0.3086/3.254	0.095	➢ Salinity Assessment GUIDE for Selected Crops
STEP 3	NIR = ETc/(1 – LF) NIR = Net Irrigation Requirement (in.) ETc = Crop Evapotranspiration (in.)		NIR = NIR = 40.01/(1 – 0.095) NIR = 40.01/0.905 ETc = 40.01 inches for Alfalfa	44.21"	➢ NM Crop Consumptive Use Requirements (NRCS FOTG – Section 1: Irrigation Guide for NM)
STEP 4	Ea = Irrigation needed (in.) ÷ Irrigation applied (in.) Ea = Irrigation Application Efficiency		Ea = Ea = 2.06/2.5 2.06" (Irr. needed) ÷ 2.5" (Irr. applied) Irr. applied: 7.5 (cfs) x 2.0 (hrs.) ÷ 6.0 (acres) = 2.5" applied.	0.824 (82.4%)	➢ Irrigation Water Req. Guide (e.g. 3' root zone & Silt Loam soil @ 10% LF = 2.06" needed) ➢ QT = DA Calculations for Assessing IWM Requirements
STEP 5	Fg = NIR/Ea Fg = Gross Irrigation Application needed		Fg = Fg = 44.21/0.824	53.7"	➢ The calculation of Fg is used in the Planning & Design of Irrigation Systems and the development of IWM Plans
STEP 6	(# Irr. /yr.) x (in. applied/Irr.) = Total in. applied/ac./yr. (Note: in. applied/Irr. is based on an avg.)		13 Irrigations x avg. of 2.5"/Irr. = (e.g., Irrigated field approximately every 2-wks on a fixed schedule (Apr. – Oct.)	32.5"	➢ Amount of Irr. Water applied can differ substantially from the planned Gross Irrigation application needed
STEP 7	Fg – (Total in. applied/ac./yr.) = (Note: evaluate reason(s) for the difference between Fg & Total in. applied/ac./yr.)		53.7" (Fg) – 32.5" (Total in. applied/ac./yr.) =	21.2"	➢ In this example, it is clear that consumptive use is not being met.

ECe(ct) is taken from a soil saturation extract & the ECiw value is taken from a water test (EC units: dS/m = mmhos/cm = mS/cm).

The LF equation used for High Frequency Irrigation is: $LF = 0.1794/Fc^{3.0417}$ (e.g. Drip irrigation)



(SQ – 7) Soil Quality Considerations*: i.e., is it Aggrading, Sustaining or Degrading

Assessing Soil Quality & Soil Health is a function of many complex interactions, inputs and management factors such as :

- Climate
- Crops & Yield (i.e., biomass produced)
- Soil type
- Water Quality/Supply
- Irrigation Water Management
- Tillage Operations
- Fertilizer & Pest Management
- Crop Rotations
- Residue Management
- Soil Amendments: Manure, mulch, effluent, gypsum, etc.
- Cover crops

Soil pH		Salinity Class (dS/m) $EC_{1:1}$	Microbial Response	Soil Respiration At optimum temp. & moisture	Lbs. CO_2-C/ac/day	Aggregate Stability (> 0.25 mm) % Organic Matter	% Water Stable Aggregates	% Clay	% Water Stable Aggregates
V. Strongly Alkaline	9.0								
	8.5	Strongly Saline > 6.07	Few halophilic organisms are active	Unusually High Soil Activity	> 64				
Slightly Alkaline	8.0	Moderately Saline 3.16 – 6.07	Salt tolerant microbes predominate	Ideal Soil Activity	32 – 64				
	7.5								
Neutral	7.0								
Mod. Acid	6.5	Slightly Saline 1.71 – 3.16	Major microbial processes influenced	Med. Soil Activity	16 – 32	12	85	80	86
	6.0			Mod. Low Soil Activity	9.5 – 16	8	81	60	82
Very Strongly Acid	5.5	V. Slightly Saline 0.98- 1.71	Selected microbial processes affected			4	77	40	78
	5.0			Very Low Soil Activity	< 9.5	2	75	30	74
	4.5					1.2	70	20	70
Ultra Acid	4.0	Non Saline 0 – 0.98	Few Organisms affected	No Soil Activity	0	0.8	66	10	65
	3.5					0.4	53	5	60

RUSLE2

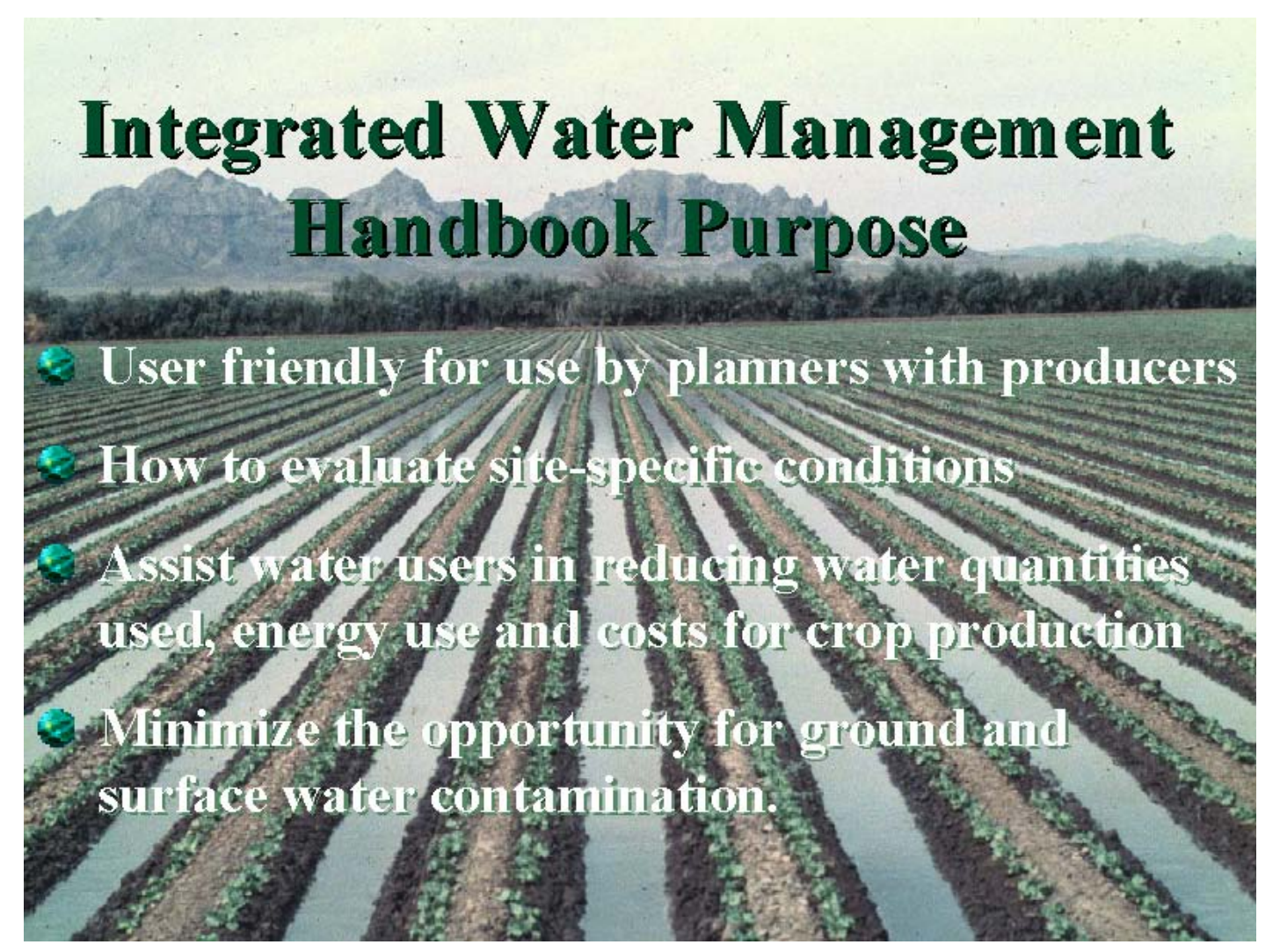
Soil Tillage Intensity Rating	Soil Conditioning Index (SCI)
STIR is based on Field Operations (tillage) & its soil disturbing actions (Invert, Mix, Lift, Shatter, Aerate & Compaction). Lower STIR values = reduced soil erosion	SCI = (OM x 0.4) + (FO x 0.4) + (ER x 0.2) If the rating is (+), the system is predicted to have increasing soil OM If the rating is (-), the system is predicted to have declining soil OM

IMPORTANT!!! Use the Farm Record Form (Case Study) guide to assist in evaluating Soil Quality Trends: i.e., is Soil Quality Aggrading, Sustaining or Declining with current cropping system

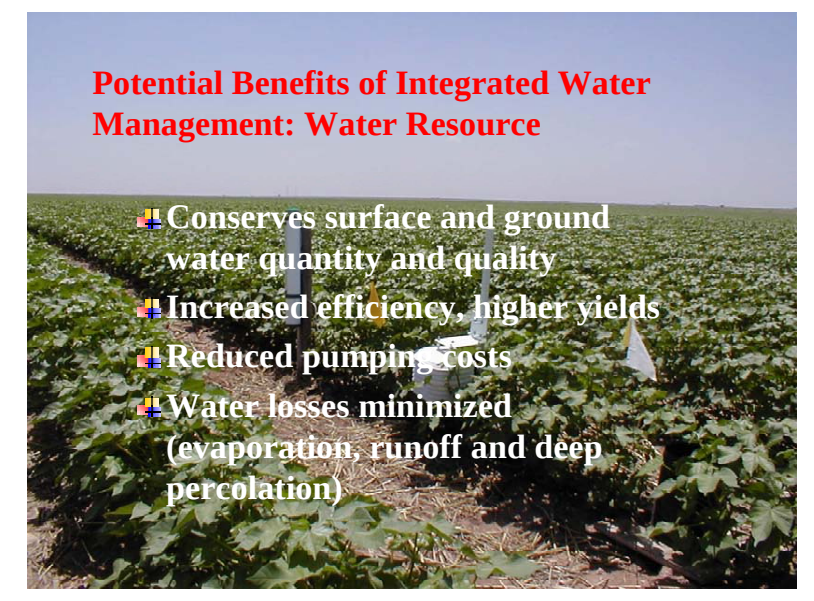
OM = Organic Matter
FO = Field Operations
ER = Soil Erosion

(*References: NRCS Soil Quality Test Kit Guide & Soil Quality Guide: Assessment & Applications for Field Staff) rudy garcia 2008

Integrated Water Management Handbook Purpose



- User friendly for use by planners with producers
- How to evaluate site-specific conditions
- Assist water users in reducing water quantities used, energy use and costs for crop production
- Minimize the opportunity for ground and surface water contamination.



Potential Benefits of Integrated Water Management: Water Resource

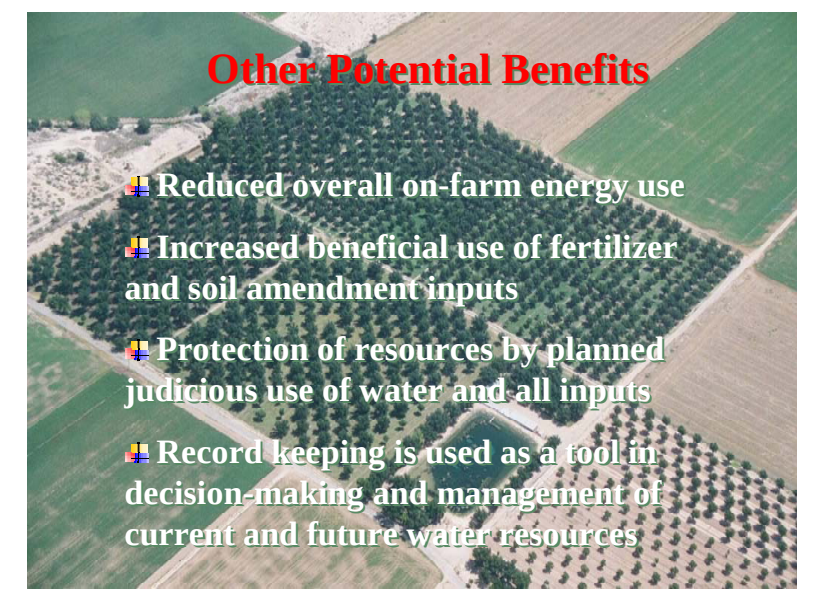
- Conserves surface and ground water quantity and quality
- Increased efficiency, higher yields
- Reduced pumping costs
- Water losses minimized (evaporation, runoff and deep percolation)

Potential Benefits of Integrated Water Management: Soil Resource

- Improved soil quality (greater yields, more crop biomass/residues, improved soil structure, organic matter)
- Reduced wind and water erosion
- Proper salinity and nutrient management (reduced use of soil amendments, reduced runoff and leaching)
- Reduction in water-logged soils

Potential Benefits: Plant Resource

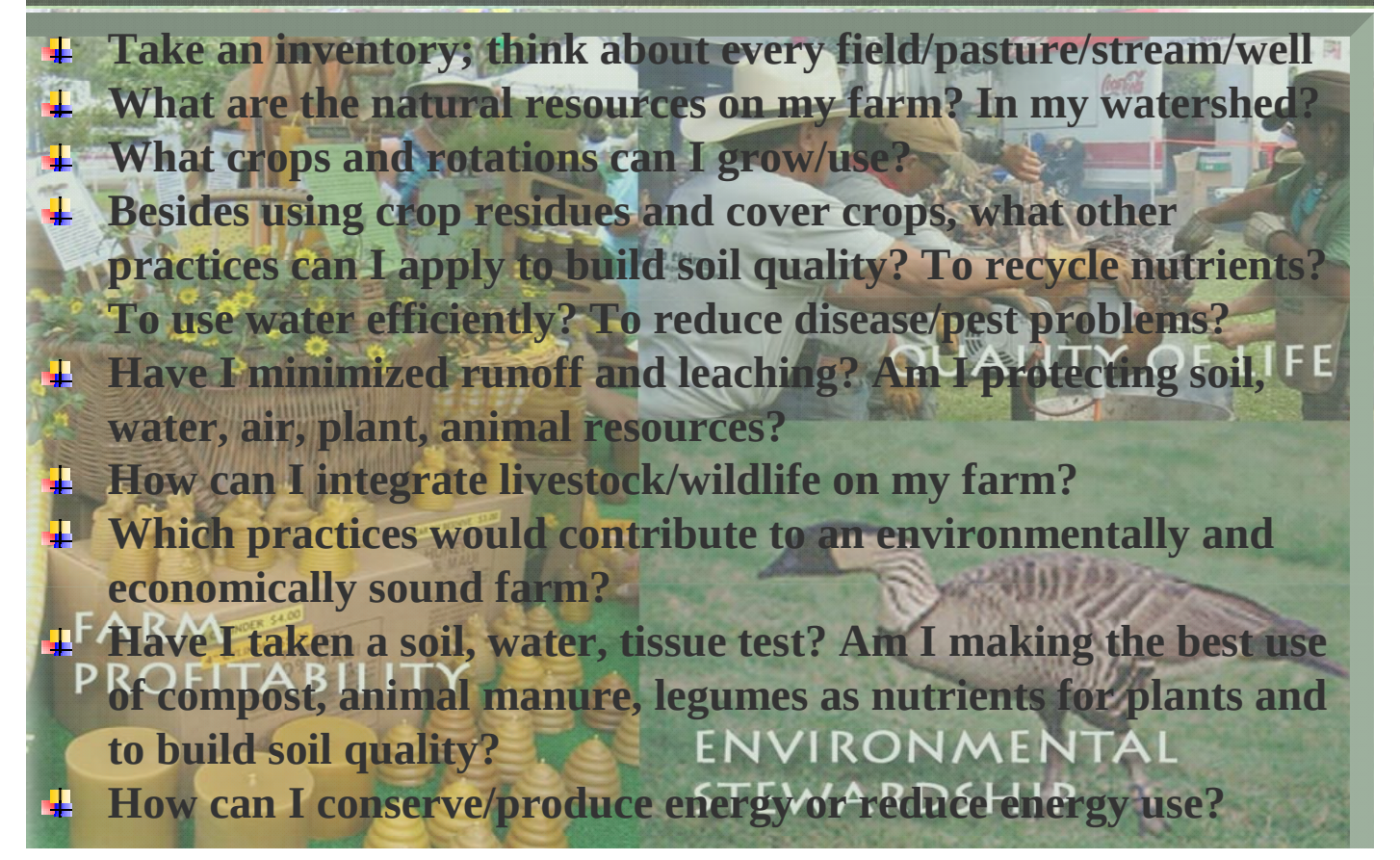
- Crop production costs reduced
- Increased crop yield and quality
- Reduced pest incidences (e.g. weeds, insects, diseases)
- Available water quantity and quality meet specific requirements of crop (consumptive use, leaching)



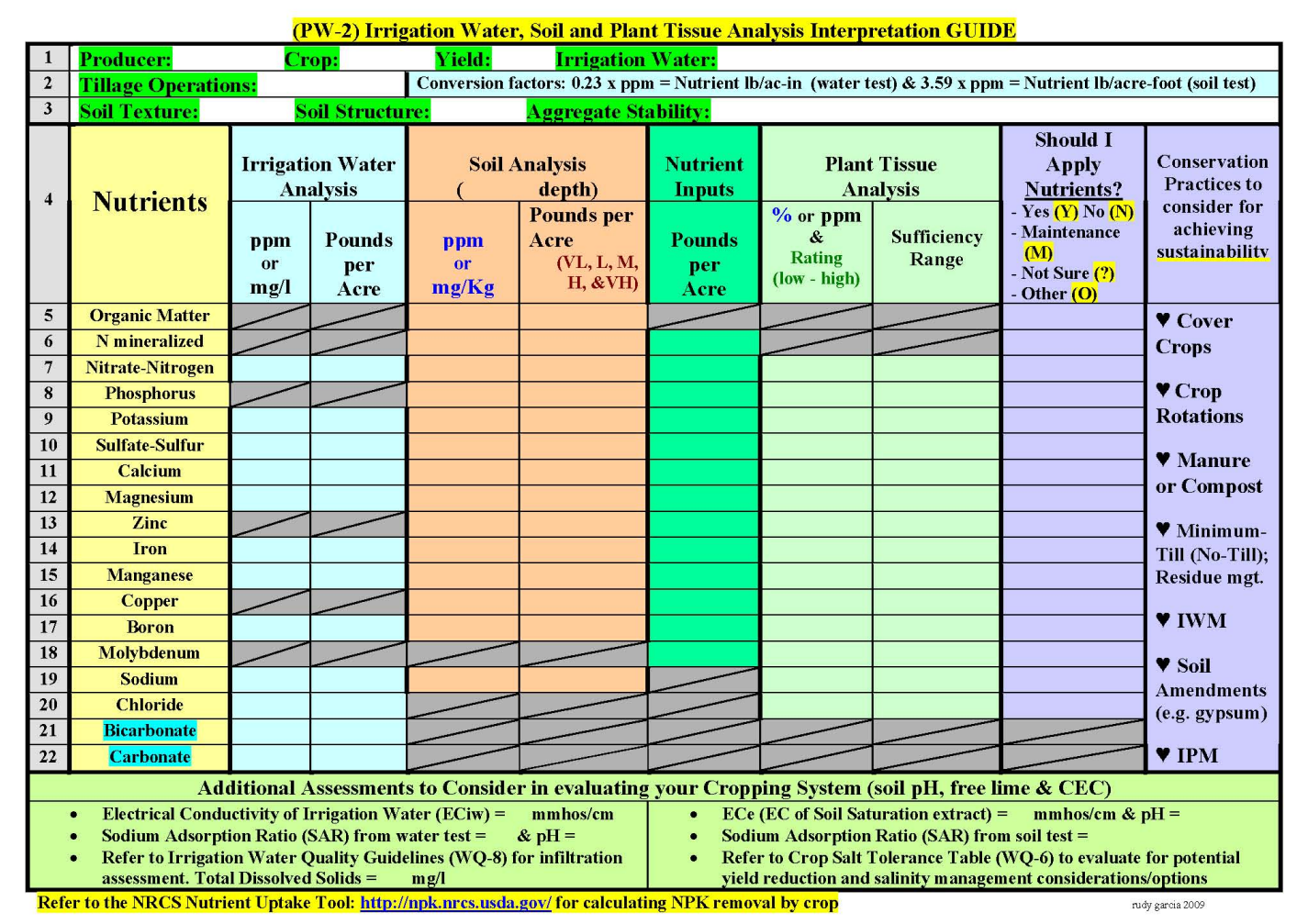
Other Potential Benefits

- Reduced overall on-farm energy use
- Increased beneficial use of fertilizer and soil amendment inputs
- Protection of resources by planned judicious use of water and all inputs
- Record keeping is used as a tool in decision-making and management of current and future water resources

Other Considerations



- Take an inventory; think about every field/pasture/stream/well
- What are the natural resources on my farm? In my watershed?
- What crops and rotations can I grow/use?
- Besides using crop residues and cover crops, what other practices can I apply to build soil quality? To recycle nutrients? To use water efficiently? To reduce disease/pest problems?
- Have I minimized runoff and leaching? Am I protecting soil, water, air, plant, animal resources?
- How can I integrate livestock/wildlife on my farm?
- Which practices would contribute to an environmentally and economically sound farm?
- Have I taken a soil, water, tissue test? Am I making the best use of compost, animal manure, legumes as nutrients for plants and to build soil quality?
- How can I conserve/produce energy or reduce energy use?



(PW-2) Irrigation Water, Soil and Plant Tissue Analysis Interpretation GUIDE

1	Producer:	Crop:		Yield:		Irrigation Water:				
2	Tillage Operations:			Conversion factors: 0.23 x ppm = Nutrient lb/ac-in (water test) & 3.59 x ppm = Nutrient lb/acre-foot (soil test)						
3	Soil Texture:		Soil Structure:		Aggregate Stability:					
4	Nutrients	Irrigation Water Analysis		Soil Analysis (depth)		Nutrient Inputs	Plant Tissue Analysis		Should I Apply Nutrients?	Conservation Practices to consider for achieving sustainability
		ppm or mg/l	Pounds per Acre	ppm or mg/Kg	Pounds per Acre (VL, L, M, H, &VH)	Pounds per Acre	% or ppm & Rating (low - high)	Sufficiency Range	- Yes (Y) No (N) - Maintenance (M) - Not Sure (?) - Other (O)	
5	Organic Matter									♥ Cover Crops ♥ Crop Rotations ♥ Manure or Compost ♥ Minimum-Till (No-Till); Residue mgt. ♥ IWM ♥ Soil Amendments (e.g. gypsum) ♥ IPM
6	N mineralized									
7	Nitrate-Nitrogen									
8	Phosphorus									
9	Potassium									
10	Sulfate-Sulfur									
11	Calcium									
12	Magnesium									
13	Zinc									
14	Iron									
15	Manganese									
16	Copper									
17	Boron									
18	Molybdenum									
19	Sodium									
20	Chloride									
21	Bicarbonate									
22	Carbonate									

Additional Assessments to Consider in evaluating your Cropping System (soil pH, free lime & CEC)

- Electrical Conductivity of Irrigation Water (ECiw) = mmhos/cm
- Sodium Adsorption Ratio (SAR) from water test = & pH =
- Refer to Irrigation Water Quality Guidelines (WQ-8) for infiltration assessment. Total Dissolved Solids = mg/l
- ECe (EC of Soil Saturation extract) = mmhos/cm & pH =
- Sodium Adsorption Ratio (SAR) from soil test =
- Refer to Crop Salt Tolerance Table (WQ-6) to evaluate for potential yield reduction and salinity management considerations/options

Refer to the NRCS Nutrient Uptake Tool: http://npk.nrcs.usda.gov/ for calculating NPK removal by crop

rudy garcia 2009

Active Carbon Test Kit (We are evaluating NM soils with Kit)

The NRCS Active C Field Kit
Does 10 samples at a time (5 gr each)

Dr. Cynthia Stiles, USDA-NRCS Lincoln, Nebraska Soils Lab, is analyzing NM soils for Active Carbon and assisting in Interpretation and application for NM farmers

Taking the color density reading

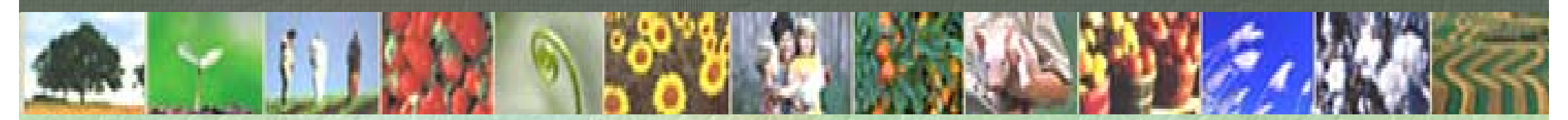
Develop a Case Study/Conservation Plan

NM Producer Sustainable Workshops

Resource Inventory Includes:

- Irrigation Water Samples
- Soil Samples
- Plant Tissue Samples
- Irrigation System evaluation
- Soil Texture, Structure and, most importantly, Aggregate Stability
- Tillage Operations
- Fertility Inputs
- IPM
- Cover Crops
- Crop Rotations

Keys to Achieving Sustainable Farming



- use integrated systems approach (ecosystem, whole farm, watershed)
- problem-posing, problem-solving
- actively seek resource, watershed, marketing opportunities
- resource efficient and resource conserving
- technology "exchange" vs. "transfer"
- develop whole farm conservation plan creatively and flexibly, step outside the box
- consider on-site and off-site effects
- focus on keeping energy flow through the integrated system
- reemphasize biological factors, improve biodiversity
- improving soil quality is key to improving soil, water, air, plant, and animal resources
- case studies, field trials, on-farm research/demonstrations, farmer-to-farmer networks
- interdisciplinary teams including producers and partners
- farmers need to demand quality service
- recordkeeping is tool in decision-making and management of current and future resources
- need user friendly fact sheets, brochures on integrated systems