Soil Loss and Nutrient Availability for Crop Production

Francisco J. Arriaga
Assistant Professor and Extension Specialist
Soil and Water Management
University of Wisconsin-Extension and UW-Madison Dept. of Soil Science
PHONE: 608-263-3913
Email: francisco.arriaga@wisc.edu

Wisconsin Agribusiness Classic Conference
January 11, 2017

Background

- Nutrient availability to crops is affected by several factors;
  - Soil properties
  - Concentration in soil
  - Soil organic matter content

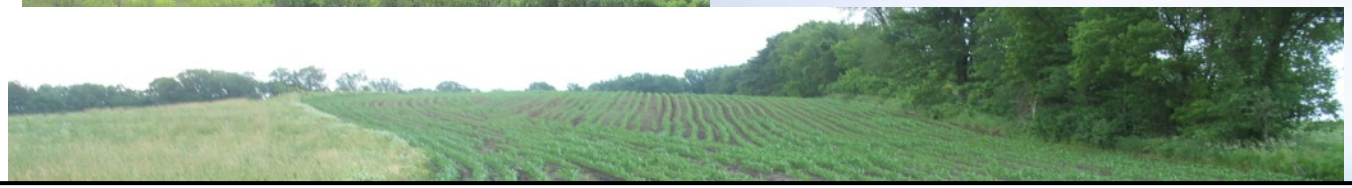
Nutrient Content of Soil – Potassium Example

Table 7.2
A2809

Soil group[a]	Soil test category: Very low (VL)	Low (L)	Optimum (O)	High (H)	Very high (VH)	Excessively high (EH)
	soil test K ppm[b]					
Demand level 1: corn grain, soybean, clover, small grains (but not wheat), grasses, oilseed crops, pasture						
Loamy	< 70	70–100	101–130	131–160	161–190	> 190
Sandy, Organic	< 45	45–65	66–90	91–130	—	> 130
Demand level 2: alfalfa, corn silage, wheat, beans, sweet corn, peas, fruits						
Loamy	< 90	90–110	111–140	141–170	171–240	> 240
Sandy, Organic	< 50	50–80	81–120	121–160	161–200	> 200
Demand level 3: tomato, pepper, brassicas, leafy greens, root, vine, and truck crops						
Loamy	< 80	80–140	141–200	201–220	221–240	> 240
Sandy, Organic	< 50	50–100	101–150	151–165	166–180	> 180
Demand level 4: potato						
Loamy	< 80	80–120	121–170	171–190	191–220	> 220
Sandy, Organic	< 70	70–100	101–130	131–160	161–190	> 190

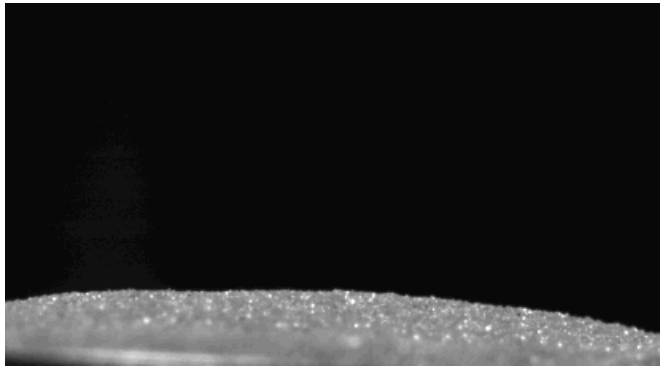
Source: Laboski and Peters, 2012

Erosion in Wisconsin

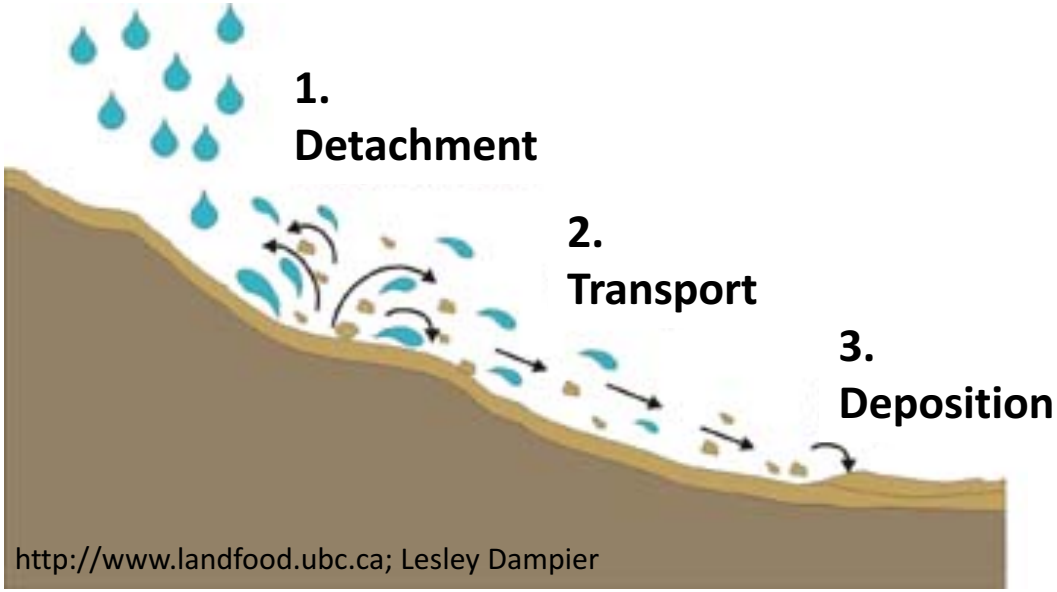


How does soil erosion affect nutrient availability at the field level?

Soil Erosion by Water
--is a three step process



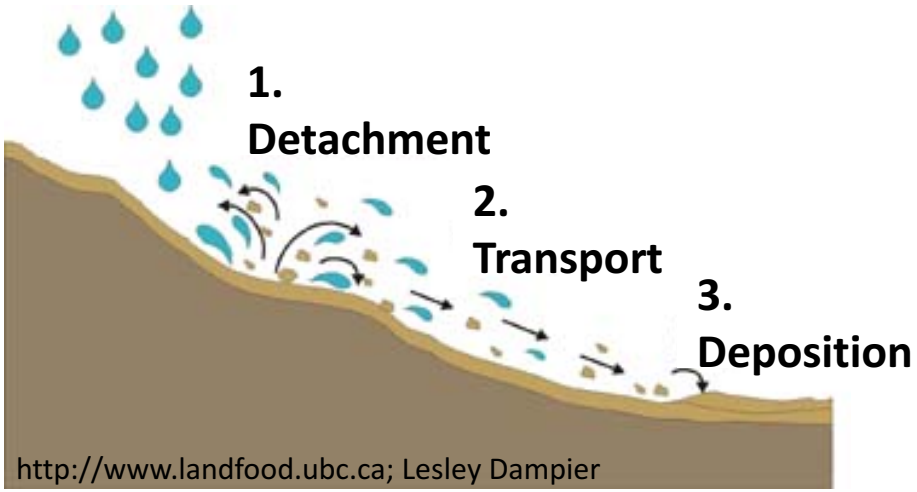
http://www.cms.fu-berlin.de/; GeoLearning



http://www.landfood.ubc.ca; Lesley Dampier

Impact of Erosion on Soil

1. Loss of nutrients and soil organic matter
2. Can reduce water infiltration and water recharge of the soil profile due to the formation of surface crusts or seals
3. Reduces the thickness of the soil
4. Lower soil layers come closer to the surface (changes in hydraulic properties and fertility)



http://www.landfood.ubc.ca; Lesley Dampier

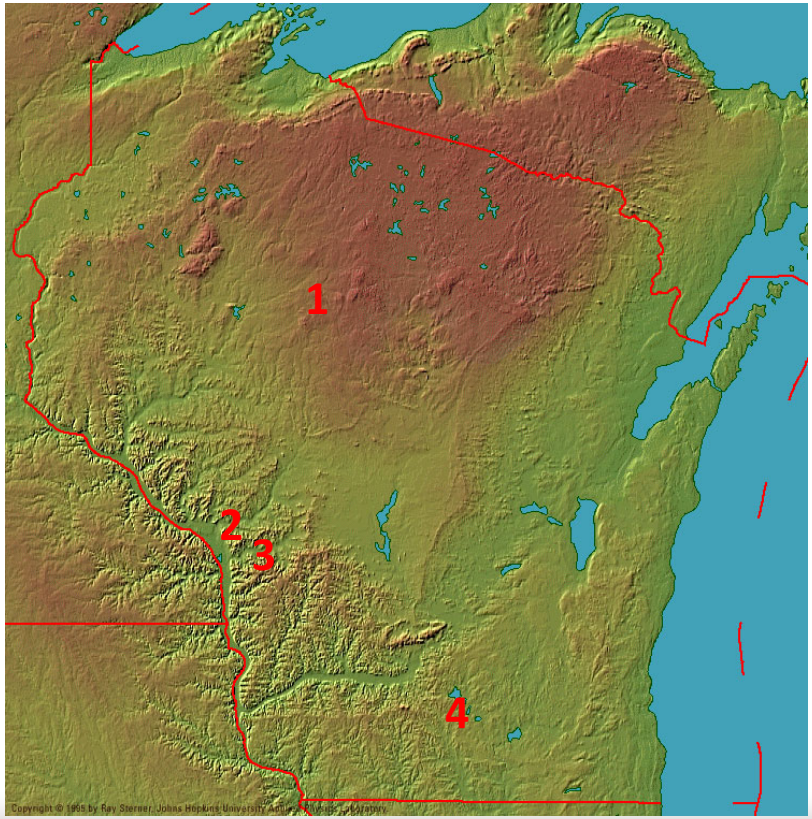
1. Nutrient Concentration in Eroded Sediment

- Research conducted by Massey and Jackson at four locations in Wisconsin measured total soil sediment, organic and ammonia nitrogen, available phosphorus, and exchangeable potassium.
- “Correlation studies were carried out in an attempt to relate the selectiveness of the erosive process for a given fertility constituent to the quantity of eroded soil and concentration of suspended solids in the runoff.”
- This work discovered greater concentrations of nitrogen, phosphorus, potassium and organic matter in eroded sediment when compared to the bulk soil in the field.

Source: H.F. Massey and M.L. Jackson, 1952

1. Nutrient Concentration in Eroded Sediment

- Locations: 1) near Owen on 3% slope, 2) near La Crosse on 11% slope, 3) SC Exp Station in La Crosse on a 20% slope, and 4) near Madison on a 9% slope



Source: H.F. Massey and M.L. Jackson, 1952

1. Nutrient Concentration in Eroded Sediment

- High correlation was found between the concentration of fertility factor and total eroded soil (range 0.67 to 0.87).
- Eroded soil sediment had: 2.1 times more organic matter, 2.7 times more nitrogen, 3.4 times more available phosphorus, and 19.3 times more available potassium than the bulk soil.
- Sediment and nutrient losses were affected by slope and other unexplained soil factors.

Source: H.F. Massey and M.L. Jackson, 1952

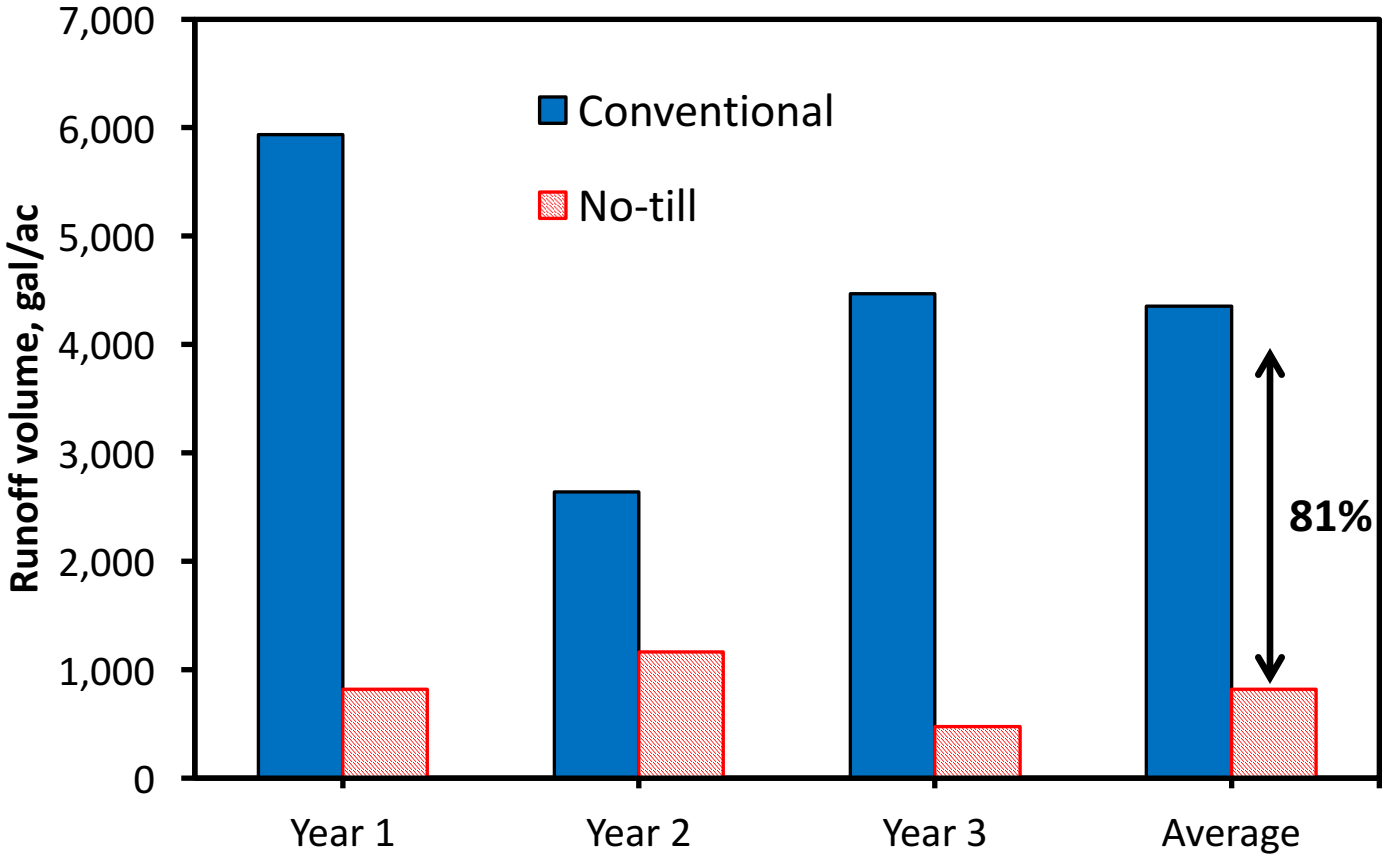
1. Soil Erosion: The Value of Nutrients and SOM

- Using manure to estimate the value of SOM, it would cost $0.12* to replace nutrients (N, P, K and micro-nutrients) per pound of SOM lost

OM content in soil	Cost of replacing nutrients
------ % ------	--- $ per ton soil eroded ---
2	4.80
3	7.20
4	9.60
5	12.00
6	14.40

* Value estimated using the MANURE-VALUE tool by Univ. of Minnesota

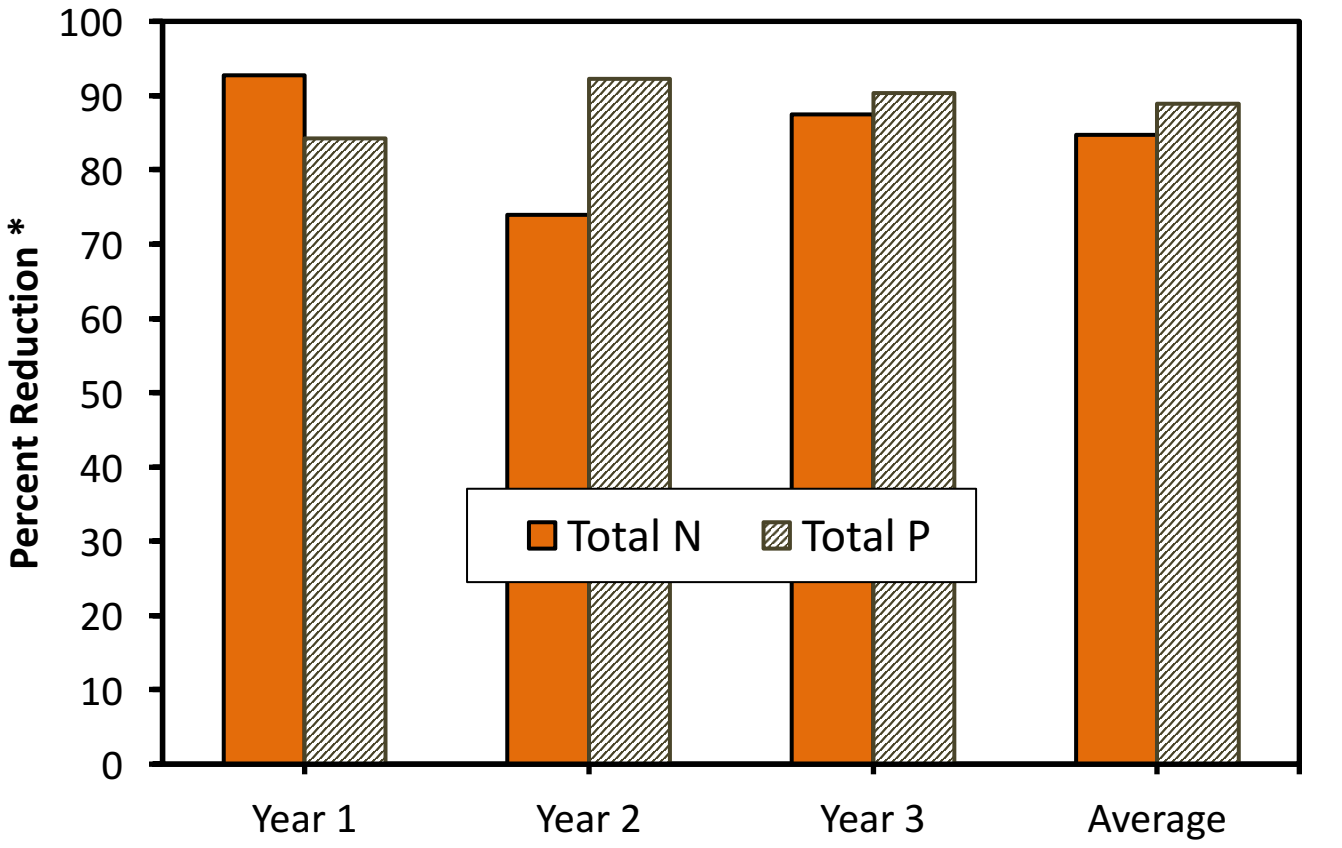
1. More Runoff = Greater Potential for…



Suspended sediment followed a similar trend and there was 87% reduction with no-tillage

(Angle et al., 1984)

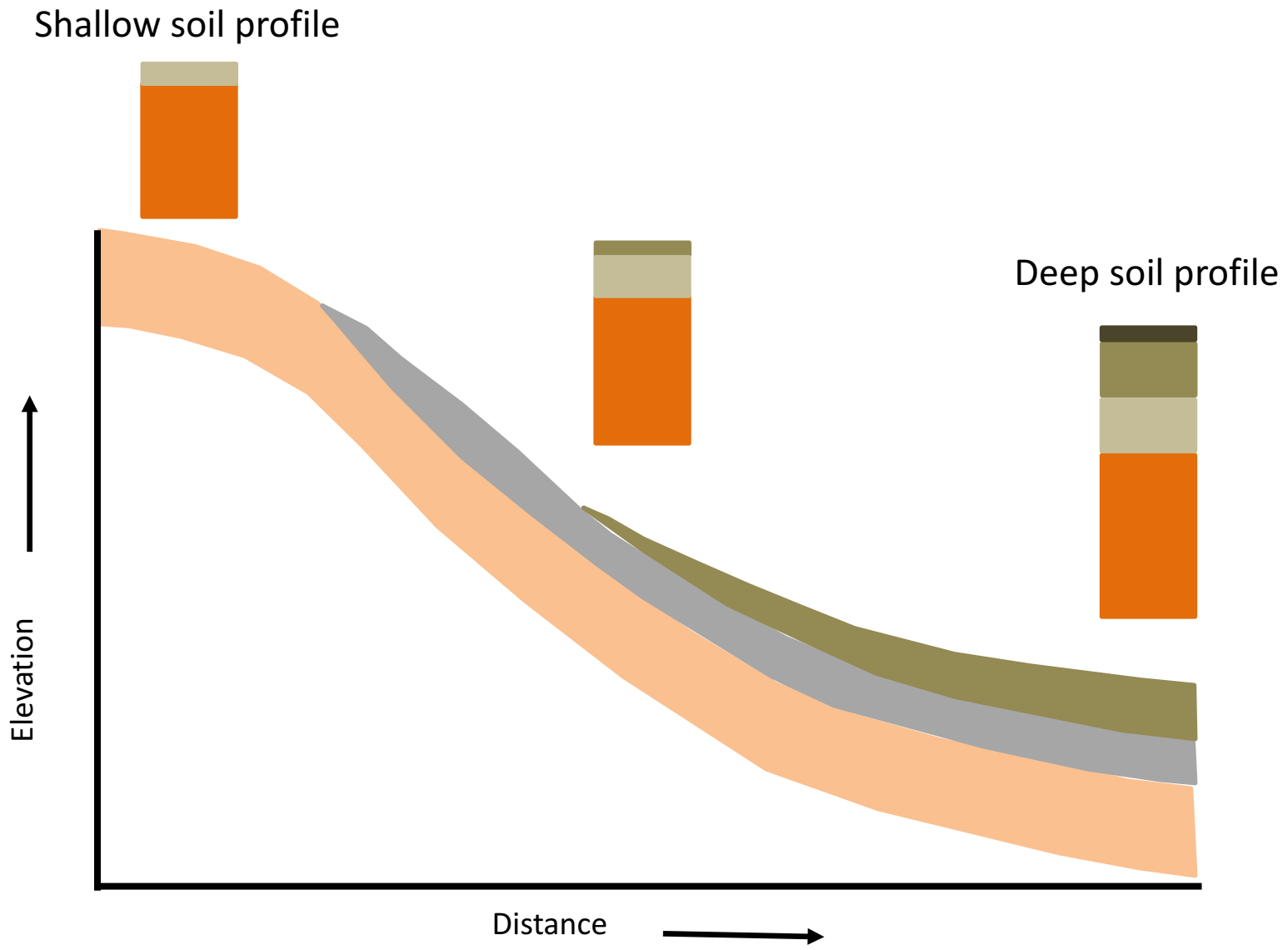
1. More Runoff = Greater Potential for… Nutrient Losses



* Percent reduction with no-tillage relative to conventional

Source: Angle et al., 1984

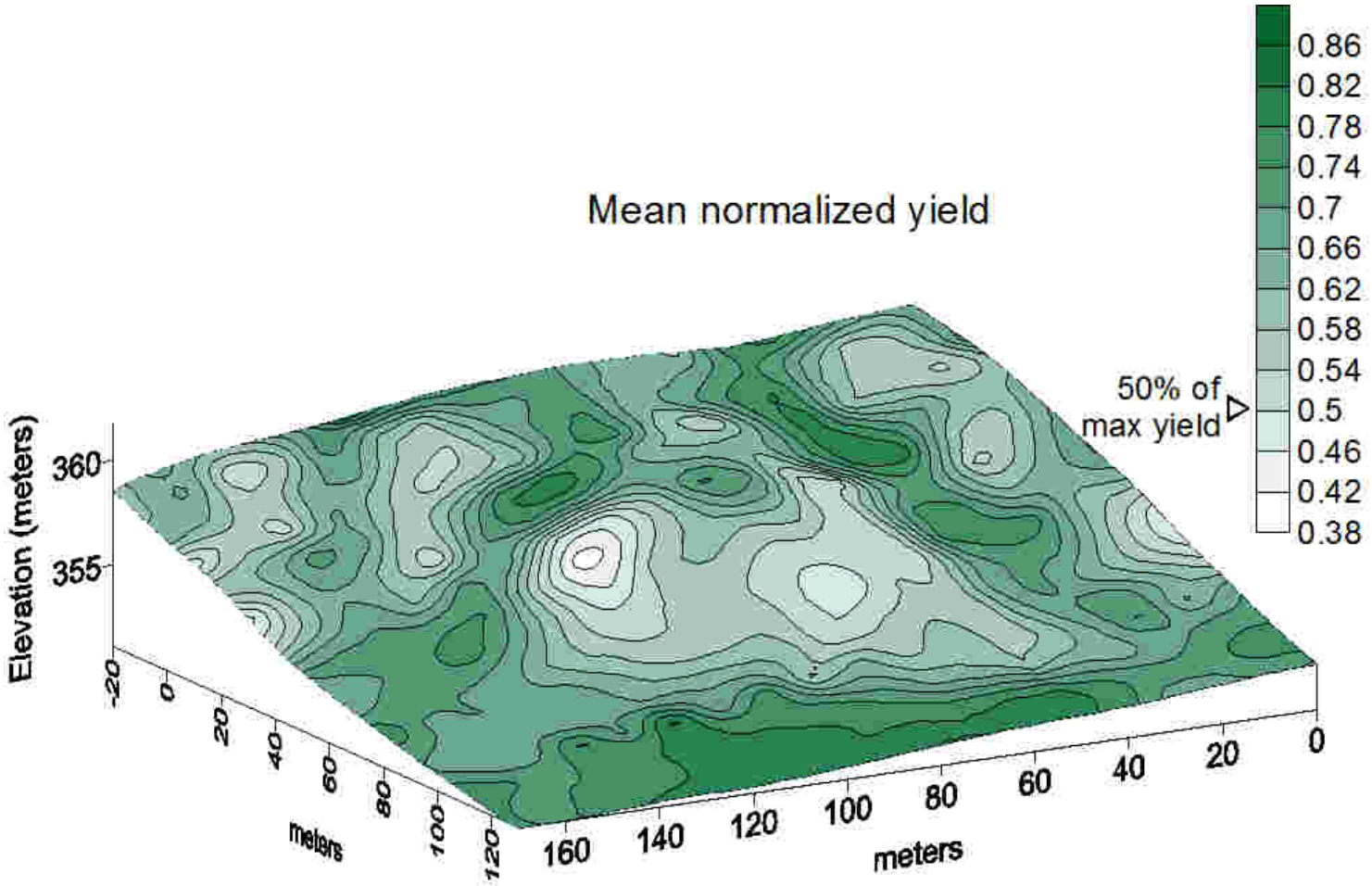
4. Soil Erosion Changes Soil Thickness and Related Properties



4. Soil Thickness and Spatial Variability of Fertility Factors

source: S. Papiernik, 2013

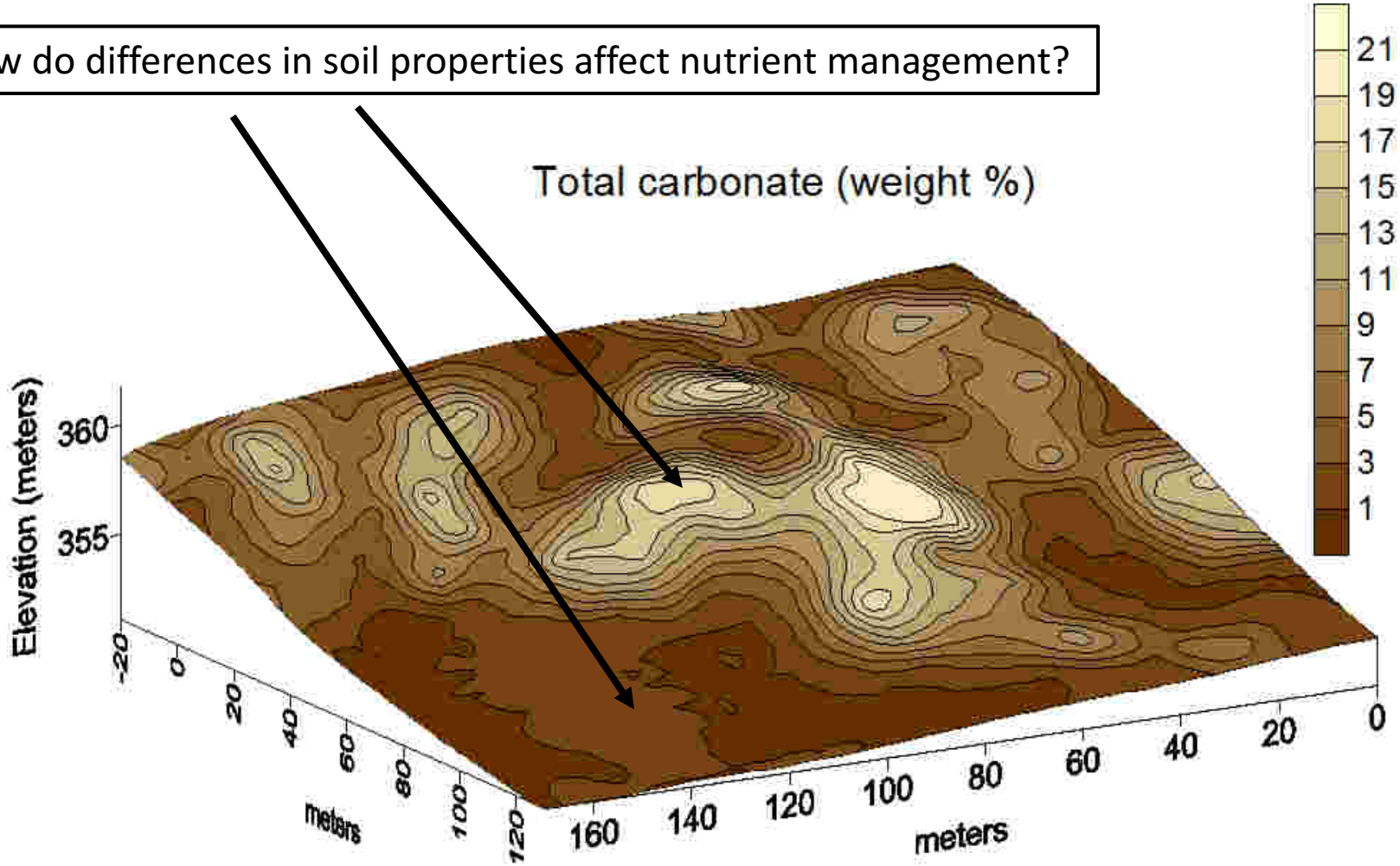
4. Soil Thickness and Spatial Variability of Fertility Factors



source: S. Papiernik, 2013

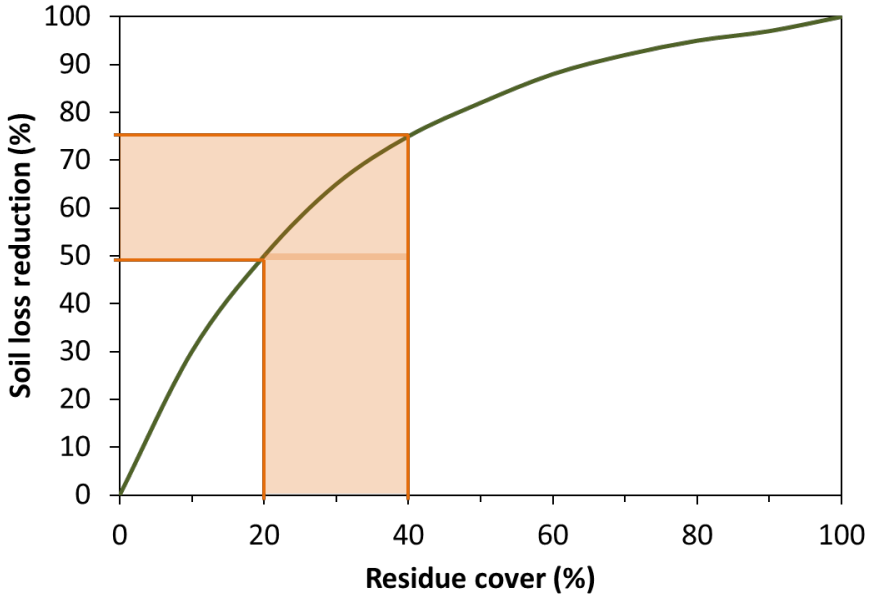
4. Soil Thickness and Spatial Variability of Fertility Factors

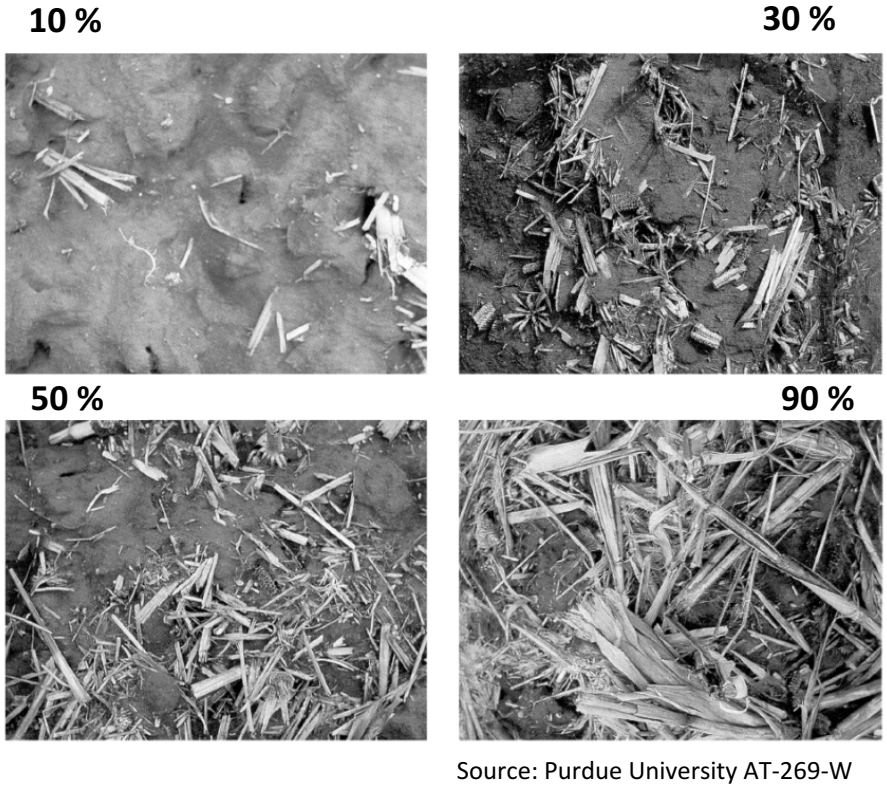
How do differences in soil properties affect nutrient management?



source: S. Papiernik, 2013

What can be done?: Crop Residue Management





Source: Purdue University AT-269-W

Crop Residue on Soil Surface Reduces Erosion

What can be done?: Cover Crops Reduce Erosion

Crop: Continuous corn silage

Tillage: Spring chisel plowing, field cultivation prior to planting

	Erosion (Ton/ac/yr)
No cover crop	4.6
Disked rye cover crop	2.0
No-till rye cover	1.8

source: Ward-Good, 2014

What can be done?: Supporting Practices

	Erosion (T/a/yr)
Cont. corn silage - up and down slope	4.6
Cont. corn silage - on contour	3.1
Cont. corn silage - with in-field grass strips	2.2
Strips – rotation 3 yrs corn silage – 4 years alfalfa hay	1.4

source: Ward-Good, 2014

Closing Remarks

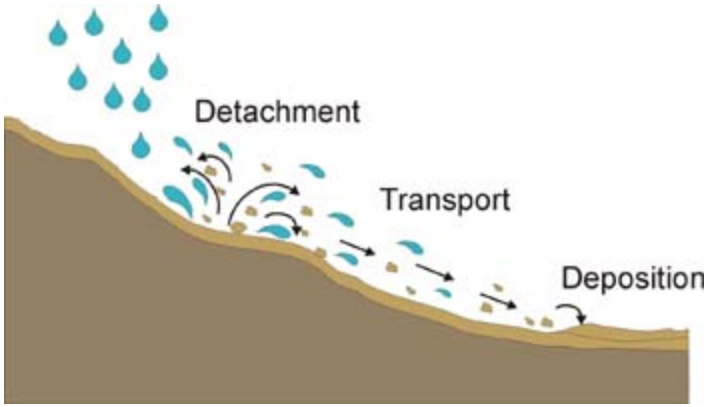
- Erosion reduces overall soil production potential through to main ways:
  1. Nutrients and organic matter are lost directly during erosion.
  2. Soil properties that affect soil fertility management are permanently changed by erosion.
- This increases spatial variability and the level of fertility management effort needed for a given field.
- Although it is difficult to quantify their economic impact directly, these factors increase the economic costs of crop production.
- Therefore, management practices that help prevent/reduce erosion (such as crop residues on soil surface, cover crops and supporting soil conservation practices) can help nutrient management in the long run.

Francisco J. Arriaga

E-mail: farriaga@wisc.edu

Office phone: 608-263-3913

Universal Soil Loss Equation (USLE)
Now RUSLE2



http://www.landfood.ubc.ca; Lesley Dampier

Universal Soil Loss Equation (USLE)

Soil loss (ton/acre) = **R** x **K** x **LS** x **C** x **P**

Factors:

R = erosive force of rainfall and runoff (amount & intensity)

K = soil erodibility

LS = slope length & steepness

C = vegetative cover & management

P = Erosion control practices (supporting practices)