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# **New directions in land evaluation for land use planning**

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# Objective

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- Encourage you to think **creatively** about problem-solving in rural and semi-rural LUP
- Familiarise you with current **trends**
- Familiarise you with new **techniques**



# Outline

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- **Problems with existing approaches**
- **Key concepts for new approaches**



# Existing approaches

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- **Top-down, technocratic, bureaucratic**
- **Supply-driven**
  - ‘Have model, will travel’
- **Based on producer expertise, *not user needs***
  - Lots of effort wasted on evaluating unrealistic options
- **‘Point’ (non-spatial) evaluations**
  - Not considering whole-area



# Key concepts to be explored

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- **The research chain**
- **Modelling**
- **Spatial analysis**



# Topic: The research chain

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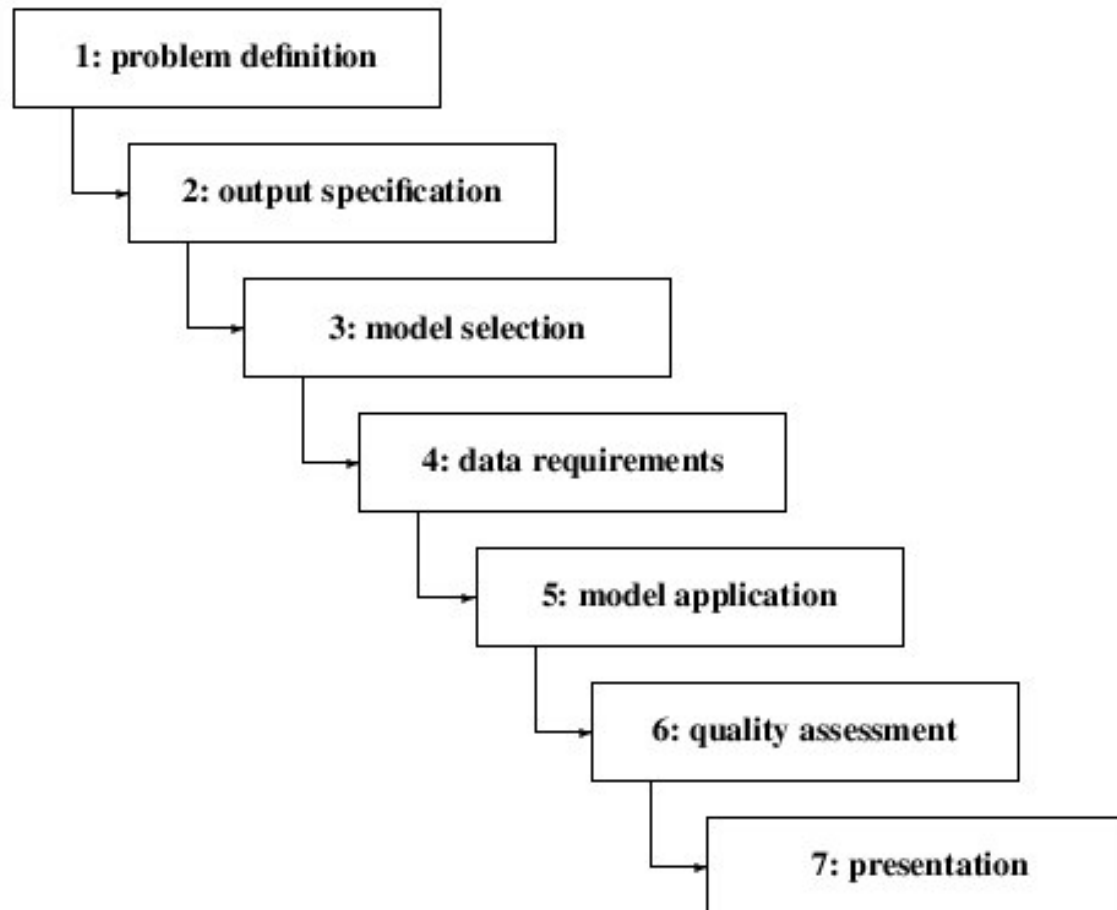
# The research chain: Objectives

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- Increase the *relevance* of research into land performance
- Increase the *applicability* of the results of such research
- Increase the *acceptance* of the results of such research



# The Research Chain



After Bouma (1999),  
“Land evaluation for  
landscape units”,  
Handbook of Soil  
Science, pp.E393-E412



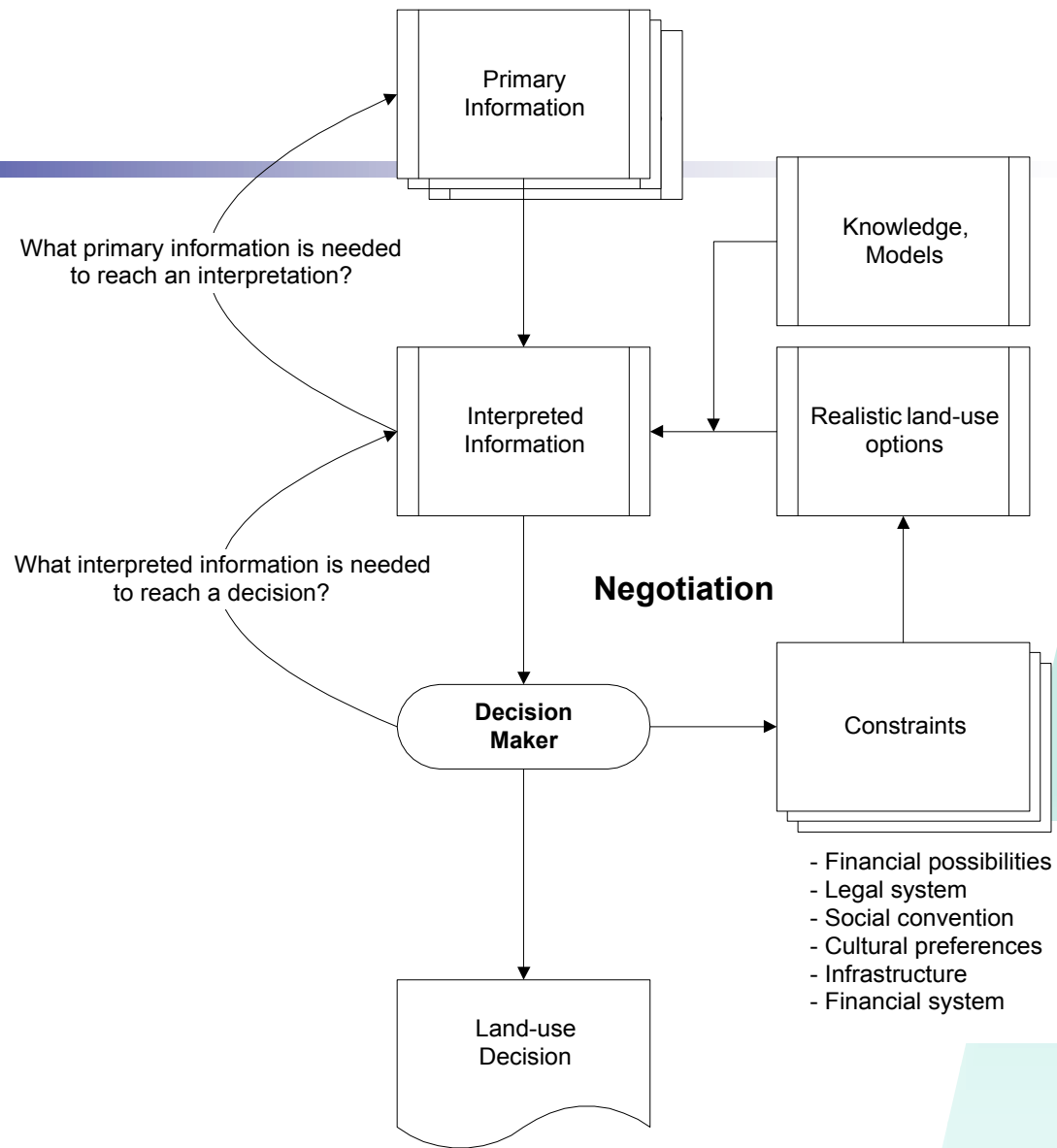
# Innovations

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- Begins and ends with client **needs** and **possibilities**
- Only **relevant** options are considered
  - Land users have limited possibility for change
- Models are selected to provide the output that is needed by the decision-maker
- Uncertainty and risk are explicit
- Communication with clients
  - includes visualisation



# Demand-driven resource inventory & evaluation



# The 'research chain' in practice

- Fairly successful models found in the USA and Canada (among others)
  - **Extensionists** deal with **end users**
  - **Specialist researchers** deal with **extensionists**
  - **Extensionists** share a common social background with **end users**
  - **Extensionists** and **specialists** share a common background and, to BSc level, a common education



# Modelling

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# Models

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- **A representation of reality**
- **Simulation of real processes**
- **Can ‘compute’ and thus make predictions**

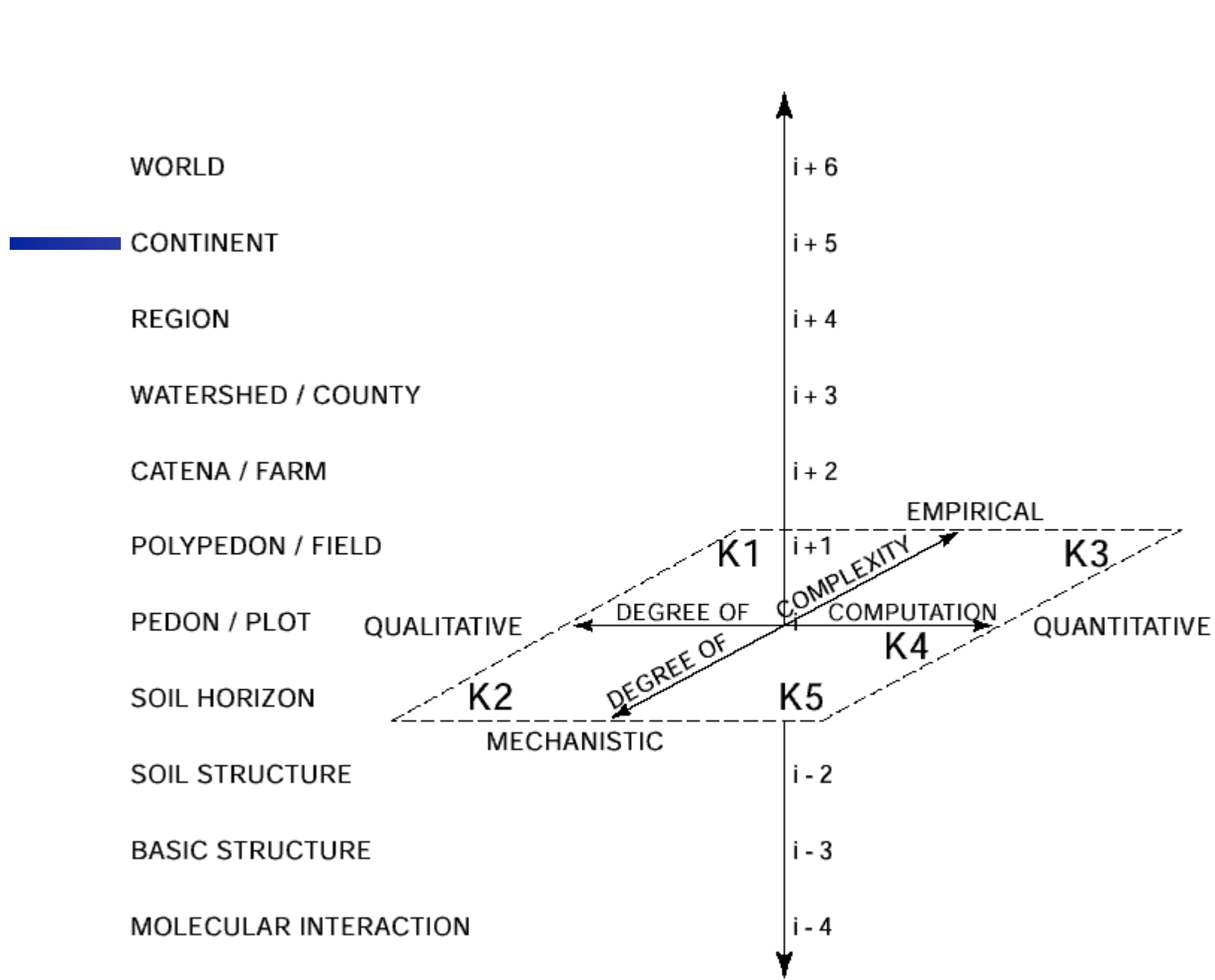


# Classification of models

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- Degree of **computation**
    - qualitative to quantitative
  - Descriptive **complexity**
    - empirical to mechanistic
  - **Level** in the organizational hierarchy
    - molecular to continental
- (from Hoosbeek & Bryant, *Geoderma*, 55:183–210, 1992)





# Levels of Knowledge

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- **K1 user expertise**
- **K2 expert knowledge**
- **K3 generalized holistic models**
- **K4 complex holistic models**
- **K5 complex models of system components**

(from Bouma, *Geoderma*, 78:1–12, 1997)



# Holistic vs. reductionist evaluation

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- **Holistic**

- evaluate system as a whole
- interactions are explicitly built into model
- Much more difficult to design, poorly-modelled interactions can cause unrealistic outputs

- **Reductionist**

- evaluate system components separately
- combine these results
- interactions are ignored or simplified



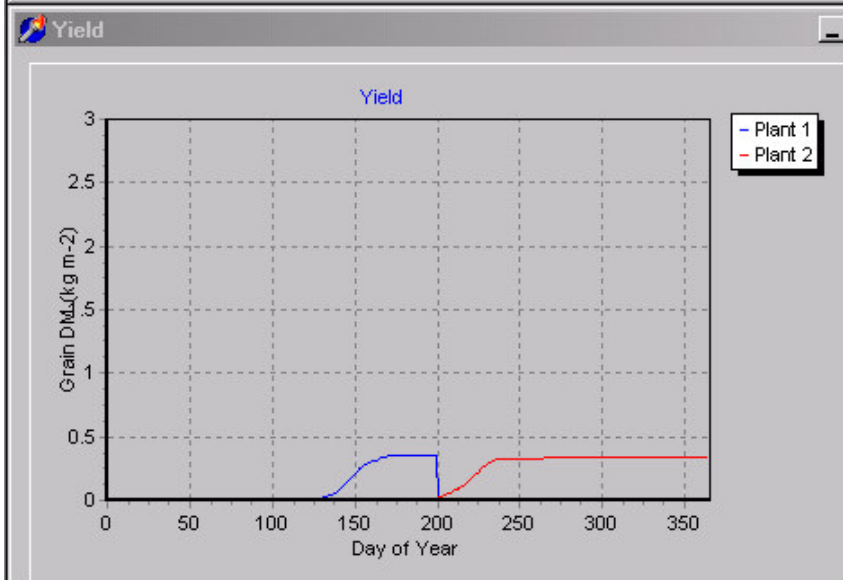
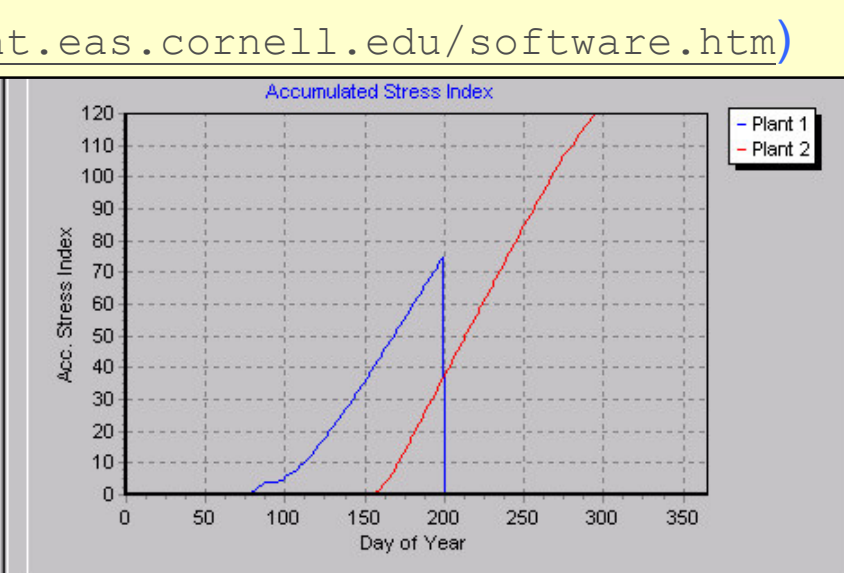
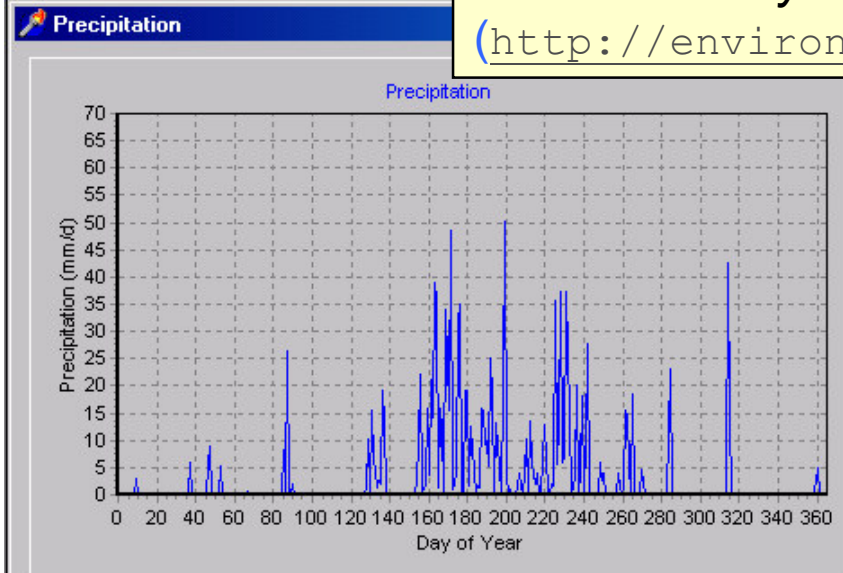
# Sieve (stepwise refinement)

- **Increasingly detailed knowledge as suitable areas are identified**
  - 1 - eliminate completely unsuited areas with user expertise (K1) or expert knowledge (K2)
  - 2 - calibrate empirical (K3) model or parameterize system models (K4 or K5) in promising areas only
    - smaller `area' of applicability  $\Rightarrow$  easier to model
  - 3 - use system models to make quantified predictions in these areas



# A K4 holistic *dynamic simulation model*: GAPS

(<http://environment.eas.cornell.edu/software.htm>)



Simulation completed

# Example

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- To show the modern Land Evaluation *approach* to problem solving
- ‘zone tillage’ in New York State (USA)
- This is a *specific* example because ‘all problems (and solutions) are local’



# 1 - Problem Definition: Context

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- **Land Utilization Type**

- high-value dairy farming
- grow as much feed on-farm as possible
- recycle manure for plant nutrients
- mechanized, high-tech, high investment

- ***Social context***

- family labour, maybe one hired worker
- sophisticated farmers, willing and financially able to experiment and innovate



# 1 - Problem Definition: Agro-climate

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- **Short, hot summer**
  - ideal for maize, but must capture the heat
  - early planting is critical for good yields
- **Cold, snowy winters**
  - saturated soil in early spring, not trafficable
- **Cool, wet spring**
  - can only prepare soil in a narrow moisture range



# 1 - Problem Definition: Summary

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- **Agronomic**

- Limited optimal planting season

- **Socio-economic**

- Labour and machinery shortage during ‘window of opportunity’ for maximum yields,
- High energy costs of full tillage

- **Environmental**

- Excessive soil loss with full tillage
- May be regulated soon



# 1 - Possible Solutions (1)

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- ***Abandon the LUT***
  - give up dairy farming?
    - would waste investment in specialised buildings and equipment
    - would waste sophisticated farmer knowledge
  - keep the cows and pasture but purchase all the high-energy feed?
    - un-economical

# 1 - Possible Solutions (2)

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- ***Keep current LUT, but adjust tillage methods***
  - shorten tillage time per hectare
  - till in wetter conditions (more hours)
- **Methods**
  - zone tillage
  - ridge tillage
  - shallow tillage
  - no-till ...



# Option: Zone tillage (1)

- Replaces conventional tillage, in which the whole soil is turned
- Three coulters work a zone about **20cm wide** and 12.5cm deep ahead of each planting unit on a planter; row spacing is 75cm, so only about **1/3 of the width is worked**; also this is about **half the depth** of conventional tillage; so **<1/6** of the energy costs
- The middle coulters are the "lead" and cuts all crop residue in half. The other two coulters follow behind and are 9cm to either side of the lead coulters; these cut the soil and then cover the seed





**The thin or narrow shank does a minimum amount of soil disturbance while leaving very little, if any, manure on the surface.**

Source: Pro-dairy, Feb. 2004 (Northeast Dairy Business)

<http://www.dairybusiness.com/northeast/Feb04/2-04ProDairy.htm>



# Option: Zone tillage (2)

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- **With *one trip across* a field, a farmer can plant the maize**
- **Herbicide trips are usually two: a "burndown" trip and one for residual weed control. Herbicide costs can be slightly higher when the cost of the burndown material is added into crop costs. Two or three tillage trips can be saved, however, which can be significant in cost and labor.**



# 2 - Output Specification

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- **Detailed description of new systems**
- **Map showing where they *may* be applied**
  - “all land is not created equal”
- **Map showing where they *should* be applied**
  - economically advantageous
    - increased profit, increased labour efficiency...



## 2 - Output Specification

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- **Note that farmers will make their own *decision* on whether to adopt the suggested options**
- **We provide reliable information on *what* would be the result *where***
- **Distributions, not just expected values**
  - '1 year in 10', etc.



# 3 - Model Selection

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- What ***predictions*** must be made?
  - Crop yield
  - Tillage time per hectare
  - Days when tillage is possible
- How ***quantitative*** must they be?
  - +/- 10% (corresponds to profit margins)



# 3 - Model Selection (1)

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- **1 - Yield as a function of heat units**
  - locally-calibrated, many years data
  - empirical but quite accurate (K3)
- **2 - Soil-moisture & trafficability**
  - physically-based model of soil behaviour, with empirical coefficients (K5)
  - *pedo-transfer functions* from available soil data (e.g. texture, mineralogy) to required parameters (e.g. bearing strength)



# 3 - Model Selection (2)

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- **3 - Moisture conditions of soil surface**
  - Evaporation from soil surface
  - Runoff, ponding and infiltration
  - Only in spring, no need to consider frozen soils ( $\Rightarrow$  limited domain of applicability)
  - physical models, pedo-transfer functions



# 4 - Data Requirements

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- **According to models**

- Time-series of daily rainfall, solar radiation, temperature; 30 years
  - from representative climate stations
- Soil physical properties
  - representative profiles from routine soil survey
  - extrapolation to similar soils



# 5 - Model Application

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- Run the models



# 6 - Quality Assessment

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- **Individual models may be tested by their developers**
- **Combined model can be compared to test plots**



# 7 - Presentation (1)

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- **Time-series graphs under historical conditions**
  - Earliest planting dates
  - Tillage hours
  - Yields
- **Statistical summaries**
  - e.g. '1 year in 10' risk



# 7 - Presentation (2)

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## ● **Demonstration Plots**

- on cooperator's farms (innovative, lead farmers) in the most promising areas
- open days

## ● **Publications**

- Commercial: Agway (farm supplier)
- State: Cornell Cooperative Extension Bulletin (New York State)
- Reference material on web



## So you want to minimum till corn ground

But what can you do about applying manure, then planting, on ground that's had little tillage?

By Eleanor Jacobs

"One reason people don't minimum till, or zone till, is they thought they couldn't inject manure," says Dave DeGolyer, managing consultant with Western New York Crop Management Association, based in Berry, N.Y. "I no longer believe that."

Dairy producers can have their cake and eat it too, so to speak. They can inject manure without too much soil disturbance and follow with one-pass corn planting. That is, if they have the right tools.

### Application systems

Three manure application systems used on western New York dairies help producers maintain minimum tillage systems, while controlling manure odors.

1. Vertical tillage. This is how DeGolyer

labels the use of an *AerWay* tool, which looks like a heavy-duty rotary hoe. Its rolling knives make 6- to 8-inch deep notches in the ground. Manure then dribbles into the notches and soaks into the upper soil surface.

"You're not injecting manure," says DeGolyer. "Vertical tillage tools make channels in the soil to lessen the chance for runoff." Odor is less compared to surface-applied manure.

The angle of the knives can be adjusted to get less or more soil-surface disturbance. "At a zero-degree angle, you are spiking the ground," says DeGolyer. The greater the angle, the more soil disturbance.

Since the *AerWay* isn't injecting manure, you won't get the maximum ammonia value from manure applied in the spring,

**Zone tillage:** Planting into an 8-inch wide area that's tilled at planting. Zone building, which can be done prior to planting, creates a deep-15 to 20 inches - slot into which corn is planted.



The *AerWay* is used to inject manure, fed to the system by a drag hose, into the ground.

### FYI

• Bosch Dave DeGolyer, managing consultant with Western New York Crop Management, at (515) 237-2833. E-mail: [ddegolyer@wycma.com](mailto:ddegolyer@wycma.com).

• For information on *AerWay*, see the website: [www.aerway.com](http://www.aerway.com).

• For information on filter injection equipment, see [www.aerway.com](http://www.aerway.com).

Extension publication;  
also available as PDF  
on the Web

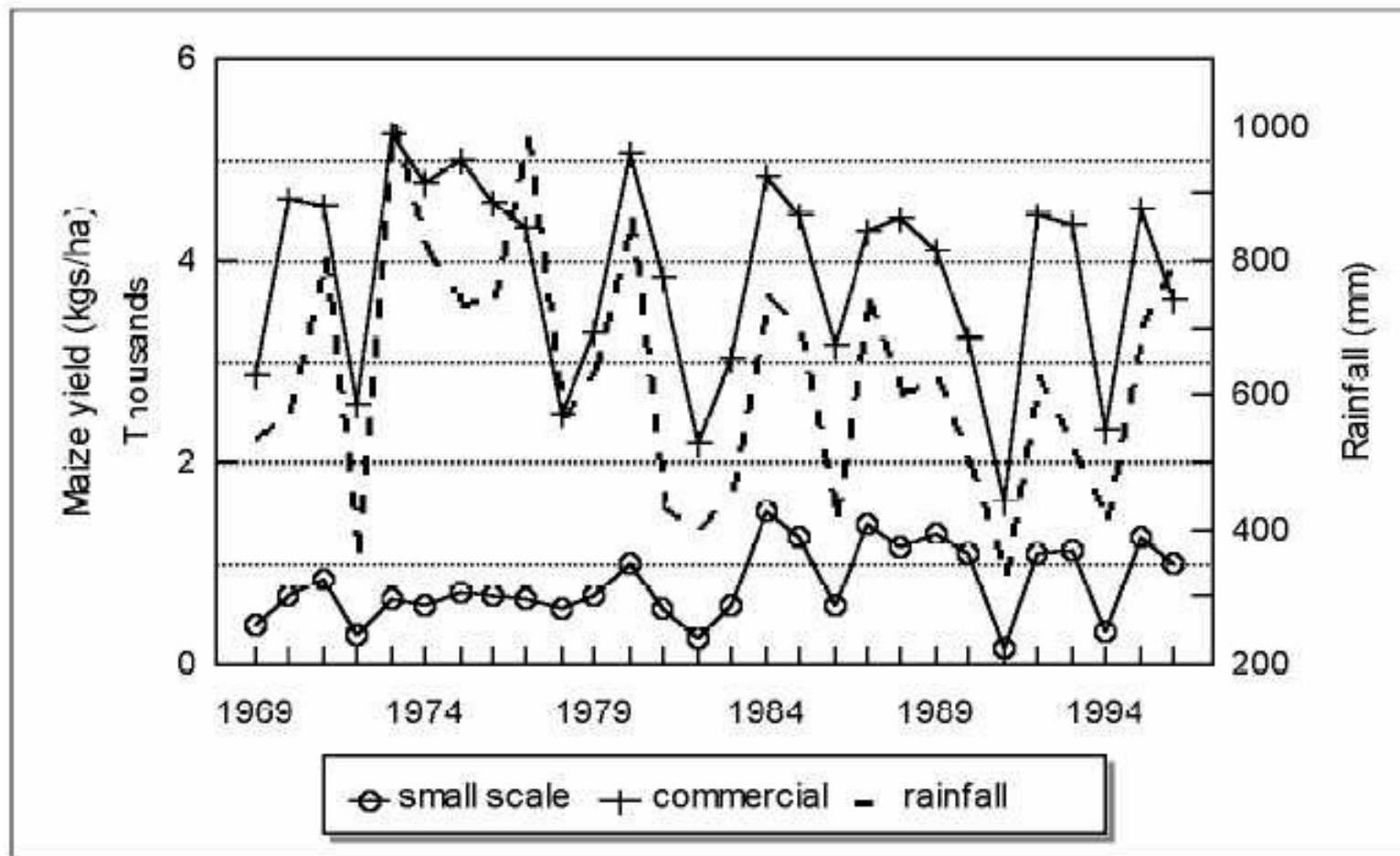


Figure 1. Time series of average maize yield in the smallholder and commercial farming sectors in Zimbabwe. The national average rainfall is superimposed.

## Example time series

Source: [Unganai, L \(2000\)](#) "Application of long-range rainfall forecasts in agricultural management: A review of Africa's experience"; in: First International Forum on Climate Prediction, Agriculture and Development; International Research Institute for Climate Prediction, Palisades, NY

# Spatially-explicit land evaluation

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- **Spatial vs. per-point land analysis**
- **Spatial land use requirements**



# Point analysis

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- Only considers land characteristics that can be measured at a *site*; predictions are made about these
- The *point* is considered *representative* for an *area* (e.g. same soil type)
- The actual location and relation between sites are not considered



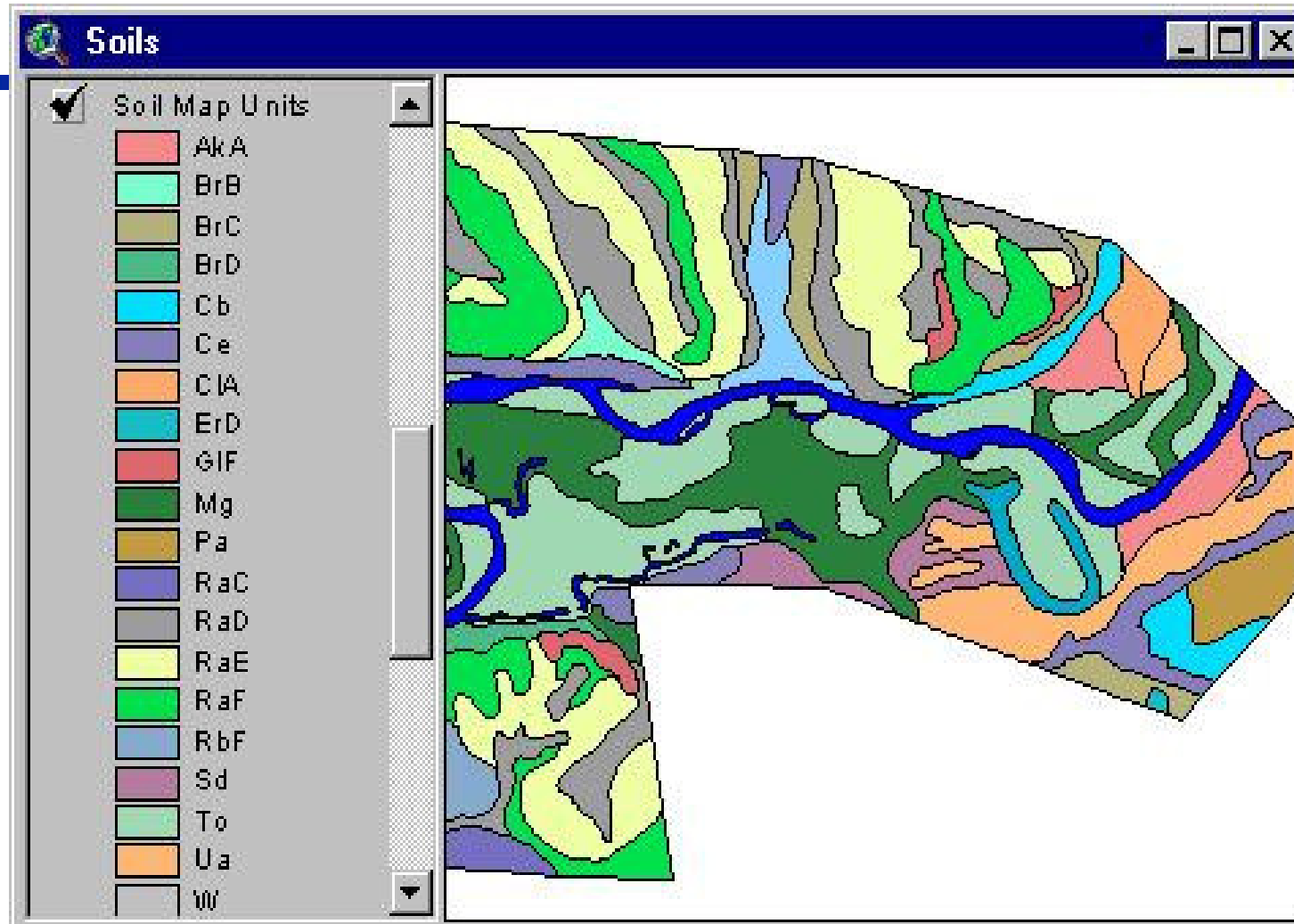
# Example of point analysis

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- **Spatial *representation* of non-spatial *analysis***
- **Does not make the analysis spatial!**



# Base map: soil map units



Map units:  
phases of  
soil series

SSURGO  
data base;  
ArcView 3

Seneca Nation of Indians, New York



# Linked attribute tables

mapunit.dbf			muyld.dbf		
Muid	Muname		Muid	Cropname	Nmyld
605AkA	ALLARD SILT LOAM, 0 TO 3 PERCENT SLOPES		605AkA	CORN	110.0
605AkB	ALLARD SILT LOAM, 3 TO 8 PERCENT SLOPES		605AkA	CORN SILAGE	22.0
605AIA	ALLARD VARIANT SILT LOAM, 0 TO 3 PERCENT SLOPES		605AkA	GRASS-LEGUME HAY	3.5
605AIB	ALLARD VARIANT SILT LOAM, 3 TO 8 PERCENT SLOPES		605AkA	OATS	90.0
605AmA	ALTON FINE GRAVELLY LOAM, 0 TO 3 PERCENT SLOPES		605AkA	PASTURE	6.5

layer.dbf																	
Muid	Layernum	Laydep	Laydep1	Texture1	Texture2	Texture3	Kfac	Kfac1	Tfac	Weg	Inch10	Inch100	Inch3	Inch30	No4	No40	No100
605AkA	1	0	9	SIL			0.49	0.49	3	5	0	0	0	0	100	100	95
605AkA	2	9	27	SIL	VFSL		0.64	0.64			0	0	0	0	100	100	95
605AkA	3	27	60	SR	S	GRV-LS	0.17	0.37			0	0	0	0	25	100	20
605AkB	1	0	9	SIL			0.49	0.49	3	5	0	0	0	0	100	100	95
605AkB	2	9	27	SIL	VFSL		0.64	0.64			0	0	0	0	100	100	95
605AkB	3	27	60	SR	S	GRV-LS	0.17	0.37			0	0	0	0	25	100	20
605AIA	1	0	9	SIL			0.32	0.32	3	5	0	0	0	0	95	100	95
605AIA	2	9	23	SIL			0.32	0.32			0	0	0	0	95	100	95
605AIA	3	23	36	SICL			0.43	0.43			0	0	0	0	95	100	95
605AIA	4	36	60	GRV-LS			0.17	0.37			0	0	0	0	25	100	20
605AIB	1	0	9	SIL			0.32	0.32	3	5	0	0	0	0			
605AIB	2	9	23	SIL			0.32	0.32			0	0	0	0			
605AIB	3	23	36	SICL			0.43	0.43			0	0	0	0			
605AIB	4	36	60	GRV-LS			0.17	0.37			0	0	0	0			

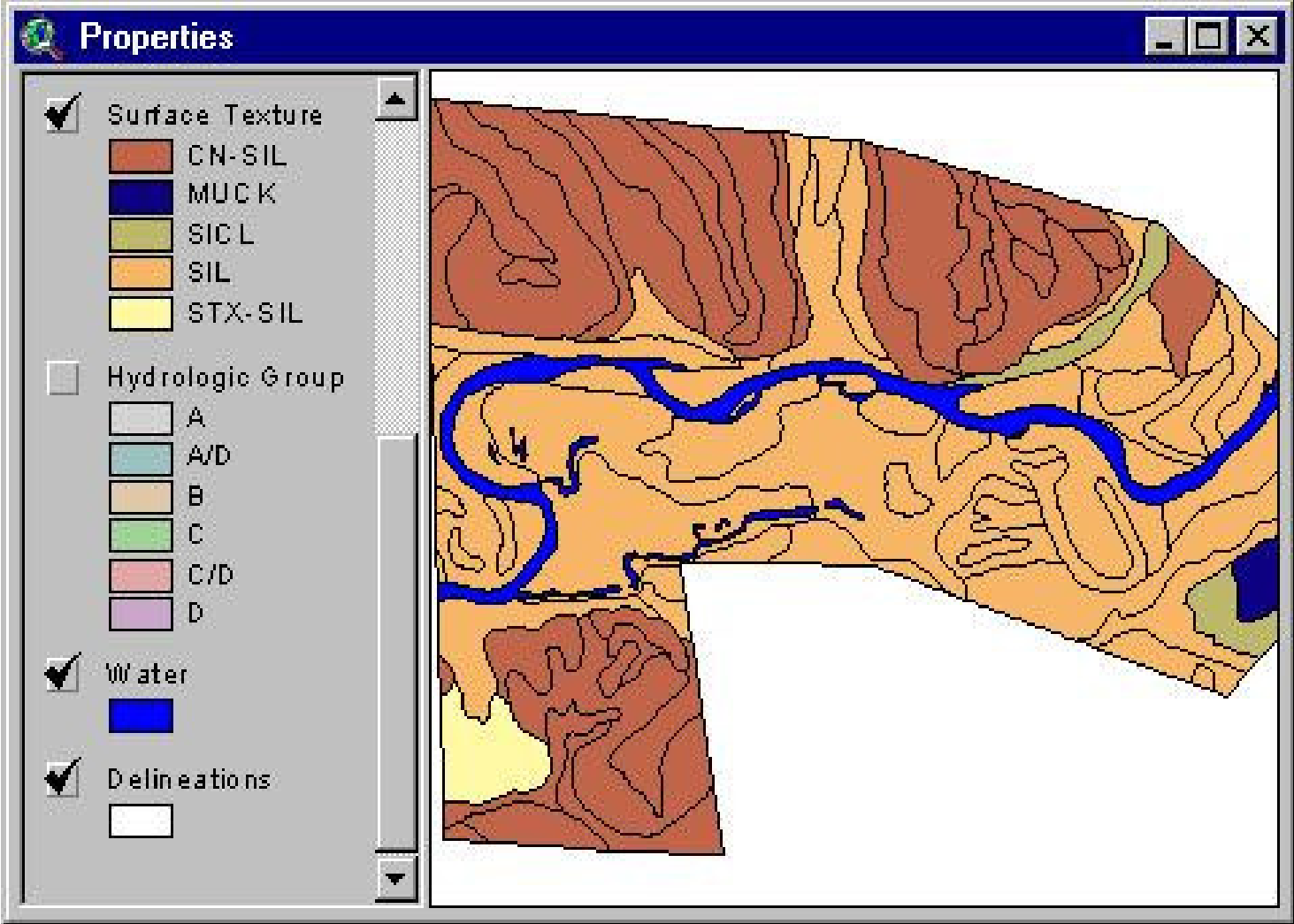
SSURGO  
data base;  
ArcView 3

Key: {Muid, (Layernum) }

Seneca Nation of Indians, New York



# Derived map: soil properties



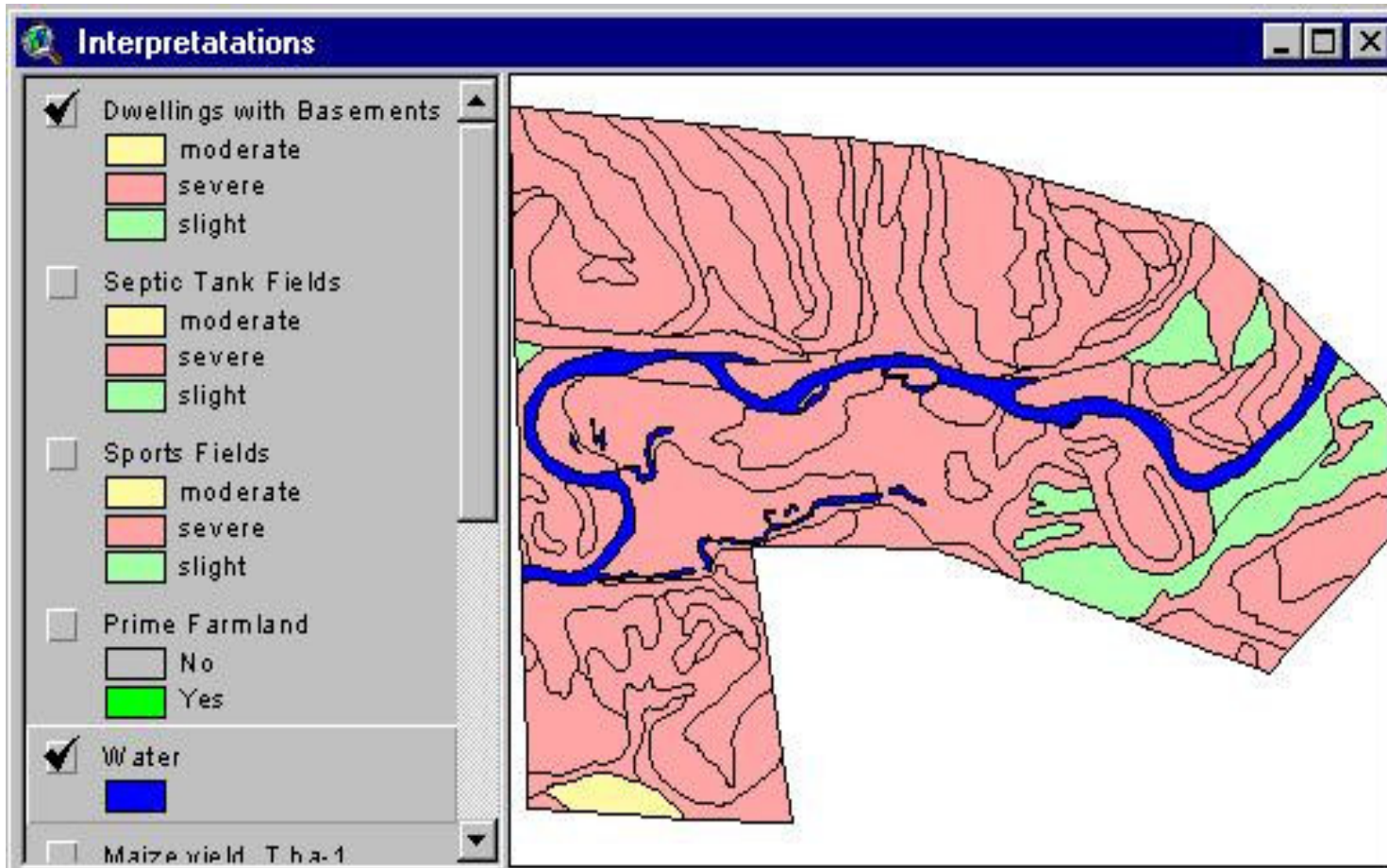
Property:  
'texture' of  
the surface  
soil

SSURGO  
data base;  
ArcView 3

Seneca Nation of Indians, New York



# Derived map: soil interpretations



**Interpretation:  
Suitability for  
dwellings with  
basements**

SSURGO  
data base;  
ArcView 3

Seneca Nation of Indians, New York



# Spatially-explicit analysis

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- **Location in space is important**
  - Relation to other areas
    - (non-)adjacency, distance
  - Flows
- **Form**
  - size, shape
- **Connectivity, pattern**
  - e.g. patchiness



# Example of spatial analysis

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- **Spatial factors were needed to achieve the result**
  - location
  - adjacency, distance
  - size
- **Based first on point studies**
- **Not quite land use planning (which makes the decisions) but close**



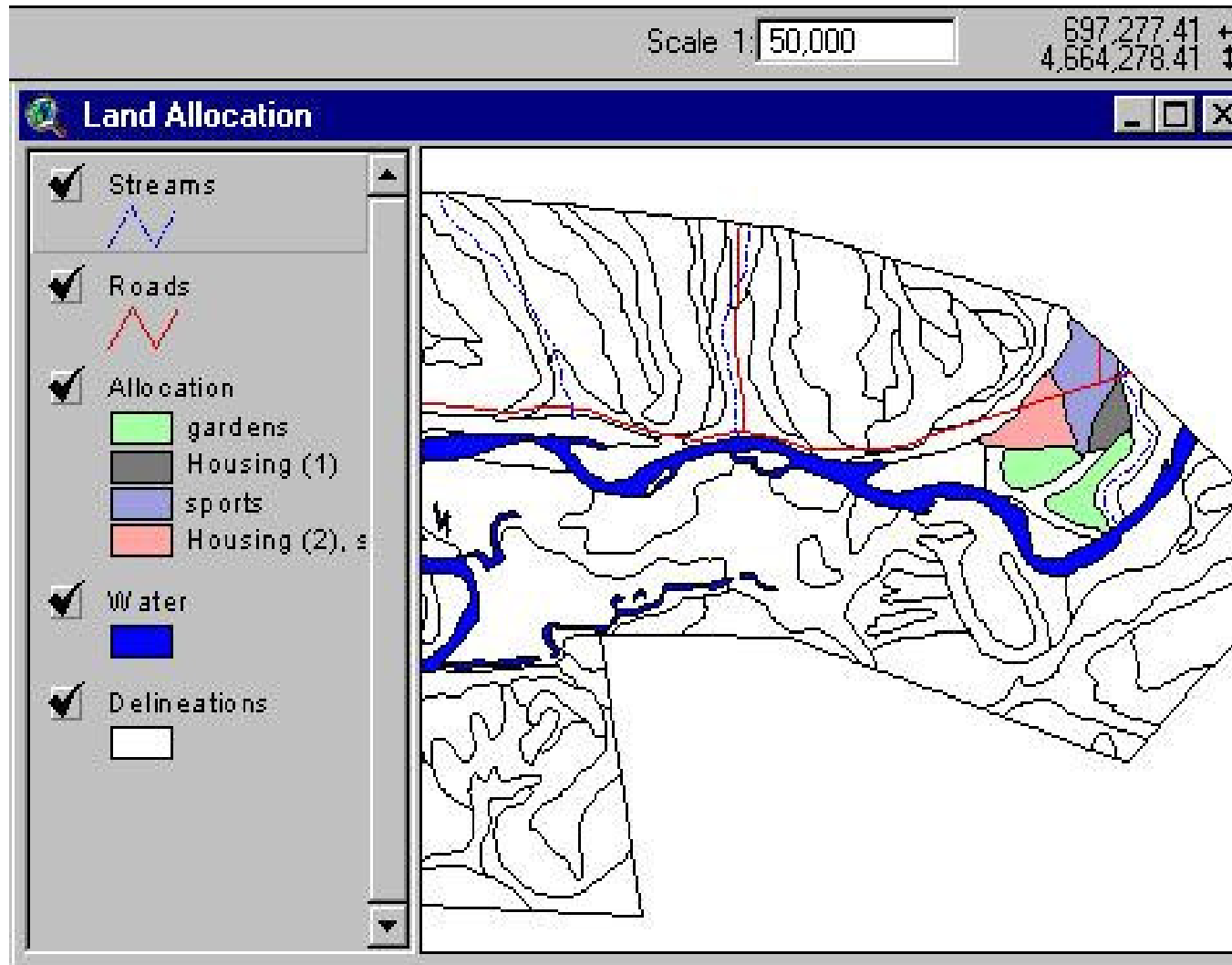
# Examples of spatial requirements

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- Sports fields and gardens should be *within walking distance* of houses
- Housing should not be *adjacent* to uses that produce manure or spread it on fields
- Agricultural areas should be *large enough* to have at least five farms and *within 4 km* of agricultural services



# Derived map: land allocation



Allocation:  
Expansion areas  
for a small rural  
community

SSURGO  
data base;  
ArcView 3

Seneca Nation of Indians, New York



# Conclusion

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- **Inadequate land evaluation concepts and methods have been replaced in theory**
- **Now it is time to replace them in practice**

