New directions in land evaluation for land use planning

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Objective

- 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

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

- 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

- The research chain
- Modelling
- Spatial analysis
Topic: The research chain
The research chain: Objectives

- 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

1: problem definition
2: output specification
3: model selection
4: data requirements
5: model application
6: quality assessment
7: presentation

Innovations

- 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

Primary Information

What primary information is needed to reach an interpretation?

Interpreted Information

What interpreted information is needed to reach a decision?

Decision Maker

Realistic land-use options

Knowledge, Models

Constraints

- Financial possibilities
- Legal system
- Social convention
- Cultural preferences
- Infrastructure
- Financial system

Land-use Decision

Negotiation
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
Models

• A representation of reality
• Simulation of real processes
• Can ‘compute’ and thus make predictions
Classification of models

- **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

- 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

- **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 ⇒ 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)
Example

- 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

- **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

- 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

- **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)

- **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)

- *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 coulter is the "lead" and cuts all crop residue in half. The other two coulters follow behind and are 9cm to either side of the lead coulter; 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)

- 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

- 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

- 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

● 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)

● 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)

- 3 - Moisture conditions of soil surface
  - Evaporation from soil surface
  - Runoff, ponding and infiltration
  - Only in spring, no need to consider frozen soils (⇒ limited domain of applicability)
  - Physical models, pedo-transfer functions
4 - Data Requirements

● **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

- Run the models
6 - Quality Assessment

- Individual models may be tested by their developers
- Combined model can be compared to test plots
7 - Presentation (1)

- Time-series graphs under historical conditions
  - Earliest planting dates
  - Tillage hours
  - Yields

- Statistical summaries
  - e.g. ‘1 year in 10’ risk
7 - Presentation (2)

● 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 none till, is they thought they couldn’t inject manure,” says Dan DeGolyer, managing consultant with Western New York Crop Management Association, based in Batavia, N.Y. “I no longer believe that.”

“Injection producers can have their cakes 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 AirWay 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 breaks into the upper soil surface.

2. Vertical tillage tools make channels in the soil to lessen the chance for manure to leak into the soil.

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

Since the AirWay isn’t injecting manure, you won’t get the maximum ammonia value from manure applied in the spring.

Extension publication; also available as PDF on the Web
Example time series

Spatially-explicit land evaluation

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

- 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

- Spatial *representation* of non-spatial *analysis*
- Does not make the analysis spatial!
Base map: soil map units

Map units: phases of soil series

Seneca Nation of Indians, New York

SSURGO data base; ArcView 3
Linked attribute tables

Key: {Muid, (Layernum) }

Seneca Nation of Indians, New York

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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

- **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

- 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

- 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

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