

# Introduction Continued: Scale and level, Processes to be modeled, Drivers of LUCC

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# Three related concepts

- Scale and/or level
- Exogenous and endogenous model components
- Conditional probabilities

# Identifying and representing spatial, temporal, and behavioral complexity (cont.)

## Main questions to consider

- What spatial, temporal, and behavioral processes do we believe are important in the system we want to model?
- How much complexity do we need to build into our model to capture those processes?
- How little complexity can we get away with?

# Cross-scale dynamics

- Higher-level processes often constrain lower-level processes
- Lower-level processes may feed back to influence higher-level processes

## Example: roads, colonization, and deforestation

- National level policies (subsidized timber prices and/or roads) encourage road construction and deforestation
- National level policies (distribution of land for frontier settlement) encourage settlement along roads
- Rural ag. producers become more integrated with the market (new people, new techniques, new opportunities)
- Results may be greater sensitivity to financial factors such as ag prices, off-farm wages, credit, timber prices) (Angelsen and Kaimowitz)

## Example: Residential location and employment

- Spatial structure at one level determined as residents locate within commuting distance of place of employment
- Spatial structure at another level determined as firm locates around other complementary firms (result is polycentric node)
- Spatial structure at higher level determined by relationship between polycentric nodes
- At a still higher level, spatial structure between cities is determined through migration (Anas et al.)

## Example: Ag production and price feedbacks

- Spike in demand may cause ag extensification (production on previously marginal lands). Example: organic rice for Japanese consumption
- Increased supply at a local level feeds back to depress globally determined price (classic cobweb model)
- Note that integration of new markets may have the same effects (example: coffee production)

## Cross-scale dynamics: implementation

- Inductive analysis of influence of drivers at different scales
- Cross-scale (multi-level statistical methods)
- Results from macro-scale distributed to micro-scale (top-down)
- In land-use change models, total quantity of change is often determined first, then distributed over space



# Backtracking ... Important challenges (An evolving list)

- Human/environment feedbacks: progress is being made
- Social drivers:
  - Demography
  - Technology
  - Economy
  - Political and social institutions
  - Attitudes, beliefs, behavioral norms
  - Information and its flow

## Important challenges cont.

- Integrating research groups across disciplines
- Temporal and spatial (a)synchrony
- Feedbacks across spatial and temporal scales
- Data: resolution of data and model, integration, consistency, formats,
- Building infrastructure: open source approaches

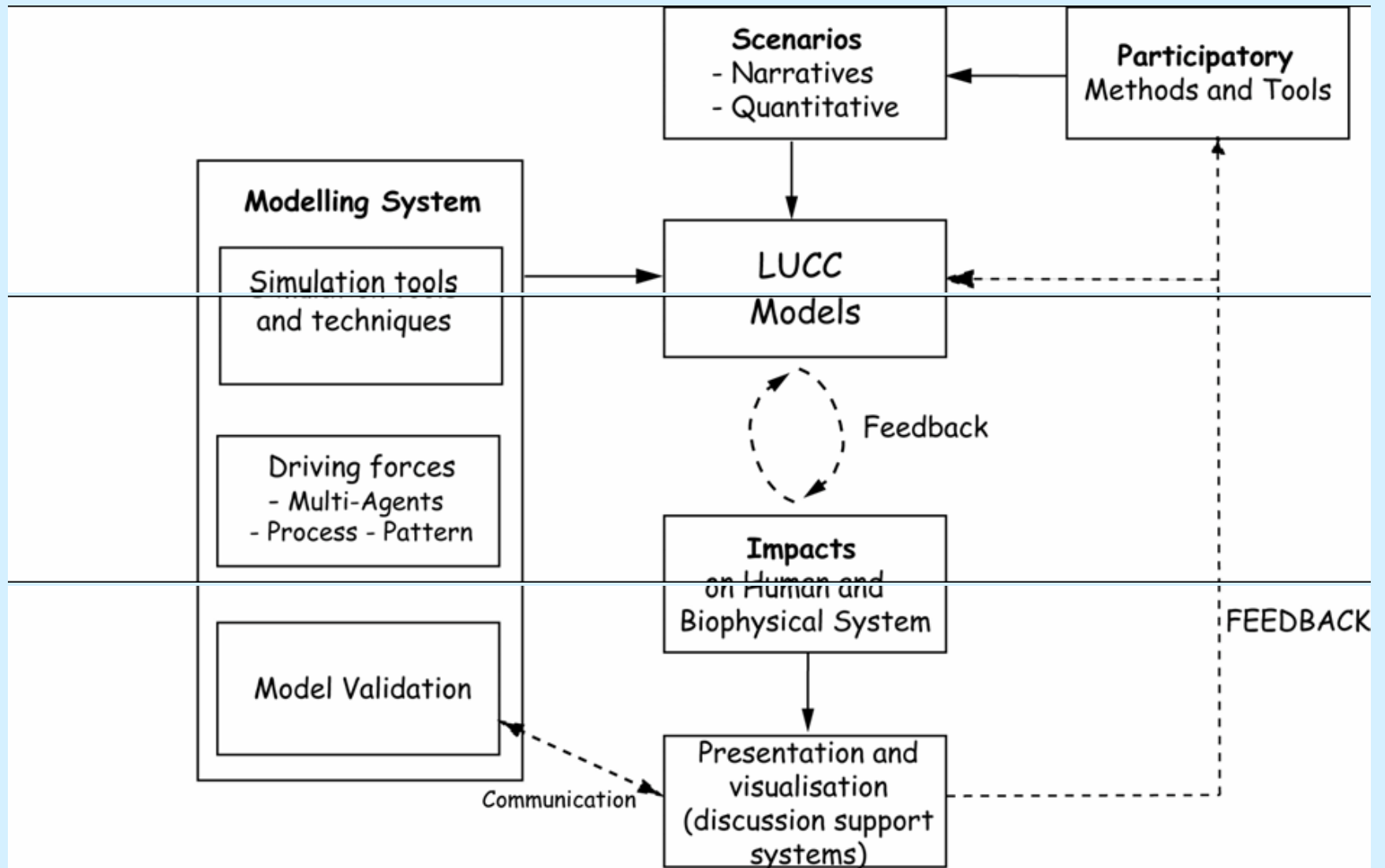
# Important challenges from Verburg 2006

- Qualitative storylines to quantitative input (Uganda project)
- Urban-rural interactions
- Continued progress on global-scale models

# Important challenges: communication with policy makers

- Focus has been on huge methodological challenges
- We know how uncertain model projection are; this is tough to communicate to policy makers who want 1 answer
- Consensus is that participatory approaches are very promising to address these problems, esp. companion modeling
- Consensus also that policy makers should be involved from the start

# LUCC to support policy (Verburg et al 2006)



# Search strategies (tangent)

- Web of science citation search
- Course syllabi
- Favorite journals (example: Environment and Planning)
- Special issues: check other articles in that issue
- Ask your buddies (most effective!)
- Look at proceeding of key workshops and conferences (see for example new TALUC conf.)

## Main questions to consider

- What spatial, temporal, and decision making processes do we believe have an influence on land-use change outcomes?
- What issues are involved in capturing these processes?
- How do we determine the appropriate spatial, temporal, and decision-making scale for our models

# Comments and highlights, Geist and Lambin

- Nice attempt to generalize from a large number of case studies
- Potential answer to question from last week: LUC models need more complexity, but structured, cross-scale
- Regional, synergistic causal factors (economic, institutional, and political) drive local deforestation

## G and L continued

- Common pattern of infrastructure expansion followed by commercial wood extraction, cultivation, and ranching. Shifting cultivation not as important
- Integration with markets (cash economy) major driver
- Institutional factors important
- Property rights impacts ambiguous

# Angelsen and Kaimowitz

- Another nice survey of a largely separate literature
- Authors are clearly more supportive of microeconomic analysis in general
- They conclude that results regarding immediate (local) causes are stronger than regarding underlying (regional, national, beyond) causes.

## A and K, cont.

- Note that for each potential immediate cause, they provide a nice discussion of potential theoretical impacts (including “it depends”), then summary of empirical evidence.
- Important data issues related to macro-level results also discussed
- Some generalization overturn common rhetoric (population, trade liberalization)

## A and K, drivers:

- Agent level: prices, technology, information, access to services, infrastructure, credit
- Higher-level: existence of market, infrastructure, property rights regimes

## A and K, empirical evidence regarding drivers (Table 2)

- High prices for ag products encourage forest clearing
- Higher off-farm wages and employment opportunities decrease clearing
- Increased accessibility increases clearing
- Effects of increased input prices and/or technological change unclear both in theory and empirically
- Increased credit, land tenure, and timber prices increase clearing, although theory is ambiguous

## A and K, evidence regarding underlying drivers (Table 3)

- Population density increases deforestation, but empirical evidence is not very strong
- Incomes and trade liberalization are unclear in theory, but empirically increase deforestation
- Answers not clear with respect to technological progress, foreign debt, and economic growth

## Anas, Arnott, and Small

- Very nice example of iteration between empirical observation and theory, if somewhat technical in places
- Notes in several places that the micro structures of cities may not resemble the macrostructures; sheds some doubt on the fractals approach and support to the complex systems approach

## Anas et al., key empirical observations:

- Density declines with distance from the city center
- Density gradients have become flatter over time
- Not clear that decreasing transport costs are responsible
- Larger cities tend to be more decentralized
- Polycentricity very important in both old and new cities
- However, city centers still play an important role
- “Edge cities” are a somewhat new development

## Anas et al.: commuting patterns

- Average commutes are three times as long as the minimum distance required. Possible explanations:
  - Personal preference for locations
  - Two-worker households
  - Frequent job shifts
  - Racial and ethnic segregation
  - Commuting norms? (discuss)

## Anas et al.: complexity and cities

- Even analytical models of polycentricity exhibit complex behavior (path dependence, multiple equilibria, threshold effects).  
Implication is that some complexity is needed for a good urban model.

## Irwin and Bockstael, main findings

- Also find increasingly decentralized urban areas
- And more complex structures (polycentricity and edge cities)
- Focus on section 3 of their chapter ...

# Urban sprawl--lots of controversy!

- Many definitions of sprawl, many data sources and mean of measurement
- Lots of controversy about whether or not it has increased, especially as relates to ex-urban development
- Not only differences in data, but also in philosophical perspective seem to drives differences in conclusions

# Density gradients

- Like Anas et al, they report decreasing density gradients over time
- Can be explained in theory by decreasing commute costs and/or increasing income
- Tiebot model predicts that residents move to suburbs in search of amenities (schools, open space, safety)
- Empirical evidence supports asc. between incomes and Tiebot hypothesis.
- But even including transport costs, does not fully explain changes in density gradients

# Employment decentralization

- Employment has also decentralized, but into subcenter or edge cities
- Theoretical explanations include agglomeration economics, rising land rent, firm competition, congestion externalities, and high commute costs
- Question: how could rising transport costs lead to emergence of polycentric nodes?
- Empirical models tend to reject mono-centric form (but don't look at drivers)

# Leapfrog development

- Again, empirical evidence is hard to come by
- Theoretical explanations include optimal land speculation, uncertainty, and negative spatial externalities
- Zoning laws and provision of services have important effects on the location of new growth--restrictions in one area can cause leapfrogging

# Sprawl--empirical drivers

- Some evidence that high black/Hispanic populations and greater political fragmentation increase sprawl, low-density zoning, and building restrictions
- High-quality farmland, geographic constraints, reliance on public sewers, and requirements for infrastructure provision with development decrease it
- For both sprawl and ex-urban development, the opportunity cost of rural land activities is an important driver/constraint

# If time--drivers of LUCC in NoVa

## Von Thunen model exercise

- 1) How do land-use patterns change as you:
  - Include a grid or a spoke transportation network
  - Change market prices of particular crops
  - Change transportation costs of particular crops
- 2) Can changes in market prices and changes in transport costs have equivalent effects?
- 3) Can you produce a polycentric city using this model?

## Definitions:

- **Proximate causes** (Geist and Lambin)/sources (Angelsen and Kaimowitz): action by agents that leads to land-use change (specifically, deforestation)
- **Underlying driving forces/underlying causes**: factors influencing agent decision making at many levels

## Definitions (economic)

- **General equilibrium:** model in which key prices and resource allocations are endogenous
- **Time preference/discounting:** Time preference refers to the weight that an agent gives to current consumption vs. future consumption. The discount rate is similar to an individual rate of interest.
- **Risk aversion:** Risk-averse agents prefer a sure payoff to a bet with an expectation of a higher payoff (explain)

## Economic defs. Cont.

- **Externality:** A cost or benefit of a choice made by a given actor that accrues to someone else, where the decision-making does not account for this cost or benefit in his/her decision.
- **Market failure:** An economic outcome in which externalities occur at a level that does not balance marginal social costs against marginal social benefits

## Economic defs, cont.

- **Perfect markets:** All goods can be traded at competitive market prices (no monopoly power)
- **Shadow prices:** The value to an agent of an additional (marginal) unit of some input resource (discuss this). In a competitive economy with perfect markets, will be the shadow price for some agent.

## Economic defs, cont.

- **Land rent:** The market value of the current land use; the shadow price of land
- **Agricultural intensification:** Many defs; generally means cultivation methods to produce more from the same land resource
- **Agricultural extensification:** Expansion of production into previously unused (often marginal) lands.

## Economic defs. Cont.

- **“Inelastic” demand:** Large changes in prices cause very little change in purchase behavior (classic example is prescription drugs)
- **Returns to scale (economic):** Average unit costs of production fall as the size of the firm increases. Geographically, this can mean it take up more space. It also may employ more people.

## Economic defs., cont:

- **Monopolistic competition:** Firms offer specialized products that potentially substitute for other similar but specialized products (restaurants). Many models of spatial monopolistic competition (spatial market niche)
- **Vertical integration:** Supply chain (from raw materials to final product marketing/distribution) integrated within a single firm

## Economic defs, cont.

- **Returns to scale (economic):** Average unit costs of production fall as the size of the firm increases. Geographically, this can mean it take up more space. It also may employ more people.
- **Economies of Scope:** Average costs of one or more products fall as the firm diversified production into other goods.
- **Economies of Agglomeration:** Economies of scale and/or scope between firms; knowledge and technology spillovers, sharing of a pool of qualified labor

## Economic defs., cont.

- **Shadow value of time:** The value to an individual of sacrificing additional leisure/labor. Often assumed to be the wage rate (thus linked to income). Explain assumptions of labor/leisure model.
- You can gloss over these sections of the Anas article that you can gloss over are posted on the “news forum” on the website