Modeldiversity

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Modeldiversity

- CAN BE a good thing
- Provided that …
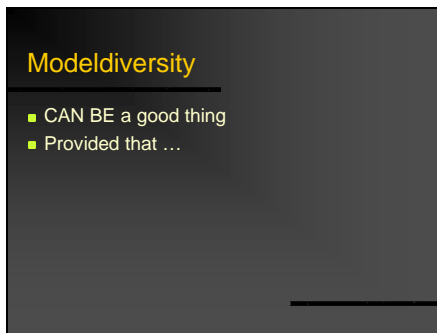
Too many different growth models? Standardize?
Not really

Outline

- Taxonomy
- Cross-fertilization
- Case studies
  - *Simple* stands: TADAM
  - Stand-level models for *complex* stands
- War or Peace
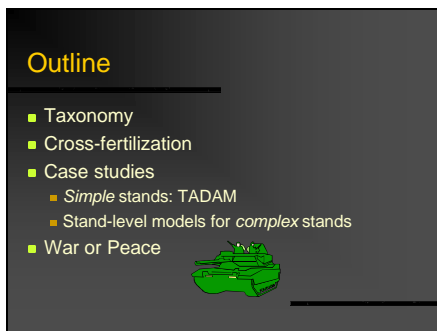
Little Tim has studied everything about the snake, and
nothing else, for his Biology exam. He sits down,
and the question is: "Write an essay on the elephant"
(oops!). Tim starts writing: "The elephant's trunk
resembles a snake. The snake..."
I know nothing about boreal mixewoods, so will pull out
a couple of snakes.

Dynamical Systems

- Static: Yield tables (VDYP, TIPSY)
- Dynamic:
  1. State
     e.g. (B, N, H) or $(d_1, d_2, …, d_n)$
  2. Rate of change (transitions)
     e.g. $\Delta B = f_1(B, N, H)$, etc.
     or $\Delta d_i = f_i(d_1, …, d_n)$, etc.
 3. Outputs
     e.g. $V = a + b\,BH$
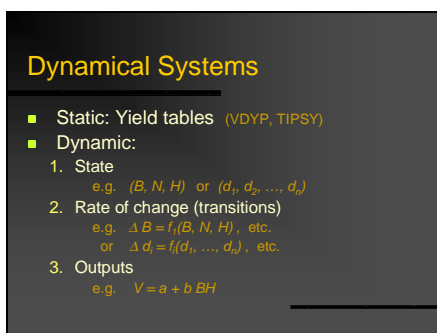
Yield tables are sufficient in many instances
But have limitations for density management, etc.
General System Theory, Systems Dynamics point of
view
Example state variables: basal area (B), trees per hectare
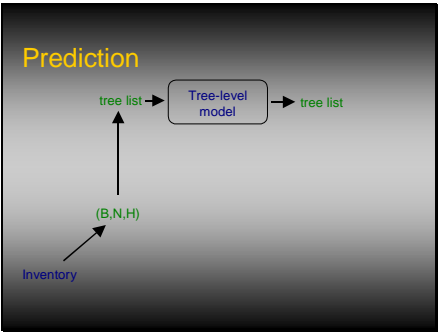(N), top height (H), individual tree diameters (d), ...

Taxonomy

Forest growth models

- Resolution level, state dimensionality:
  - Tree-level
    - Spatial
    - Aspatial
  - Stand-level

- Uses:
  - Basic research (understanding)
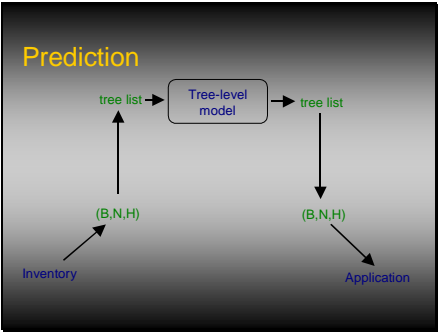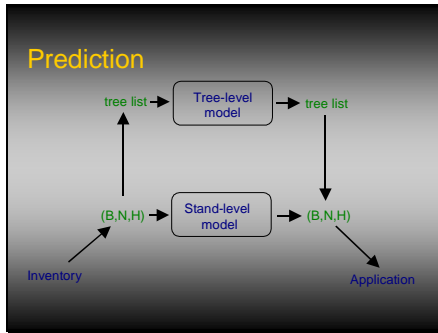 - Decision-making (prediction)
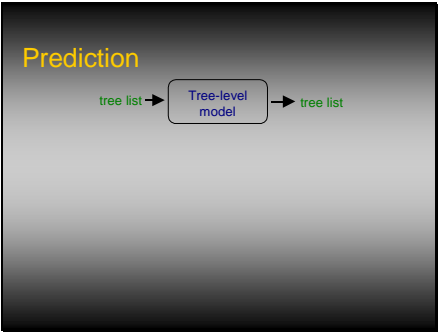
Individual-tree models project detailed stand description (e.g. tree list)
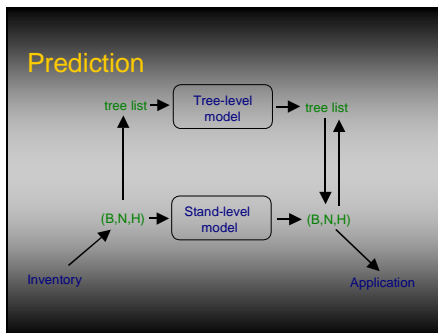
Prediction

tree list → Tree-level model → tree list

Initial state usually unknown. Reasonable estimates only for stand-level variables (e.g. B, N, H).
"Tree list generation"

Prediction

tree list → Tree-level model → tree list

(B,N,H)

Inventory

Projected state summarized for decision-making

Prediction

tree list → Tree-level model → tree list

(B,N,H)   (B,N,H)

Inventory   Application

An alternative (sometimes)

"But individual -tree models produce useful detailed outputs..."
If the detail can be made-up at the start, it can be made-up at the end.
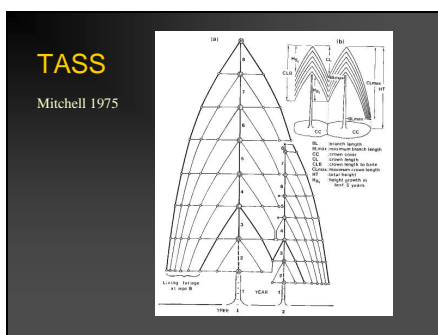

Ideally, knowledge from one kind of model should become useful for the other.
To-date, mostly independent developments.
One possibility is to aggregate tree-level models to the stand level, mathematically.
Another, to approximate with empirical aggregated models.
I'll show an example of the latter.

TASS, a highly detailed mechanistic model for even-aged stands.
It models development and interaction of individual crowns. Tree volume increment is function of its foliage and that of its neighbours. Increment is distributed along the stem according to Pressler's law (aka the pipe model theory).
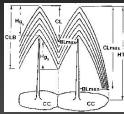
TASS - Pros & cons

- Bio knowledge, logic
- Low (development) data requirements
- High prediction data requirements
- Complex, costly → TIPSY
- TIPSY: static
- Stochastic

Not often used directly.
Yield tables generated by TASS, accessed through TIPSY, are widely used in BC.
Mostly from bare ground. Problems projecting existing stands.
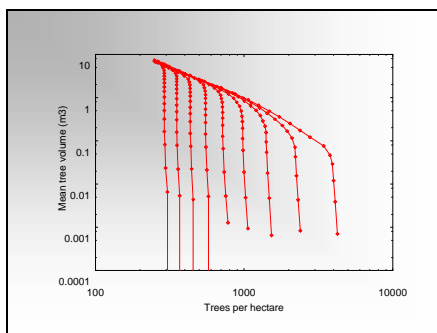
Metamodelling

→ (B, N, H) ?

Could we approximate TASS with just a few stand-level state variables?

2-D?

Stand density management diagrams (SDMD, Farnden 1996)

Essentially, SDMDs try to get away with 2 state variables.
Farnden' derived SDMDs from TIPSY's TASS - generated yield tables.

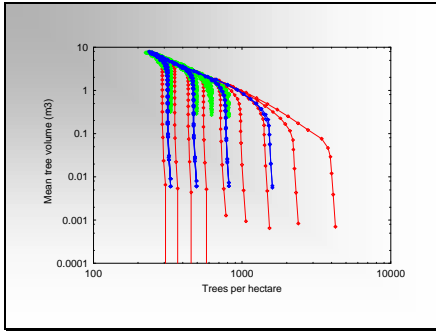The basic idea: trajectories in a 2-D plane.
Assume limiting ('self -thinning') line on logarithmic axes.
Some use basal area or dbh instead of volume.
Unthinned TASS-TIPSY predictions (planted Coastal Douglas-fir).
Dots on lines mark top heights. Corresponding heights are supposed to be on a same curve (isolines).
Looks good.

Pre-commercial thinnings (blue) and commercial thinnings (green).

Isolines don't work. Logical flaw in SDMDs: thinning – caused jumps do not need to follow the isolines.

Could be fixed, at the cost of some more complexity in SDMD usage.
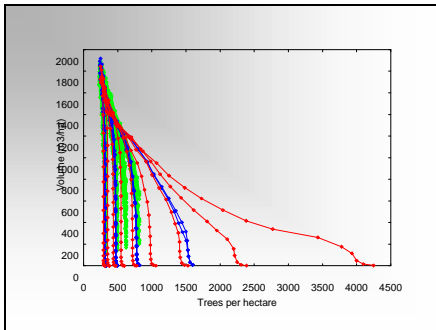
Anything hiding behind the log transforms? (Weller 1987)

The logs might hide detail where it matters.

Hmm, can't see much. Actually the log N was better in spreading out the data.
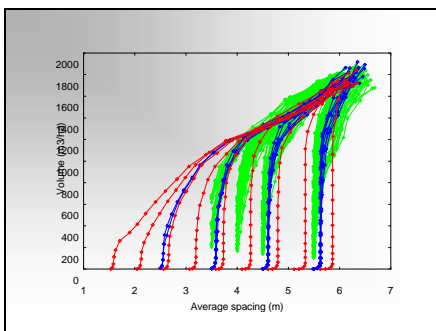
Try mean spacing instead (S = 100 / sqrt(N), same info.)

OK for unthinned stands, but fails with thinnings.

Trajectories cross, i.e., different movement directions (transitions) for the same state.

Two state variables not enough (at least not these two).
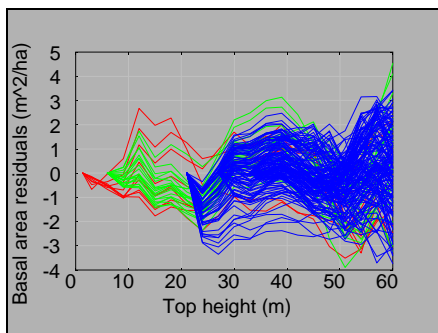
Need another one. How about height?
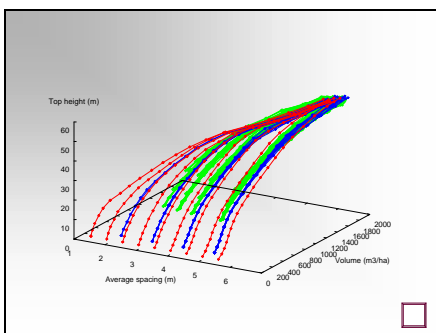
Might work...

(fancy 3D dynamic graphics omitted here)

3-D: TADAM

TASS Approximation by a Dynamical
Aggregated Model
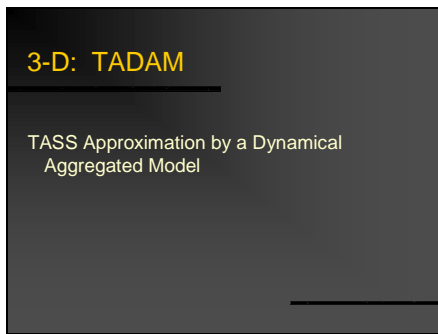
TADAM: a 3-D stand model approximating
TASS/TIPSY (planted Coastal Douglas-fir, for now)
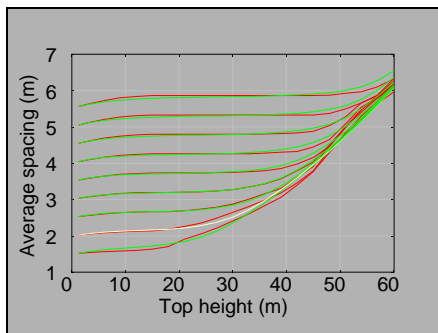
TIPSY (red) and TADAM predictions from initial point
(green). Unthinned.

Easier to see: TIPSY minus TADAM basal areas. Red =
unthinned, green = pre-commercial thinning, blue =
commercial thinning.

As expected, some over-prediction immediately
following thinning, due to temporary less than full
site occupancy. Could be improved with more
complex model, including additional occupancy state
variable.

Anyway, not bad, mostly within +/- 2 sq.m/ha.

An implementation

web.unbc.ca/~garcia/tadam
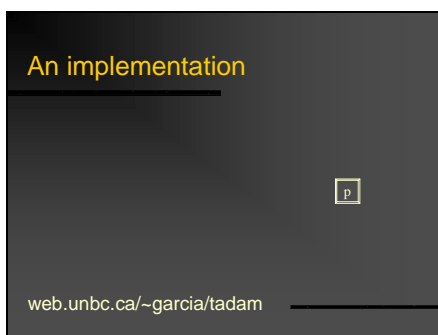
Demo on Palm PDA emulator, omitted here. See web
site.

Implementations ≠ model.

Conclusion: 3 state variables seem sufficient for most
practical purposes (even-aged single-species stands).

FLORES - CIFOR, Indonesia
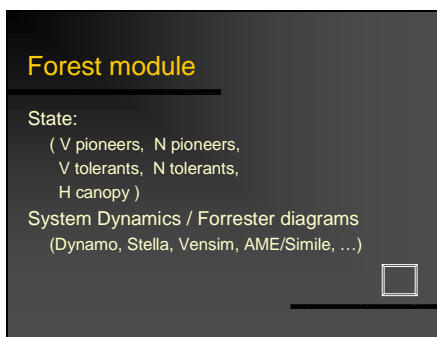
Figure 1. A few simple equations…

Second snake...
A (very) crude mixedwood whole stand model prototype.
Why do anti-deforestation policies and aid programs usually backfire? FLORES project: modelling socio-economic/resource interactions at the forest edge (http://www.ierm.ed.ac.uk/flores).
In February 1999, after a field tour making them instant experts in Sumatran forestry, an interdisciplinary bunch of people from all over the world was thrown into a room, and asked to come up with a working FLORES prototype within 4 days.

Forest module

State:
   (V pioneers, N pioneers,
     V tolerants, N tolerants,
     H canopy)
System Dynamics / Forrester diagrams
   (Dynamo, Stella, Vensim, AME/Simile, …)

Forest module state variables: canopy height, volume and trees per hectare for "pioneers" and "tolerants"
FLORES used AME, a graphical System Dynamics - based modelling system.
(Vensim demo omitted here).

AME
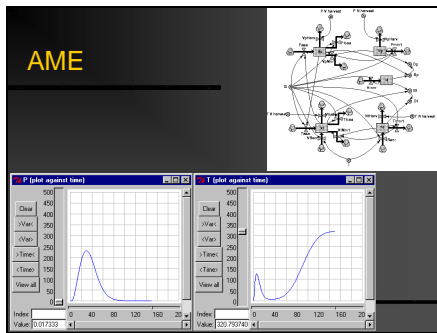
Forest module, in AME. Boxes are state variables (levels, "stocks"). Ra tes (transitions) represented by "pipes" connecting state levels and the outside world. Rates ("flows") controlled by "valves" depending on variables indicated by the arrows.
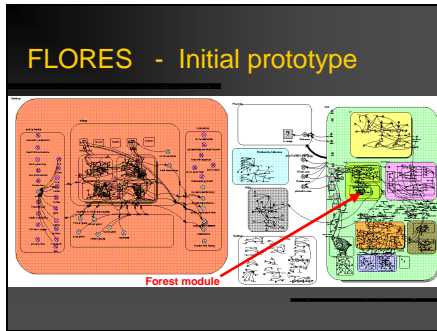System Dynamics modelling usually described in terms of stocks and flows. But actually can be more general: levels and rates do not need to represent physical flows.
Shown, pioneer and tolerant volumes over time.
Initial "blip" in tolerants. Does it make sense? Anything wrong with our assumptions/understanding?
Crude, but might point a way to practical mixewood modelling for decision-making.

FLORES - Initial prototype

Forest module

More: http://web.unbc.ca/~garcia/flores/nuts.htm
And FLORES? This was it!

The World

Piet Hein (Denmark)

To watch in modelling by committee: ***My*** bit is the most important, and should carry the most detail.

Model Wars or Synergy?

- The perfect model?
- The NIH syndrome
- All or nothing?
- Brand naming
- Modularity, reusable software components
- Generic software
- Documentation, transparency

No Silver Bullet.

Difficulties/requirements for getting the most from different approaches.

NIH: "Not Invented Here".

Best bits and ideas from a model could/should be used in others.

Some model naming resembles the old axe story: the handle was replaced four times, and the head twice, but it is still the same axe! "Brand names" are at best confusing, and can hinder progress.

Mathematical model $\neq$ computer implementation.

Some sort of "generic" software, capable of running different models, might (or not) be useful.
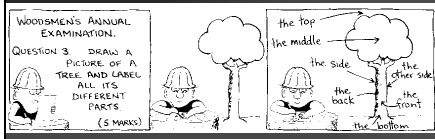
Resist temptation to obfuscate.