

Balancing, Optimizing and Sustaining Multiple Forest

Functions

- using System Engineering, Big data, AI, and Cloud computing

Guoliang Liu, Ph.D.

gliu@aiTree.ltd, <http://aiTree.ltd>,

aiTree Ltd, North Vancouver, BC, Canada

Canada forest cloud: <http://forestcloud.com>

China forest cloud: <http://forestcloud.com>

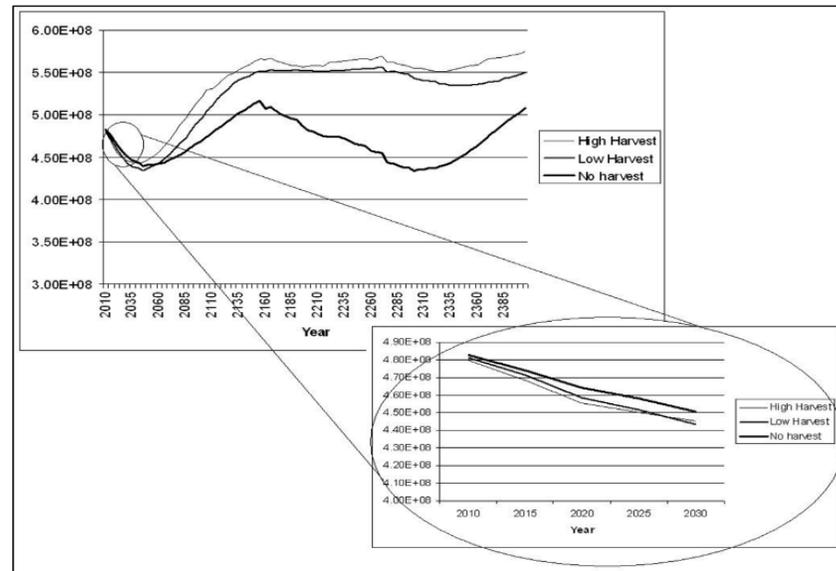
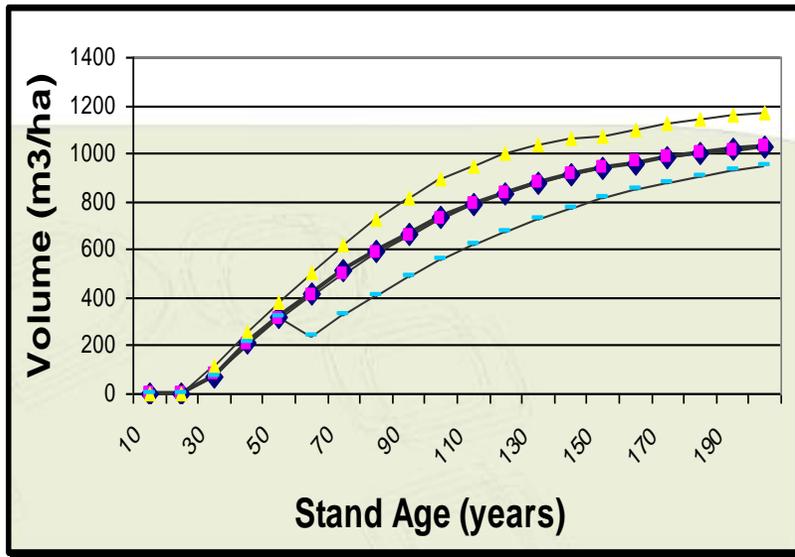
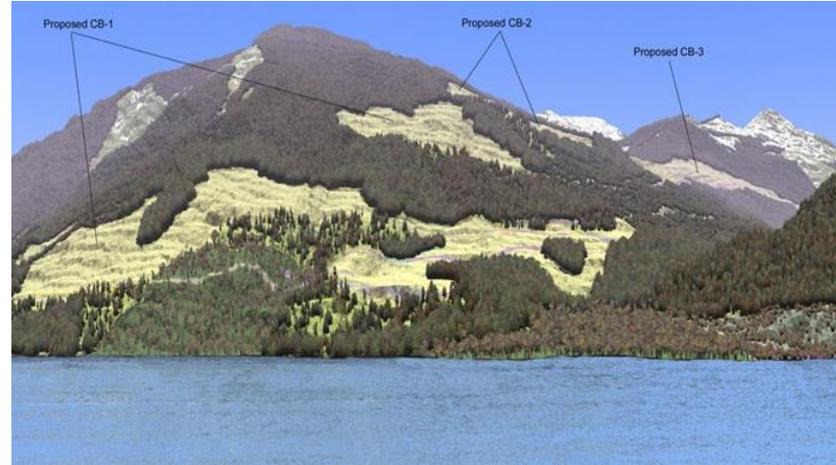


How can we let people participate?



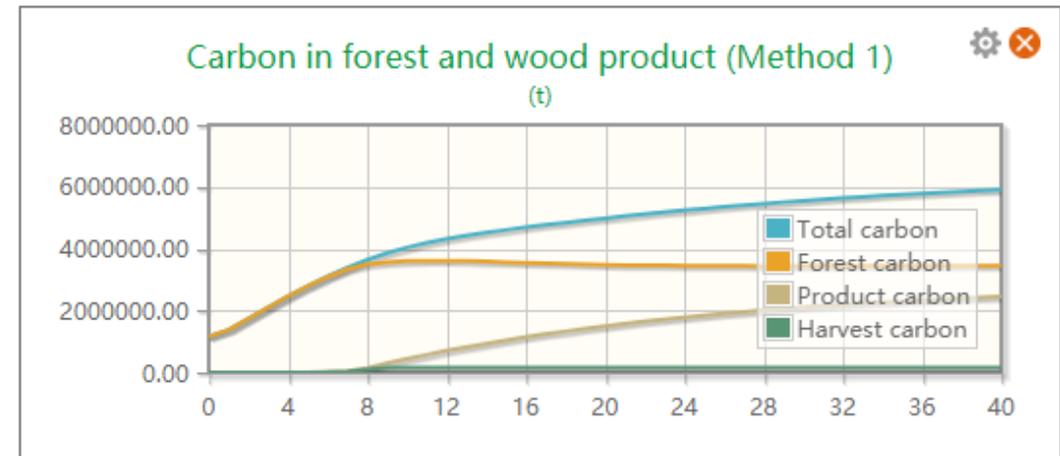
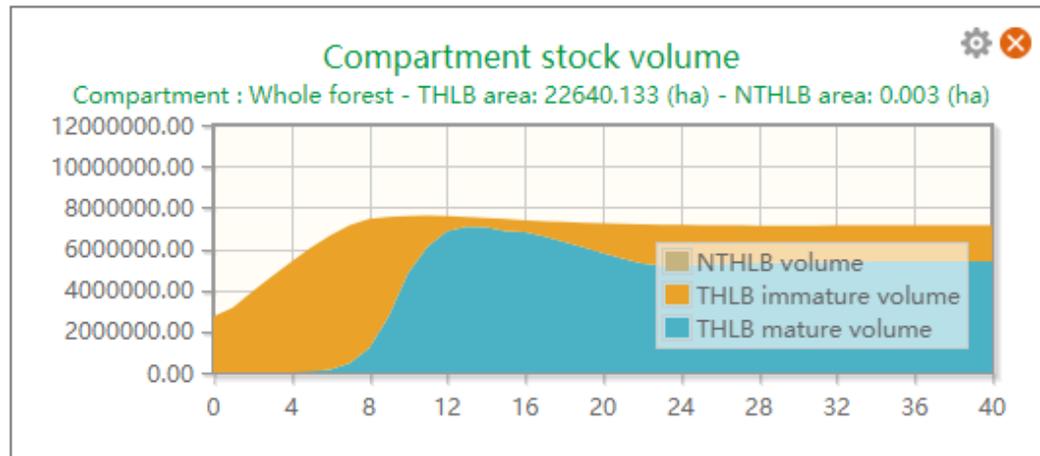
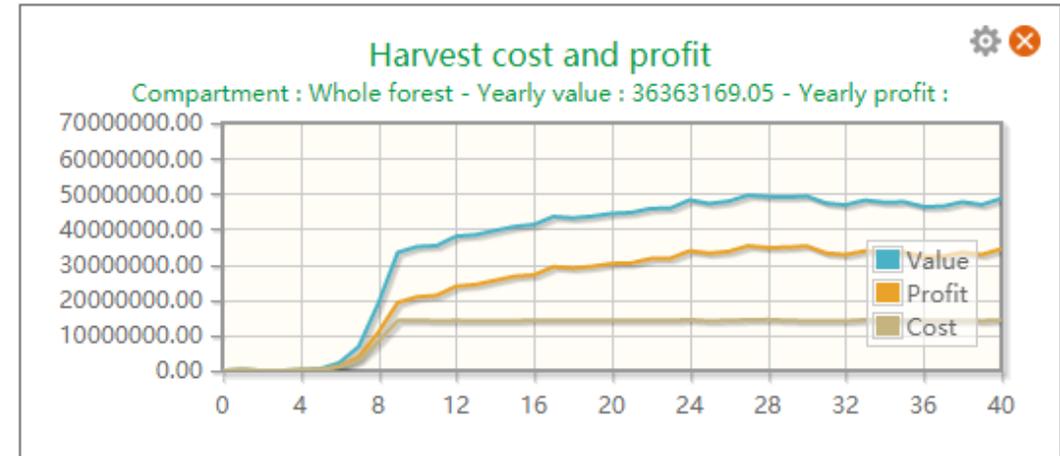
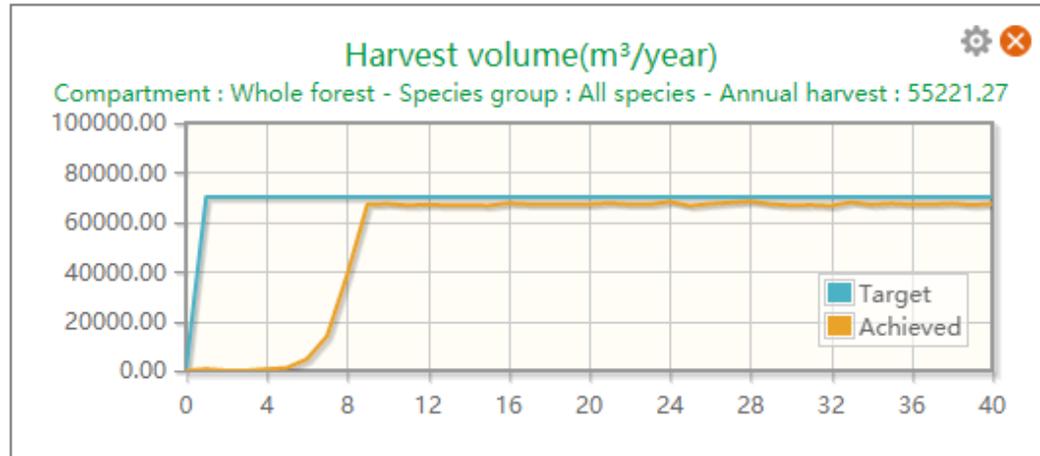
Multiple temporal
and spatial scales
Make the problems
a million times
more complicated.

Trees, Stands, Forests, Temporal, Spatial





Balance and Optimize using Artificial Intelligence from multiple temporal and spatial scales



We need models

- Strategic and Tactical
- Simulation and optimization
- Regulation-based and target-oriented
- Spatial and non-spatial
- Trees, stands and forests

FSOS

FSOS is a Forest Simulation Optimization System model.

FSOS uses artificial intelligence (Simulated Annealing) to generate forest management plans to transform forests to their desired states, maintain the desired states, balance and sustain profit and product flows.

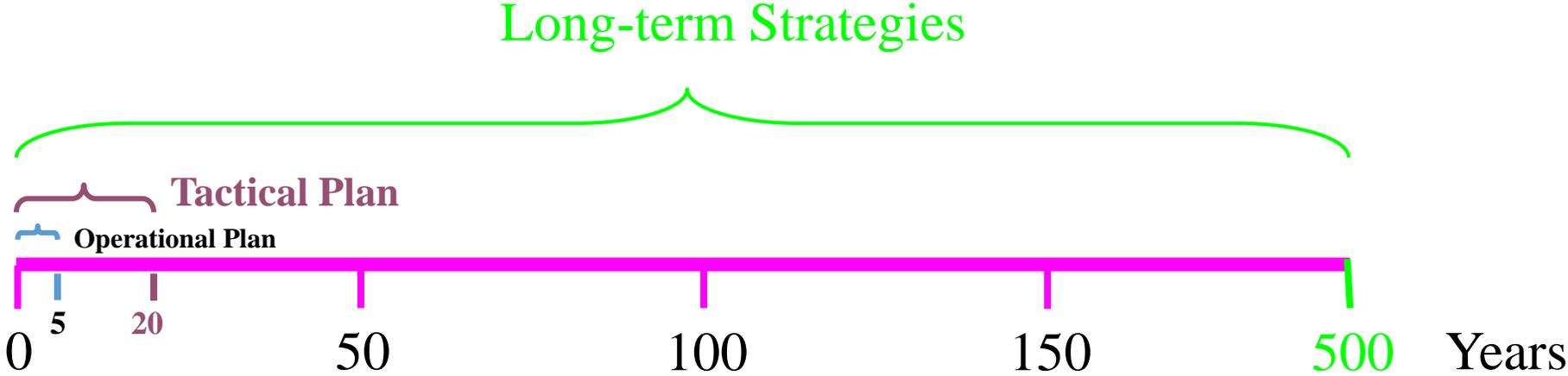
Desired states are defined from the perspectives of watershed condition, carbon storage, wildlife habitat, biodiversity, recreation, visual quality objective etc. Timber flows can be outputs of FSOS.

FSOS uses cloud computing, you can use any internet browser to run FSOS at any time and any places and do not need to install any particular software. Using FSOS is like playing a game. It is a good tool for forest planners, researchers and students to learn forest modelling, artificial intelligence algorithms, and parallel cloud computing.

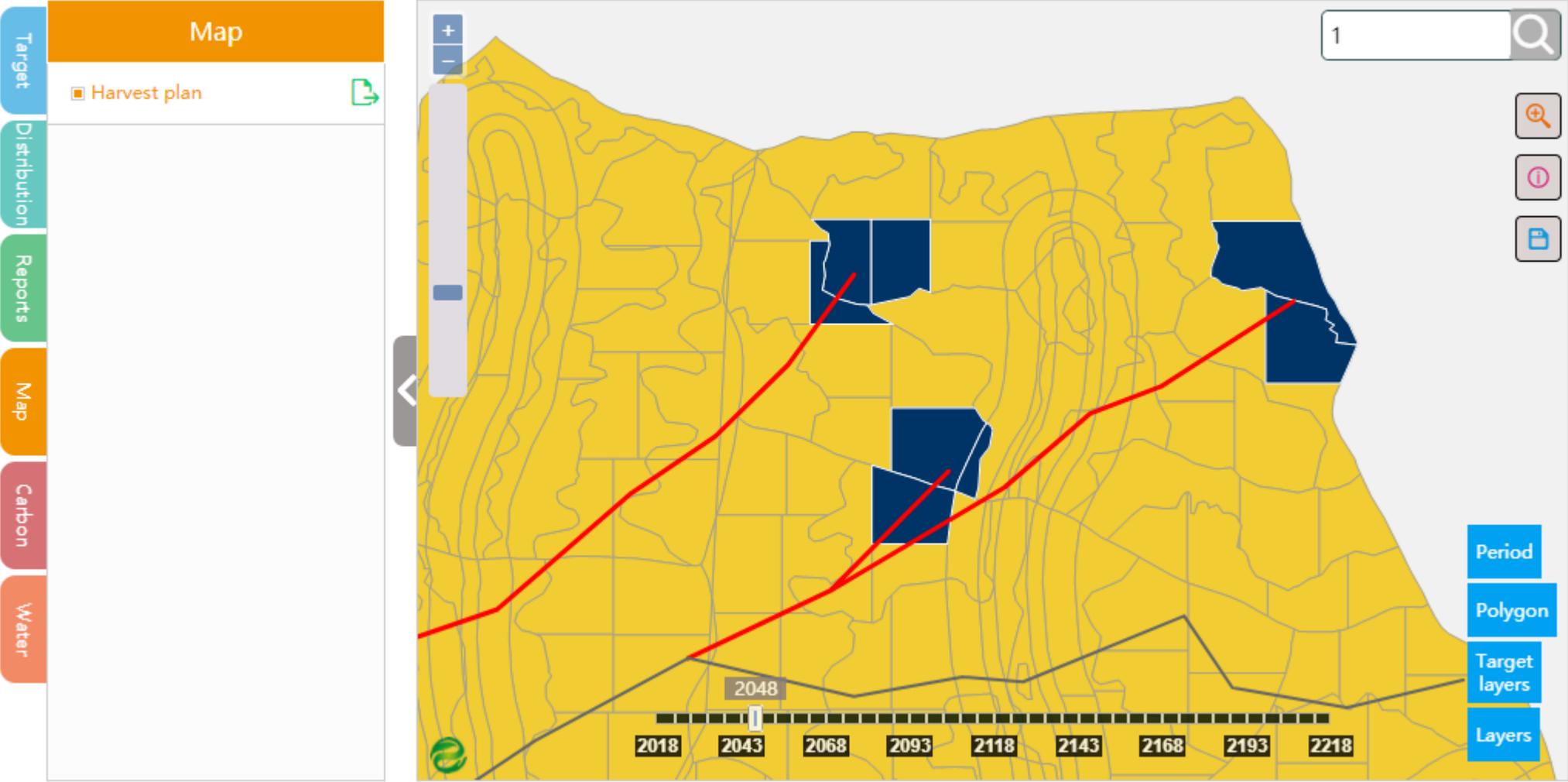
FSOS key features

1. FSOS focuses on both “what we can take from the forest” and “what we can create in the forest”.
2. FSOS uses our own cloud computing technology “EasyCloud” that can allocate a number of computers in the private network or the cloud to find good solutions in shorter time.
3. FSOS uses an artificial intelligence algorithm simulated annealing to optimize, balance and sustain forest ecosystem services.
4. Trade-offs can be made between temporal scales because all periods are considered simultaneously.
5. Trade-offs can be made between ecosystem objectives, areas and layers because all layers and zones are considered simultaneously.
6. Layout road and blocks, and schedule simultaneously.
7. FSOS can integrate stand levels in landscape levels modeling.
8. FSOS combines spatial and non-spatial in one model.

FSOS Integrates Strategic and Tactical

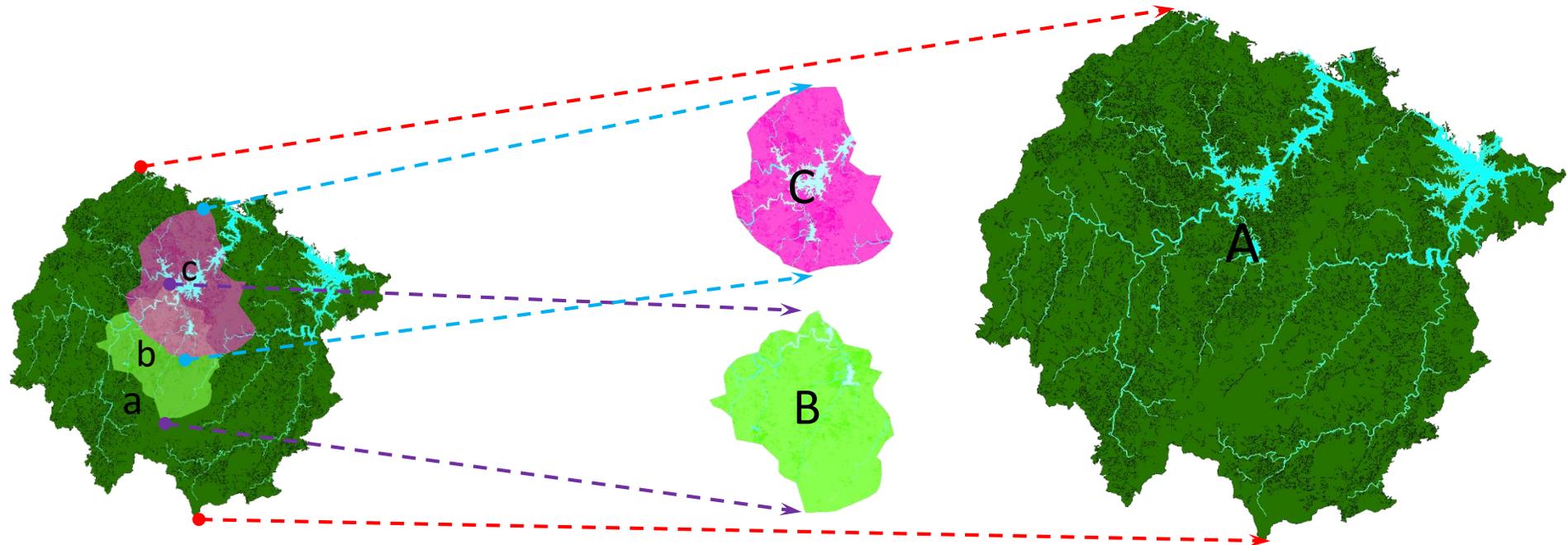


FSOS integrates block, road locations and scheduling



Understanding Desired forest-driven

- Water
- Carbon
- VQO
- Wildlife
- Biodiversity
- Timber
- Economy
- Others



Simple and powerful

Procedure



1, Polygon query, edit and tools



Polygons

Polygon information			
Polygon Id	Polygon area	Average age	Compartment
1	0.00115	0	Whole forest
2	0.19684	0	Whole forest
3	3.77986	21	Whole forest
4	6.02993	21	Whole forest
5	0.40404	0	Whole forest
6	0.15905	0	Whole forest
7	15.65341	0	Whole forest
8	0.00233	0	Whole forest
9	45.21095	0	Whole forest
10	0.00282	0	Whole forest
11	7.60432	21	Whole forest
12	0.06786	0	Whole forest
13	1.02255	0	Whole forest
14	0.53733	0	Whole forest



Import polygons

Load polygons from files of dbf, access or csv



Map

Maps of polygons, adjacent polygons and polygon groups



Tools

- Find adjacency
- Split polygons
- Import map
- Group polygons
- Map more fields



Extra tools

2, List all tree species and generate dynamics using knowledge database



Modify tree species - SF

Help

Basic info **Growth curve** Envir response Carbon

Growth parameters

Site condition: Condition 1

Volume

MAI: 7

TMax: 60

mValue: 3

Height

MAI: 0.34

TMax: 60

mValue: 2

Age	Volume(m ³ /ha)	Height(m)	DBH
0	0	0	
5	2.308	0.415	
10	14.593	1.494	
15	39.188	3.03	
20	74.398	4.864	
25	117.144	6.876	
30	164.25	8.976	
35	212.987	11.097	
40	261.251	13.189	
45	307.548	15.219	
50	350.911	17.163	
55	390.784	19.005	
60			

Adjust growth curve

Volume Height DBH Stems Price

3, Define stands, generate dynamics, link polygons

Modify stand - Stand34

Help

Basic info

Harvest rules

Species composition

Main curves

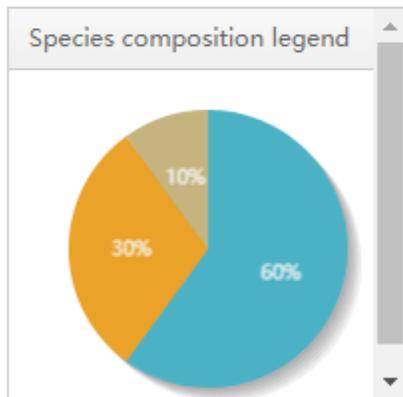
Carbon curves

Water conservation

Stand transition

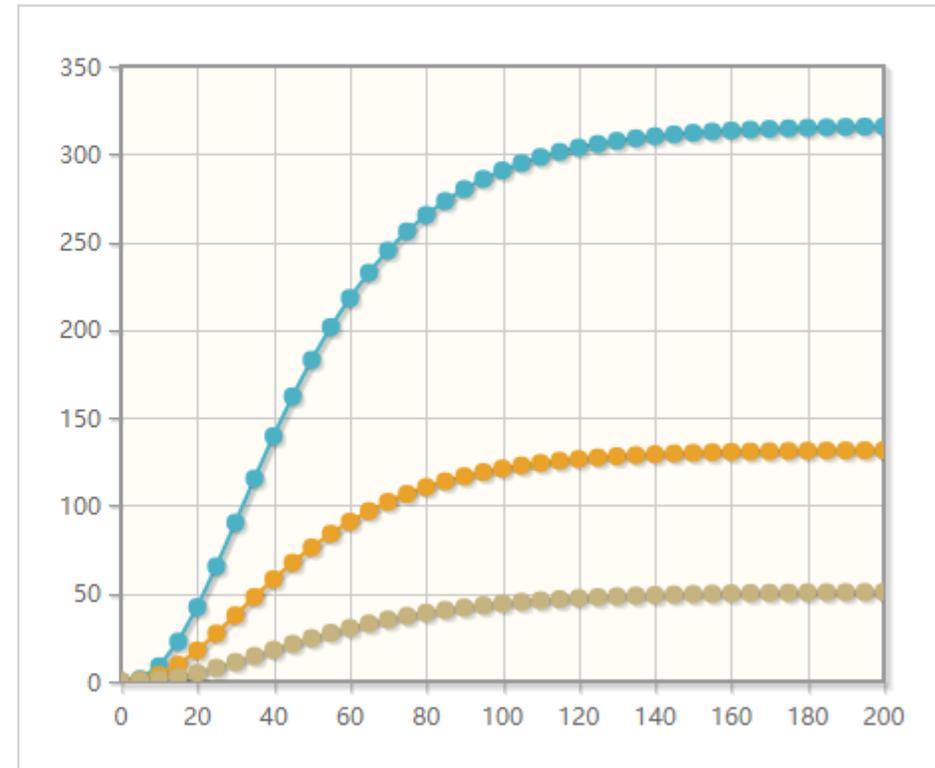


Legend	Species	Proporti...
	SB	60
	HD	30
	OT	10



Age	Volume(m ³ /ha)
0	0
5	1.393
10	8.623
15	22.699
20	42.296
25	65.45
30	90.298
35	115.352
40	139.55
45	162.205
50	182.929

Volume Height DBH Stems Price



4, Define layers, set regulations and desired states

The screenshot shows a software interface for managing layers and regulations. On the left is a vertical toolbar with icons for home, forest, chart, layers, roads, documents, lists, maps, and power. The main area is titled 'Layers' and contains a table of layer information. To the right, there are sections for 'Create layers', 'Map', and 'Tools'.

Layers

Layer information

Id	Layer name	Allow harvest
0	Whole forest	<input checked="" type="checkbox"/>
2	Road50m^01	<input checked="" type="checkbox"/>
3	Rip50m^50	<input checked="" type="checkbox"/>
4	Rip100m^100	<input checked="" type="checkbox"/>
5	Rip200m^200	<input checked="" type="checkbox"/>
6	Watershed-01	<input checked="" type="checkbox"/>
7	Watershed-02	<input checked="" type="checkbox"/>
8	Watershed-03	<input checked="" type="checkbox"/>
9	Watershed-04	<input checked="" type="checkbox"/>
10	Watershed-05	<input checked="" type="checkbox"/>
11	Watershed-06	<input checked="" type="checkbox"/>
12	Watershed-07	<input checked="" type="checkbox"/>
13	Watershed-08	<input checked="" type="checkbox"/>
14	Watershed-09	<input checked="" type="checkbox"/>

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1 / 2 GO

Create layers

Create layers and assign polygons.

Map

Maps of stand distributions

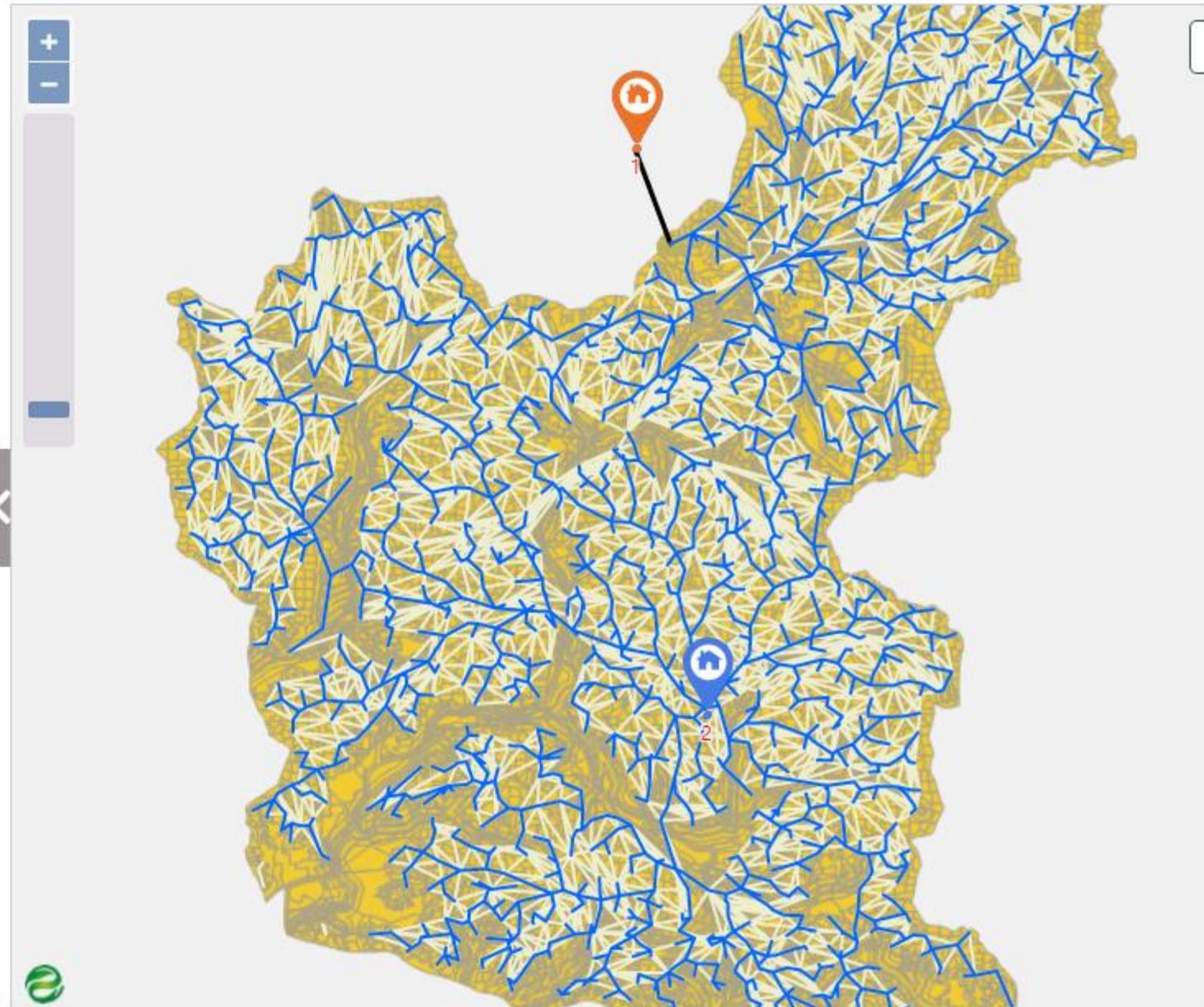
Tools

- Import/export**
- Desired states and definitions**
- Make new stands
- Empty layers
- ECA definition

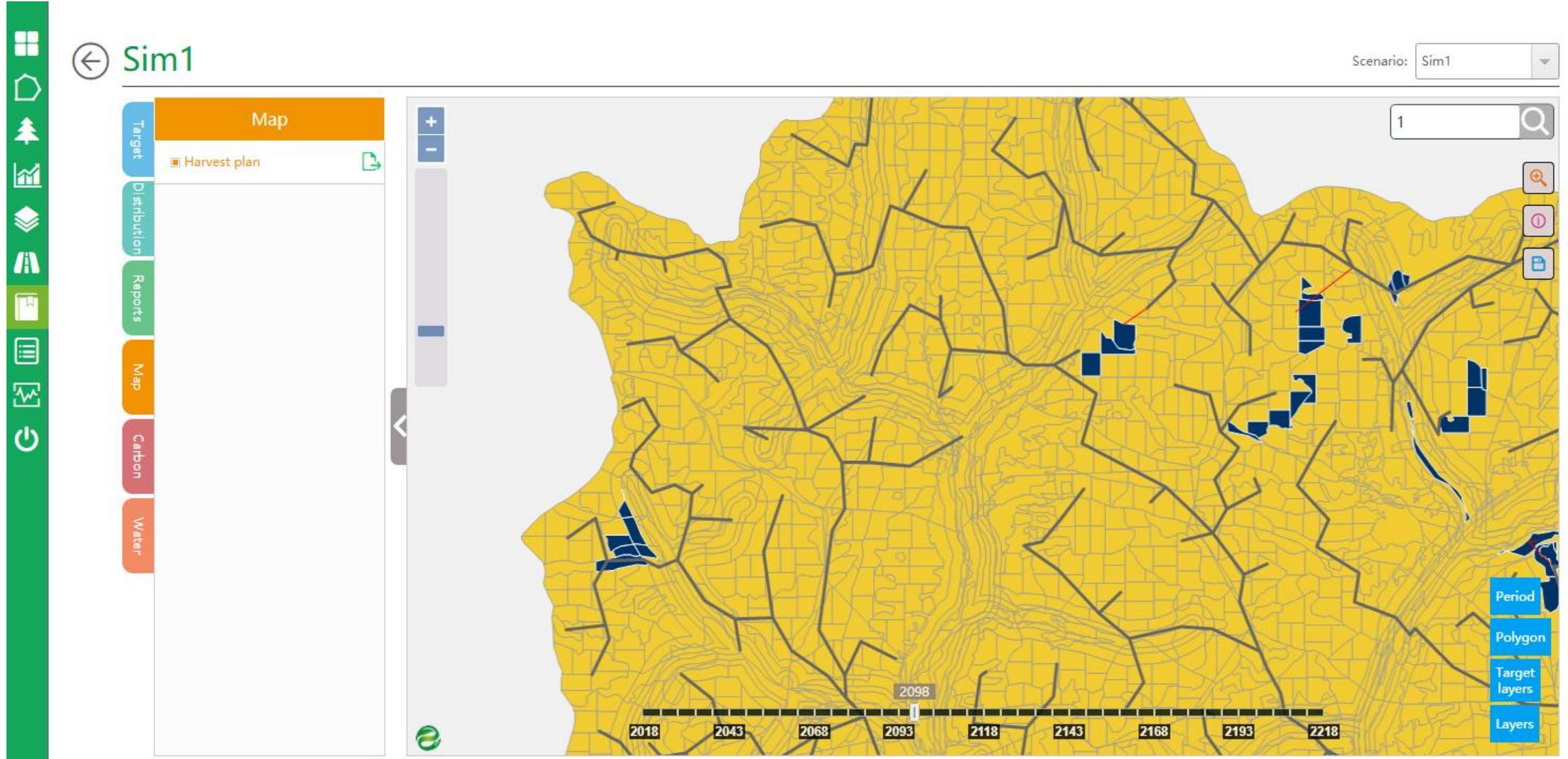
5, Integrate demand and supply

Supplies	Possible roads	Demands
Id	X Coordinate	Y Coordinate
1	22393730.542616	5013654.138319
2	22393065.384806	5013988.945203
3	22393197.965528	5014246.923548
4	22392775.126494	5014072.293988
5	22392550.652914	5014320.116808
6	22392463.921377	5014219.770912
7	22392321.989233	5013961.314828
8	22392081.220742	5014282.823115
9	22392045.270614	5013655.75117
10	22383703.919117	5016835.384142
11	22383637.867911	5017018.375484
12	22382438.083357	5018272.461145
13	22382351.627107	5018156.057242
14	22399541.978437	5032751.689008
15	22399333.318935	5034218.256608
16	22399252.794468	5034687.188943
17	22399289.96359	5032897.315264

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6, Scenarios



Conclusions

FSOS can do simulation and optimization with the same data and parameters. Both simulation and optimization have advantages and disadvantages.

FSOS can produce strategies to transform forest layers from different initial states to the desired states.

Combining blocking and scheduling is an effective way to achieve and maintain patch size distribution targets over the planning horizon while maximizing timber flows.

Conclusions

FSOS can identify treatment strategies under different natural disturbance regimes to transform forest layers to desired states.

FSOS integrates tactical and strategic planning processes. It produces a long-term treatment schedule according to current states, desired states, projected dynamics and the sustainability of resources. The short-term schedule (1 – 20 years) is a subset of the long-term schedule, which guides current forest operations.

Conclusions

FSOS is an efficient tool for adaptive forest management. Forest blocks are dynamic and treatment schedules can be modified when forest engineers reshape the blocks, update the database or when natural disturbance occurs.

FSOS uses simultaneous planning for multiple layers and multiple rotations. Tradeoffs can be made between resources and between rotations. This differs from time-step simulation, which requires explicit intervention of the analysts to examine tradeoffs between resources and between rotations (or periods).

Conclusions

FSOS demonstrates that there are numerous high quality solutions to the problems, and each solution has a different spatial pattern. From operations research perspectives, it is frustrating that there is no global “optimal” solution. However, from a forest management perspective, this is good news because it indicates robustness in the forest management.

Thanks !



Guoliang Liu

gliu@aiTree.ltd, <http://aiTree.ltd>,

**Canada Tel: 1 604 889 6787, China Tel:
13337802168**

Canada forest cloud: <http://forestcloud.ca>

China forest cloud: <http://forestcloud.cn>