



skog+
landskap

NORWEGIAN FOREST AND
LANDSCAPE INSTITUTE

Optimizing terrain transportation with environmental Constraints - Key habitats vs profit

Graz 11.10.2011

Nils Egil Søvde
Norwegian Forest and Landscape Institute
Molde University College

Magne Sætersdal
Arne Løkketangen

Nils Egil Søvde

- > Employed at the Norwegian Forest and Landscape Institute (www.skogoglandskap.no).
- > PhD student at Molde University College (www.himolde.no).
- > Part time farmer (grain), including some young forest
- > Supervisors:
 - > Arne Løkketangen, Professor of Informatics, Molde University College.
 - > Bruce Talbot, the Norwegian Forest and Landscape Institute.



skog+
landskap

NORWEGIAN FOREST AND
LANDSCAPE INSTITUTE

Introduction

- Background
- Methods
- Some cases & results

- The future



skog+
landskap

NORWEGIAN FOREST AND
LANDSCAPE INSTITUTE

Key woodland habitats

- > Ongoing registration of key woodland habitats
- > Complex legislation
- > Issues
 - > Driving
 - > Harvest (percentage)
 - > Location
 - > Compensation



skog+
landskap

NORWEGIAN FOREST AND
LANDSCAPE INSTITUTE

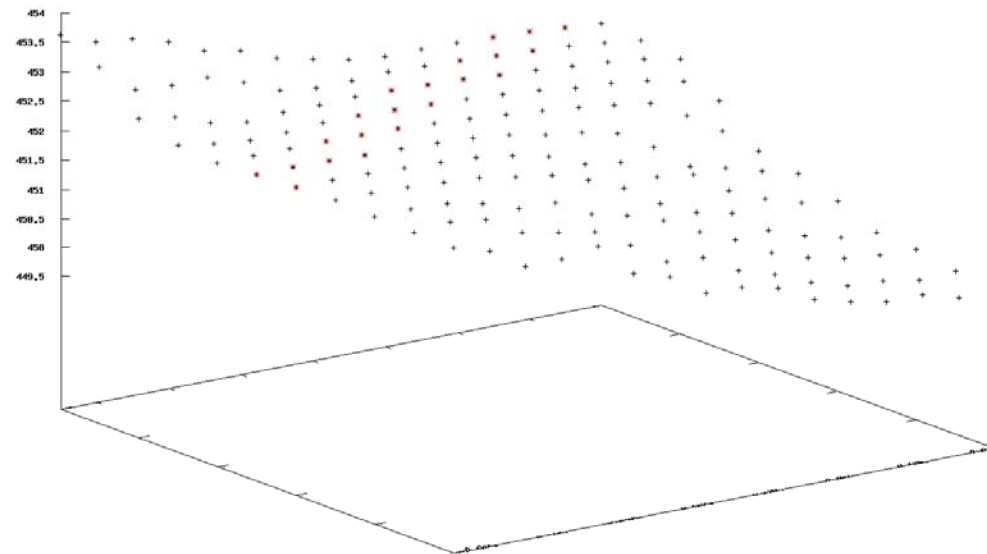
New technology -- LIDAR

- > Light detection and ranging
- > ~10 measurements per square meter



skog+
landskap

NORWEGIAN FOREST AND
LANDSCAPE INSTITUTE



Where can we drive?

- Elevation at each wheel
- Roll r : max inclination of the axes
- Pitch p : inclination between the axes

- $C_{AB} = C_d d P_r P_p$

- C_d = cost of transport per km per m^3 in flat terrain

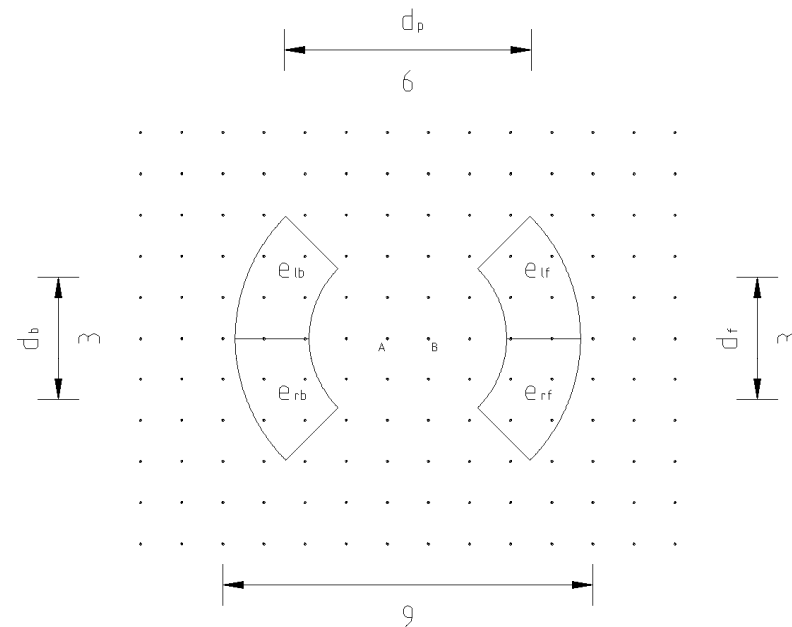
- $P_r = 1 + 2r,$ $r \leq 0.23$
 $\infty,$ $r > 0.23$

- $P_p = 1 + p,$ $p \leq 0.35$
 $\infty,$ $p > 0.35$



skog+
landskap

NORWEGIAN FOREST AND
LANDSCAPE INSTITUTE



Underlying Objective Function



skog+
landskap

NORWEGIAN FOREST AND
LANDSCAPE INSTITUTE

$$\text{Net profit} = V * (P - (C_h + C_{ff} + C_f))$$

- > V = volume of timber at a point
- > P = average price of timber (per cubic meter)
- > C_h = cost of felling, delimiting, cross cutting (per cubic meter)
- > C_{ff} = fixed cost of forwarding (loading and unloading, per cubic meter)
- > C_f = cost of terrain transport of 1 m³ timber from vertice to forest road

The solver

- Based on submitted article '*An extraction trail generator using GRASP*', International Journal of Forest Engineering
- Dijkstra's shortest path algorithm
- Finds the cheapest possible path from each point to a road
- A good and fast estimate of the cost



skog+
landskap

NORWEGIAN FOREST AND
LANDSCAPE INSTITUTE

Scenarios



skog+
landskap

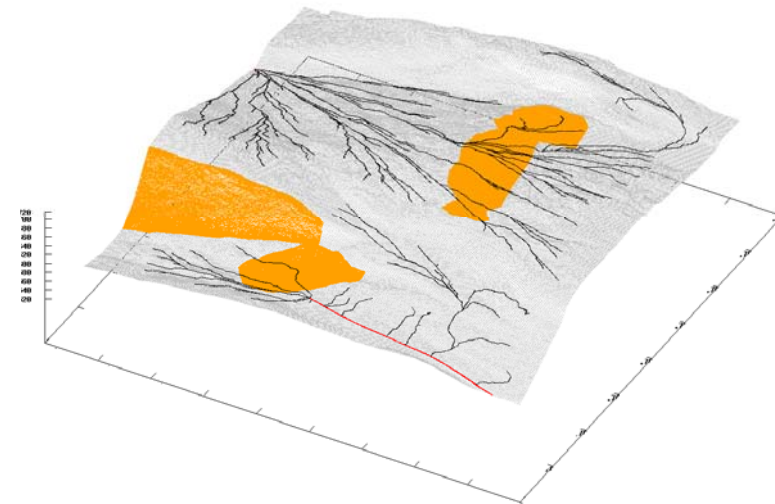
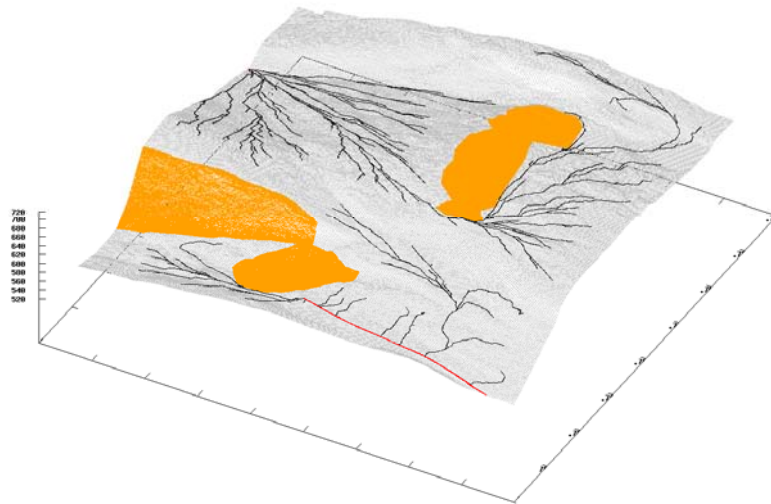
NORWEGIAN FOREST AND
LANDSCAPE INSTITUTE

Scenario	Driving	Harvest
1	No	No
2	Yes	No
3	Yes	30 %
4	Yes	70 %
5	Yes	100 %

Case 1



skog+
landskap

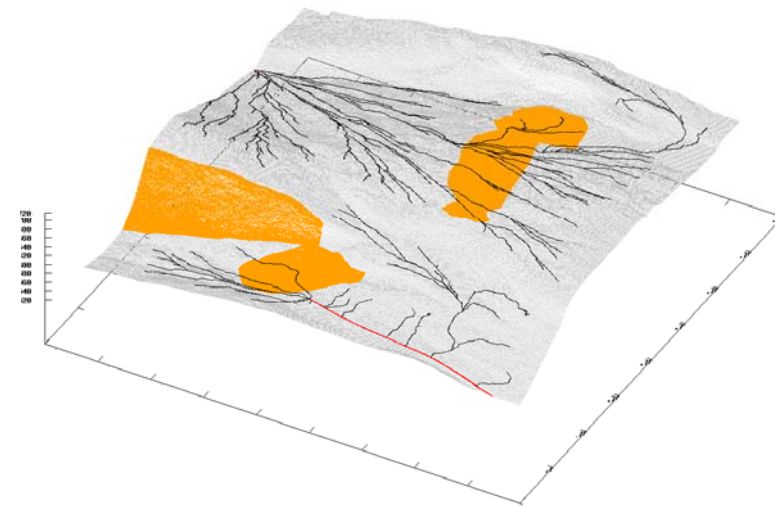
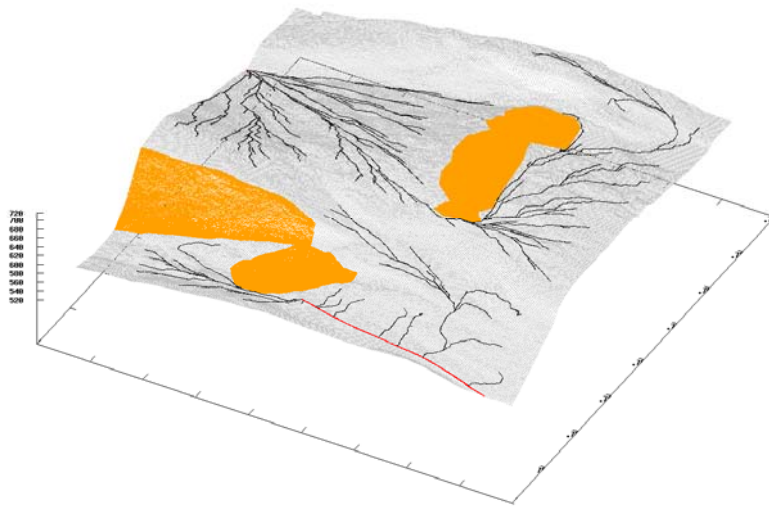


- Total area 111 *ha*, hotspot area 13.6 *ha*
- Objective improved 20250 € (4.7 %) from driving through hotspots (Scenario 1 vs. Scenario 2)

Case 1



skog+
landskap

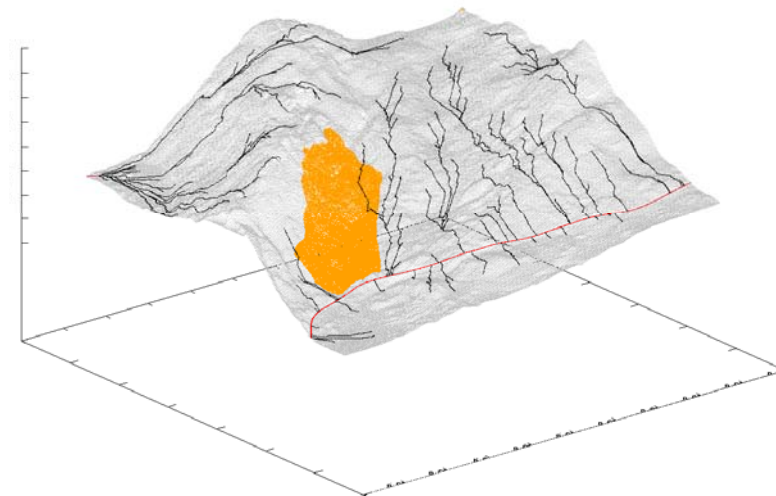
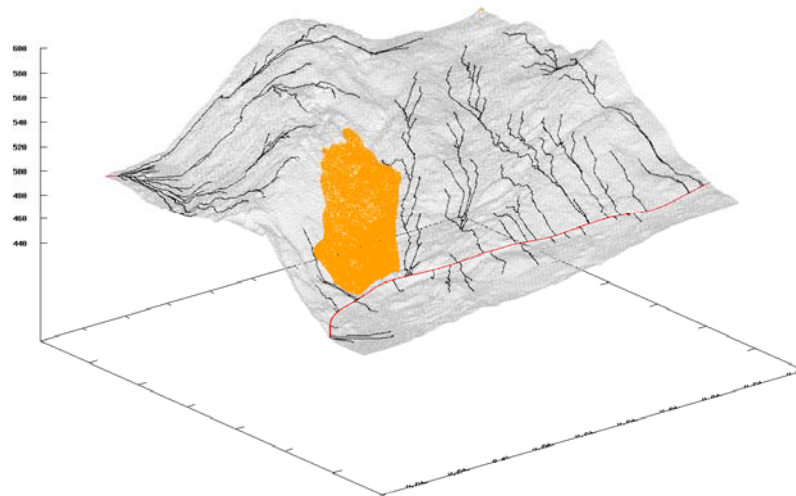


- Average objective wo. hotspots (per ha): 5 201 € (scenario 2)
- Average objective from hotspots (per ha): 5 138 € (scenario 5)

Case 2



skog+
landskap

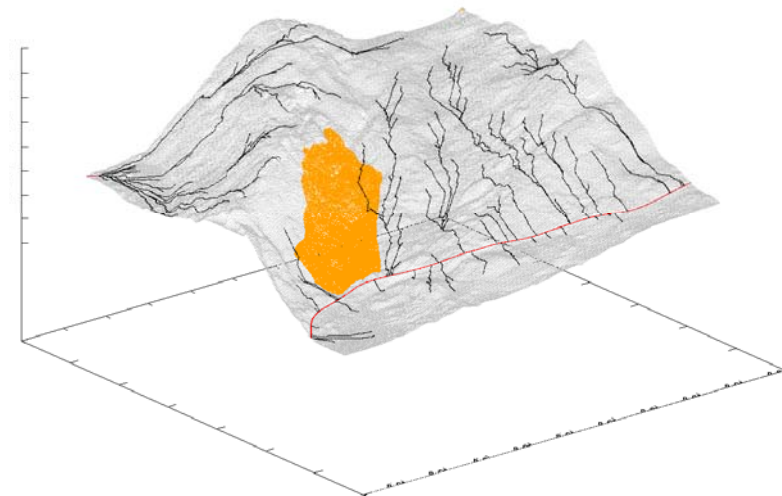
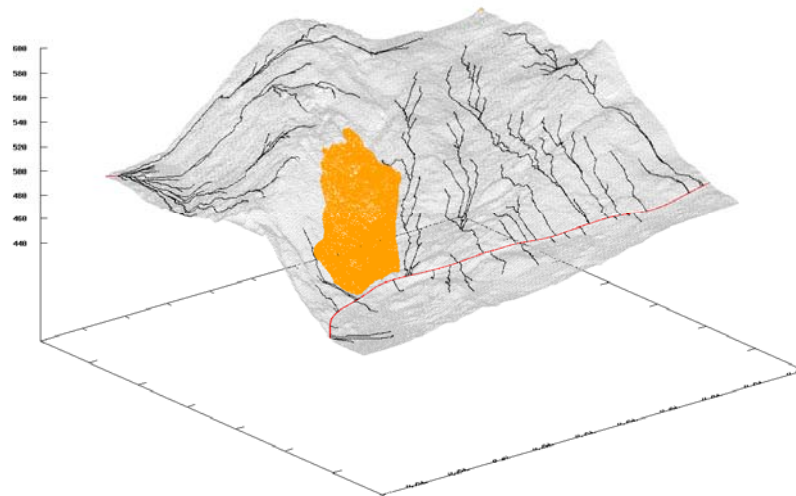


- Total area 94 *ha*, hotspot area 6.5 *ha*
- Objective improved 125 € (0.0 %) from driving through hotspots (Scenario 1 vs. Scenario 2)

Case 2



skog+
landskap

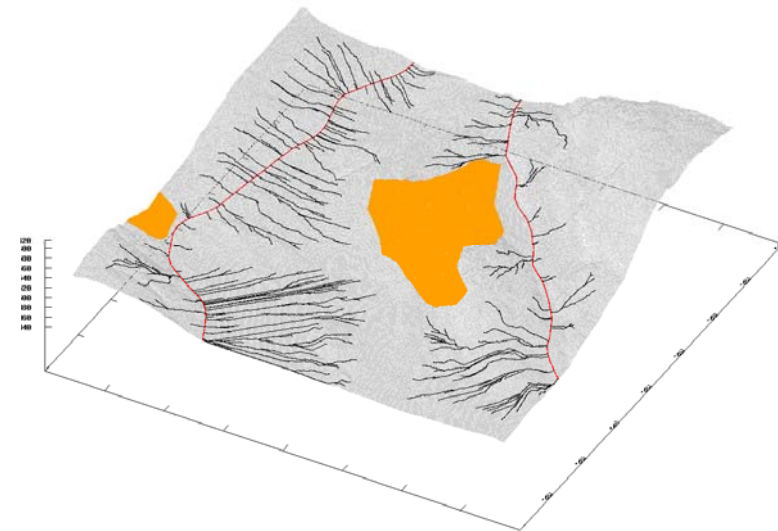
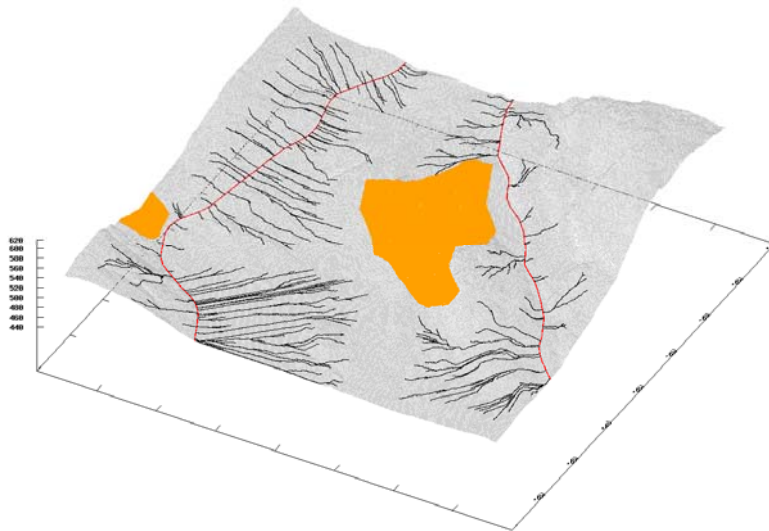


- Average objective wo. hotspots (per ha): 5 610 € (scenario 2)
- Average objective from hotspots (per ha): 5 727 € (scenario 5)

Case 3



skog+
landskap

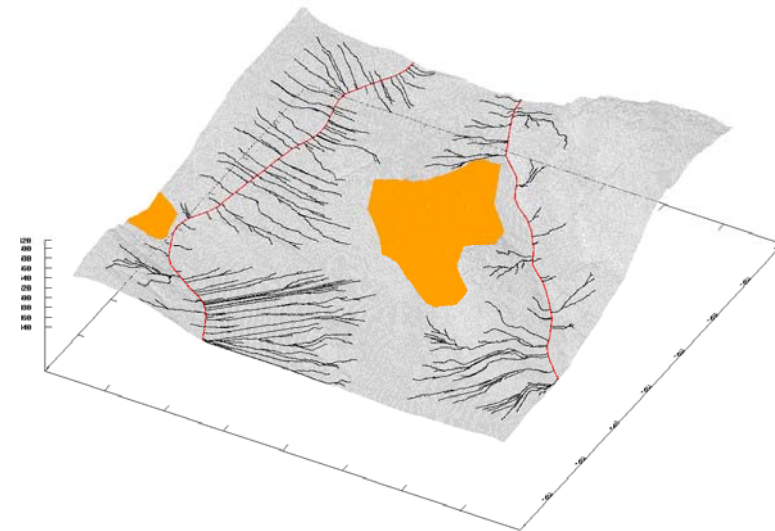
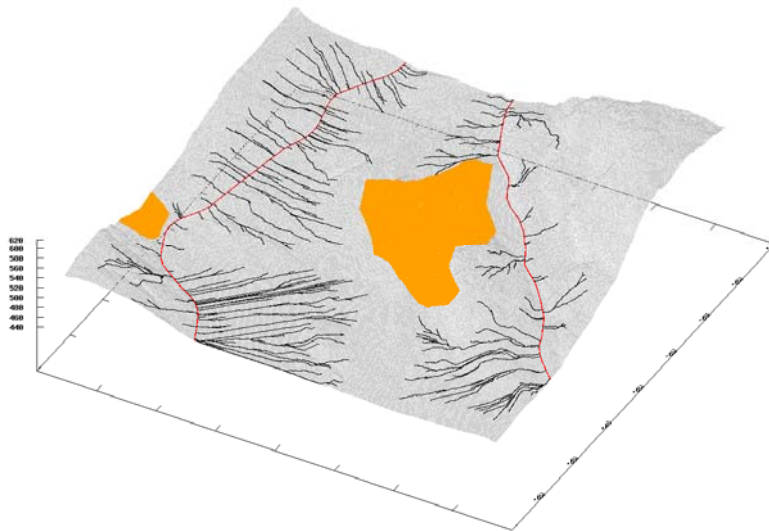


- Total area 203 *ha*, hotspot area 18.8 *ha*
- No improvement from driving at hotspots
(Scenario 1 vs. Scenario 2)

Case 3



skog+
landskap

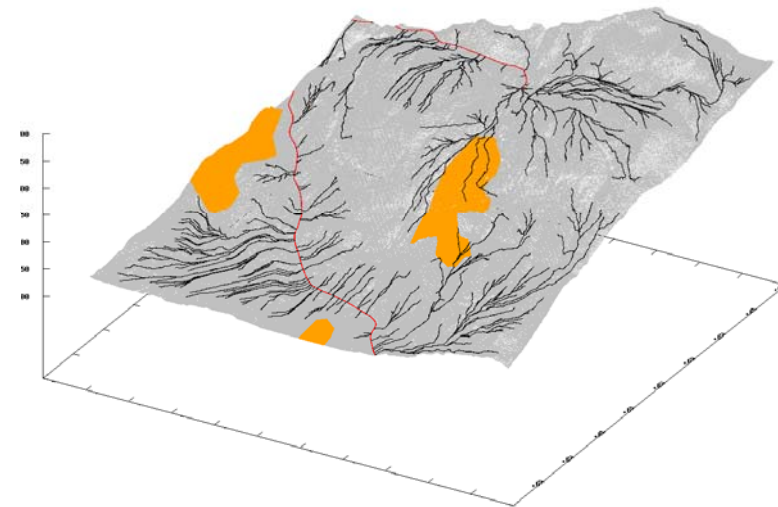
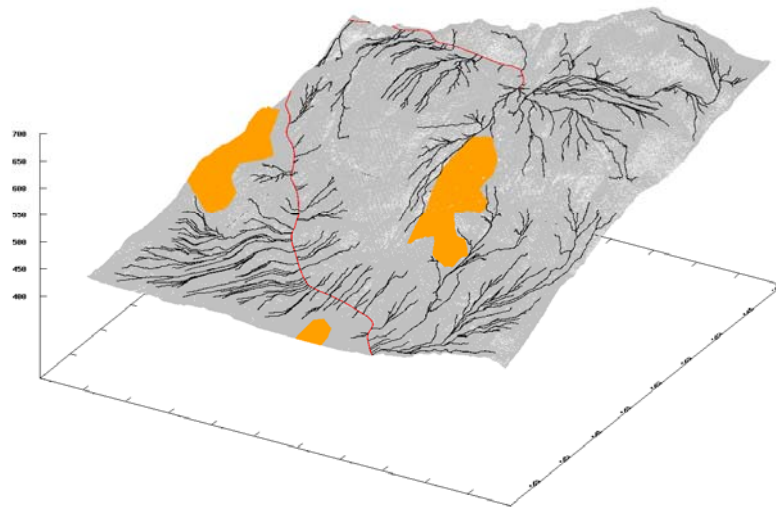


- Average objective wo. hotspots (per ha): 5 908 € (scenario 2)
- Average objective from hotspots (per ha): 5 657 € (scenario 5)

Case 4



skog+
landskap

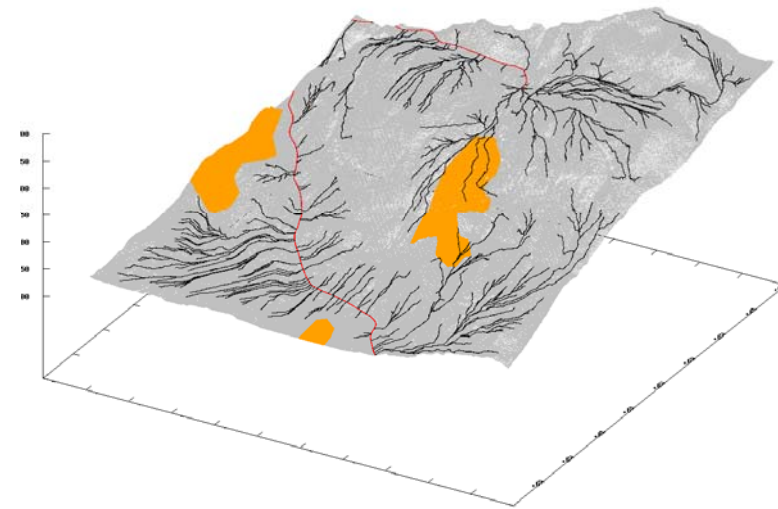
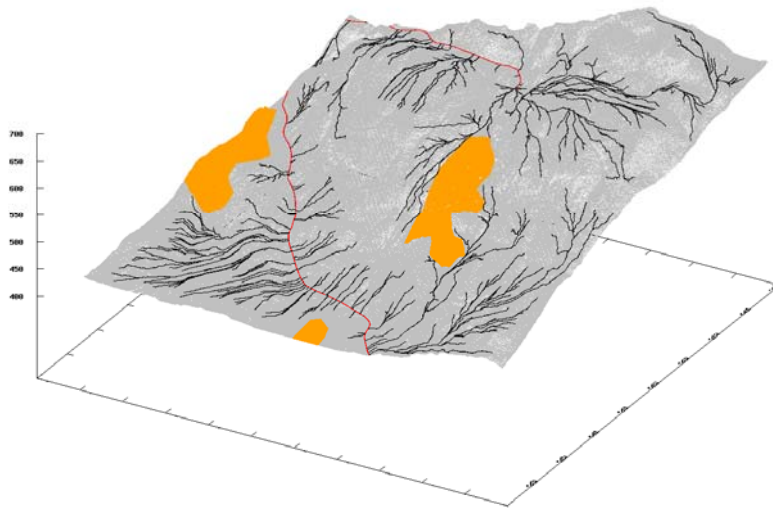


- Total area 345 *ha*, hotspot area 24.2 *ha*
- Objective improved 1 250 € (0.1 %) from driving through hotspots (Scenario 1 vs. Scenario 2)

Case 4



skog+
landskap



- Average objective wo. hotspots (per ha): 5 316 € (scenario 2)
- Average objective from hotspots (per ha): 5 205 € (scenario 5)



skog+
landskap

NORWEGIAN FOREST AND
LANDSCAPE INSTITUTE

Thanks to Mathiesen Eidsvold Værk for supplying some of the data.

Thanks for your attention.

nis@skogoglandskap.no