



INFORMS CONFERENCE ENRE SESSION

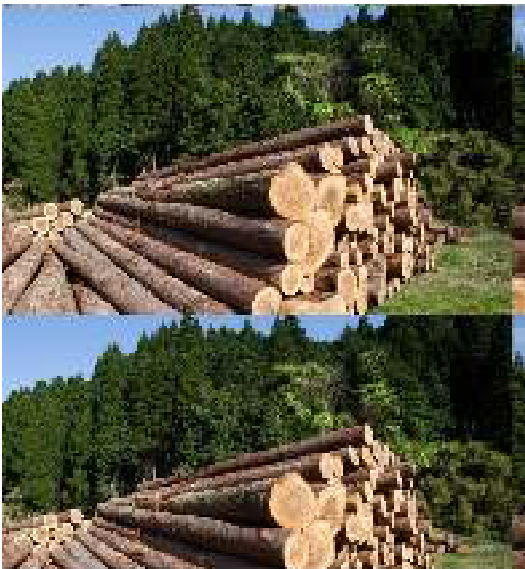
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A Personal Story



Forestry



Mining



Salmon Industry

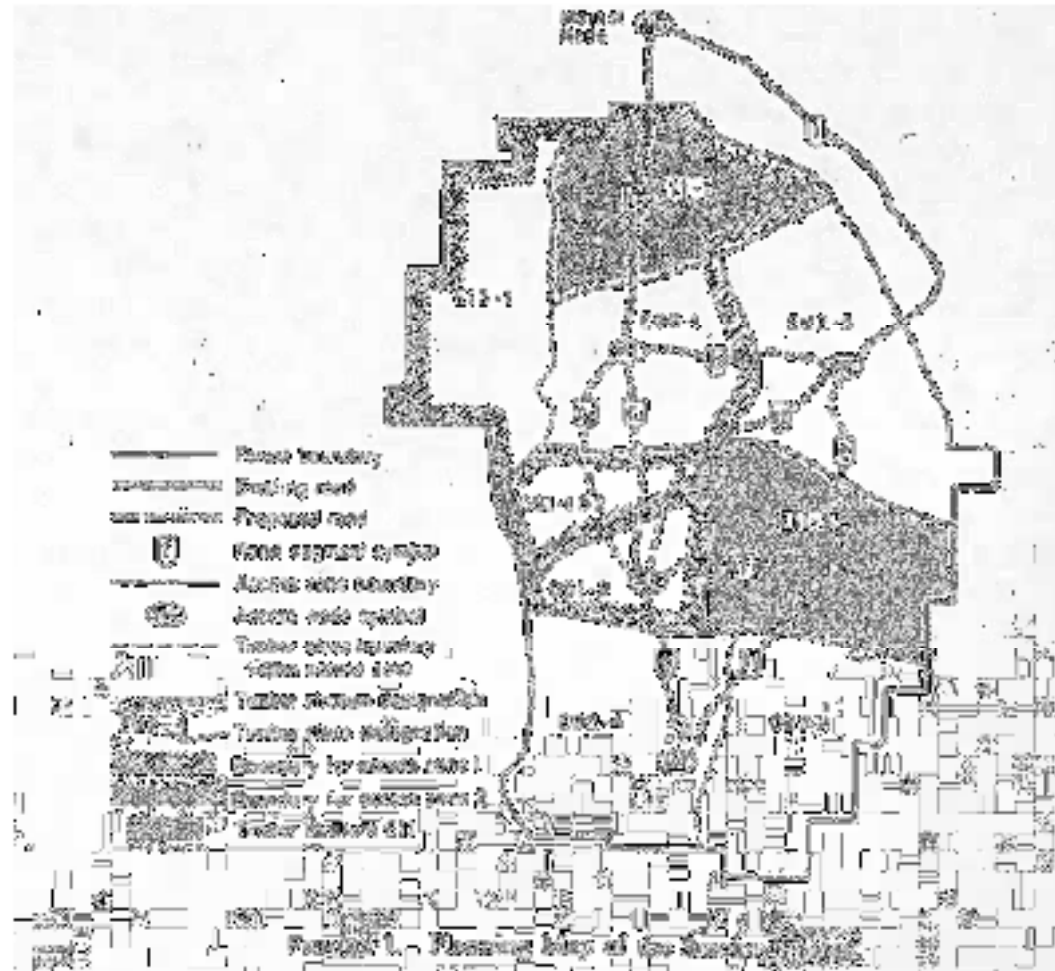


Forestry

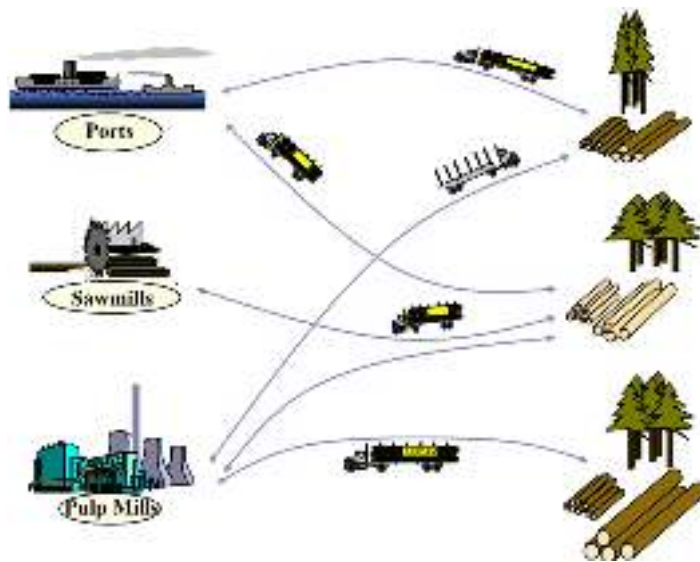
- Divided in 4 phases
 - US Forest Service (1972 – 1990). Berkeley
 - Chilean Forest Industry (1988-...)
 - Methodological Research
 - Forest Fires

US Forest Service

- How I got and stayed there
 - My boss **Daniel Navon**, developer of the first LP system widely used
- How Congress led to use of LP
 - Environmental problems with Sierra Club
 - Developed Mixed-Integer Programming Model to include road building (**Mel Kirby**)
 - Used by several regions in the 10-year planning cycle in the 1980's
 - ¼ time from 1974 to 1990 (Research Engineer UC Berkeley, IEOR, Grants USFS.

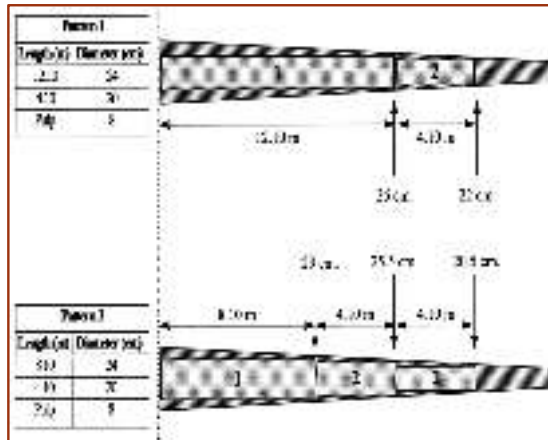


Chilean Forest Firms

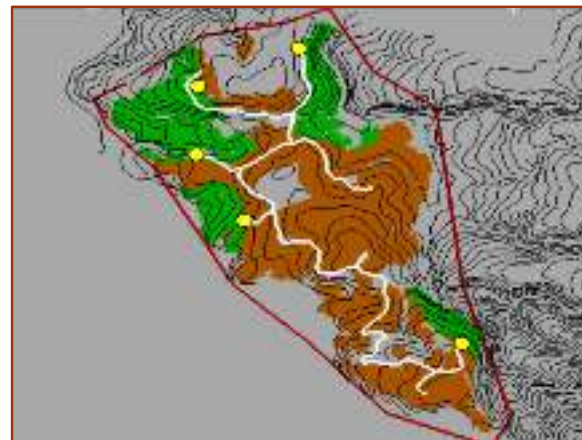


- Developed systems used by multiple firms
- Work with **Rafael Epstein**, who still directs this work
- Daily Truck Transportation (ASICAM)
 - Simulation with heuristics
 - Reduced costs 15 -25%
 - Also used in Brazil, Argentina, South Africa
 - Mondi (South Africa) Logistics Prize 1994

Other systems



Short term harvesting
 Define supply in specific logs for 45-day demands
 LP with Column Generation

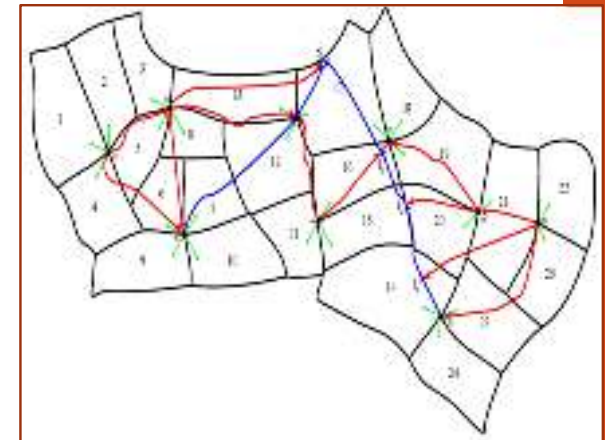


Machine Location and access roads (PLANEX)

GIS-MIP Heuristics

Won the EDELMAN PRIZE 1998

ASICAM and PLANEX are still in use

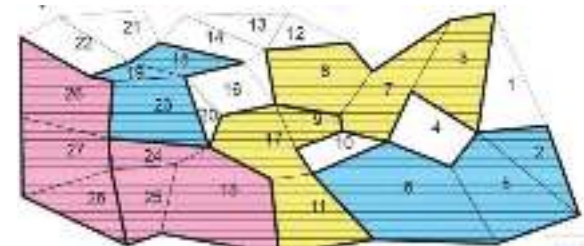


Tactical Planning and road building



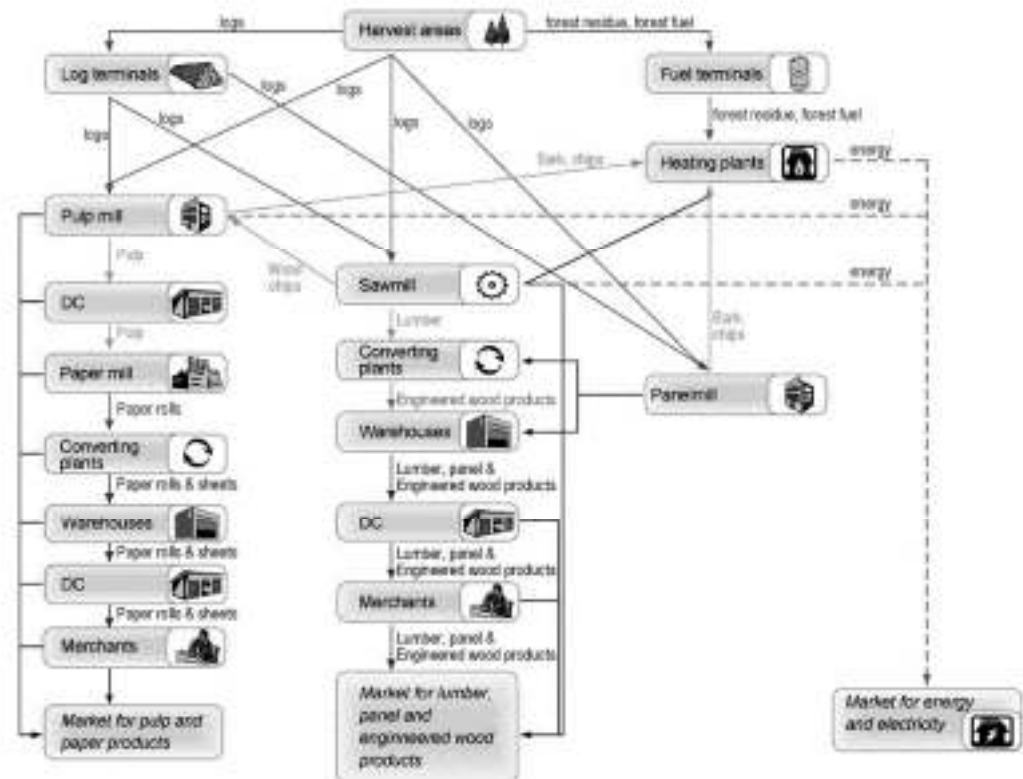
Methodological Research

- Some of the areas, central to many researchers
- MIP models for planning and tactical planning
 - with **Monique Guignard**.
- Models for machine location and road building
 - Plant location plus network flows with fixed costs
 - Tabu worked well
- Spatial planning to:
 - Protect wildlife, scenery environment, ADJACENCY, OLD GROWTH .
 - Difficult combinatorial problems
 - Collaboration includes **J.P. Vielma, Rafael Epstein, Francisco Barahora, Dave Ryan, Felipe Caro, Isabel Martins, Richard Church, Rodolfo Carvajal**.



Methodological Research

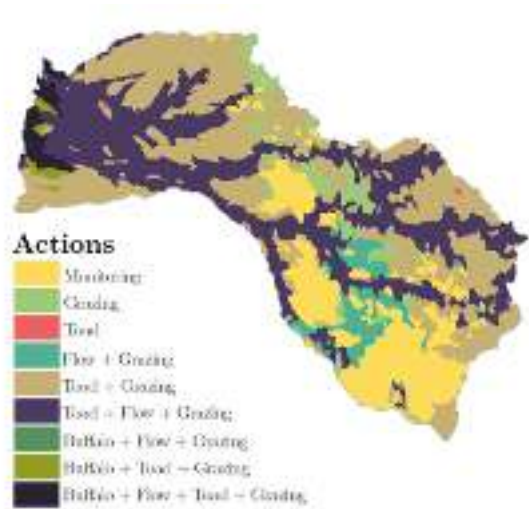
- Forest Supply chain
 - How to integrate different actors in forest production:
 - Harvesting, transport to plants, processing in plants
 - Work with Mikael Rönqvist, Sophie D'Amours, Juan Troncoso.



Stochastic Programming

- Uncertainty in Markets (Price), Future timber yields, climate change
- Chance constrained programming in the 90s (**Jorge Vera**)
- Scenario trees in the 2000s
 - Uncertainty reflected as scenarios
 - Values of parameters in each period
 - Maximize expected objective, such that solution is feasible under all scenarios
 - Well known non - anticipativity constraints.
 - Difficult to solve with many scenarios: Progressive hedging, decomposition heuristic approach).
 - Generating scenarios also a challenge
- Collaboration include **Monique Guignard, Antonio Alonso, Laureano Escudero, Roger Wets, David Woodruff, Jean Piere Watson, Cristobal Pais, Jaime Carrasco, Jordi Garcia, Eduardo Alvarez, Martin Quinteros, J. Bachmatiuk, Ignacio Rios, Sandor Toth.**

Protection of wildlife species



- How to invest resources to purchase land and implement protection measures.
- Collaboration with ecologist in Spain ([Virgilio Hermoso](#)).
- Introduce OR algorithms
- OTHER PROBLEMS
- Multicriteria (Environmental protection, Carbon Emissions, Economic Goals)
 - Collaborators include [Eduardo Alvarez, Salgado-Rojas, Juan Pablo Cavada](#)
- Hierarchical Planning
- Cost of environmental measures
 - Collaboration Include [Carlos Romero, Diaz-Balteiro](#).

State Of The Art Papers

- Multiple on different areas,.
- Collaborators include **Bruce Bare**, **Dave Martell**, **Carlos Romero**, **Alan Murray**, **Richard Church**, **Monique Guignard**, **Eldon Gunn**.
- Handbook in OR in natural resources :
 - Agriculture (**Carlos Romero**)
 - Fisheries (**Trond Bjorndal**)
 - Mining, Forestry (**Rafael Epstein**, **Andres Weintraub**)



Forest Fires

- Line of work intense last 5 years
- It is a mayor problem, specially given climate change
- Work with **David Martel** since 2005
- Later also **David Woodruff, Cristobal Pais, Jaime Carrasco**
- Developed fire spread simulator **CELL2FIRE**
- Good simulators (Canada, US) used to fight fires in progress



Our Work, Fuel management

- Uncertainty in ignition-spread. Ignition can be random (lightning) or due to human action.
- Spread depends on weather (wind, moisture, temperature), cover (trees, grass...) , topography (slope...)
- How to manage forest so that when fire occurs, minimize damage.
- In particular when human lives are threatened. (Wildland Urban Interface)

Simulator CELL2FIRE

- It is a cell-based fire spread simulator
- Fast (parallel runs)

Real fire

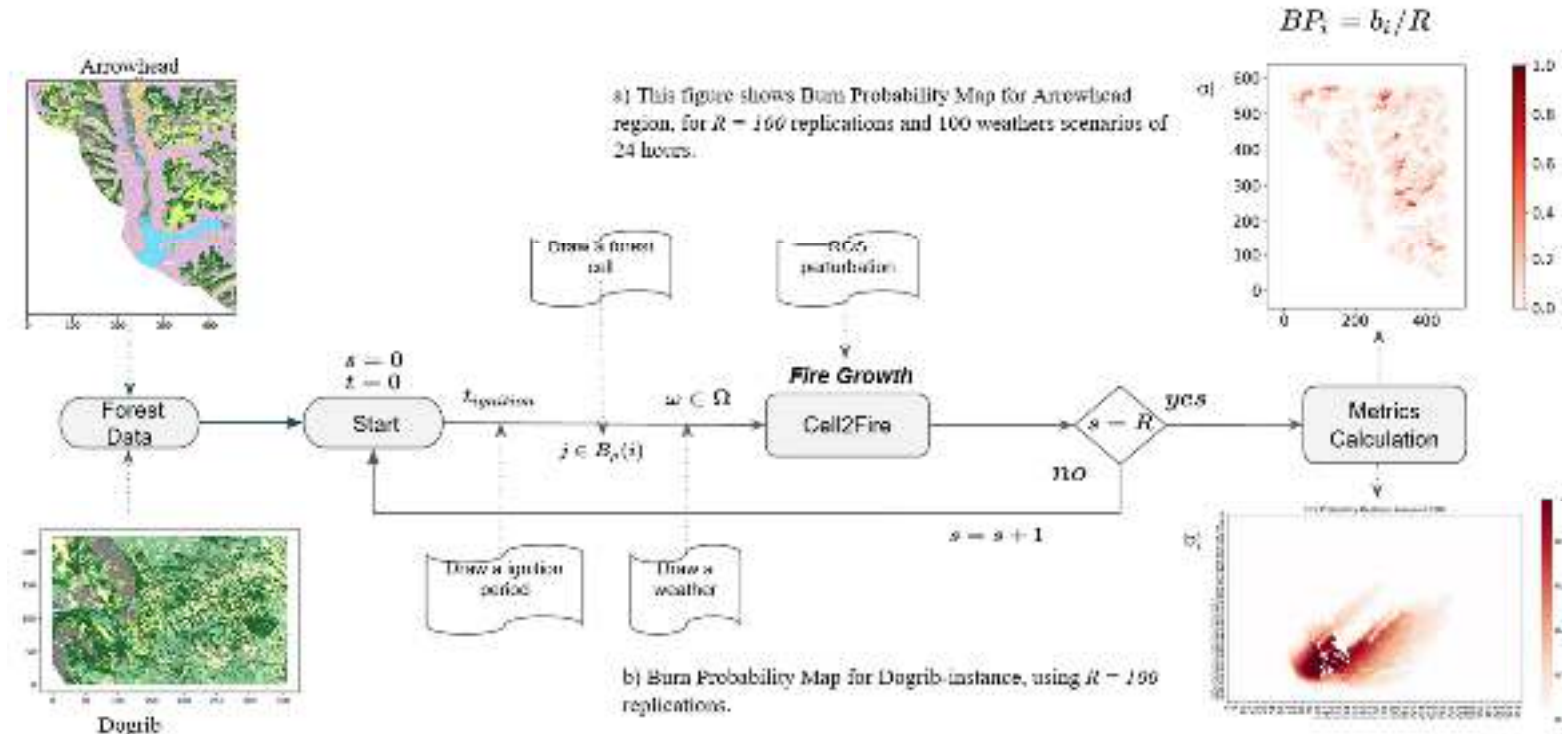


Cell2Fire

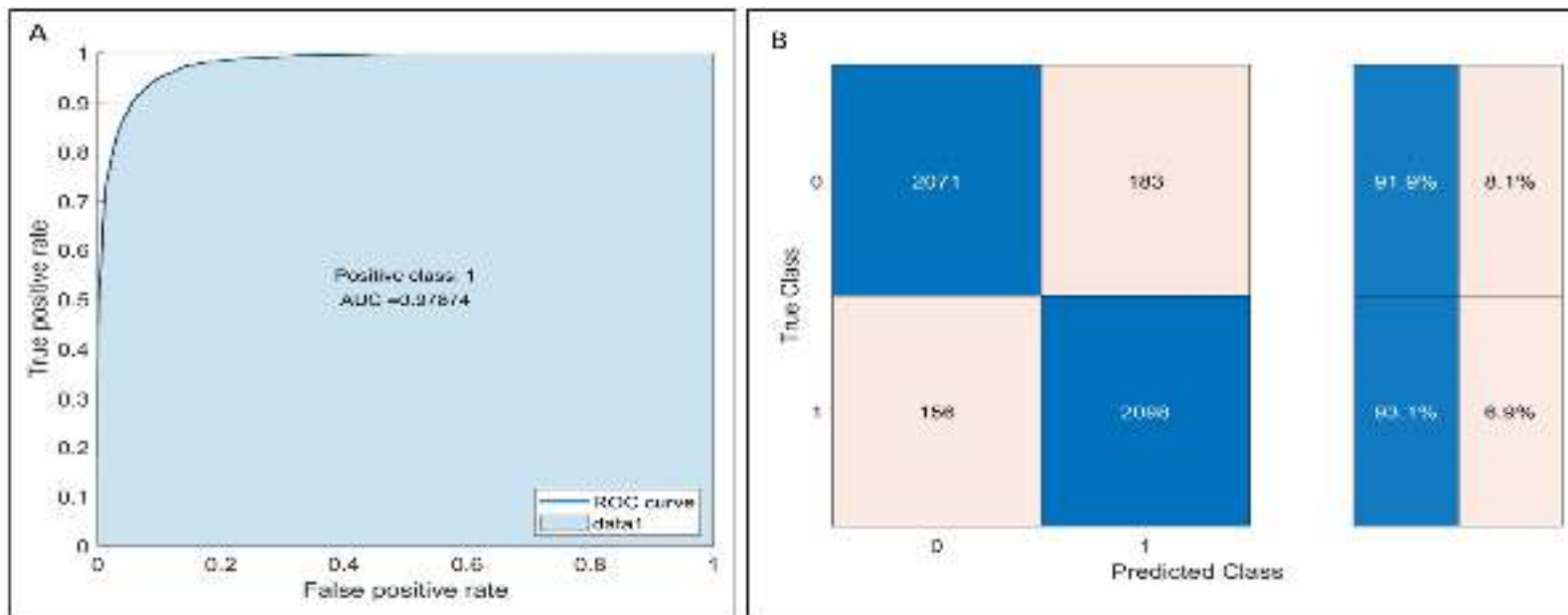


Machine learning to predict ignitions

- Heuristics, optimization (MIP), Reinforcement learning .



Model KPI: WUI Concepción



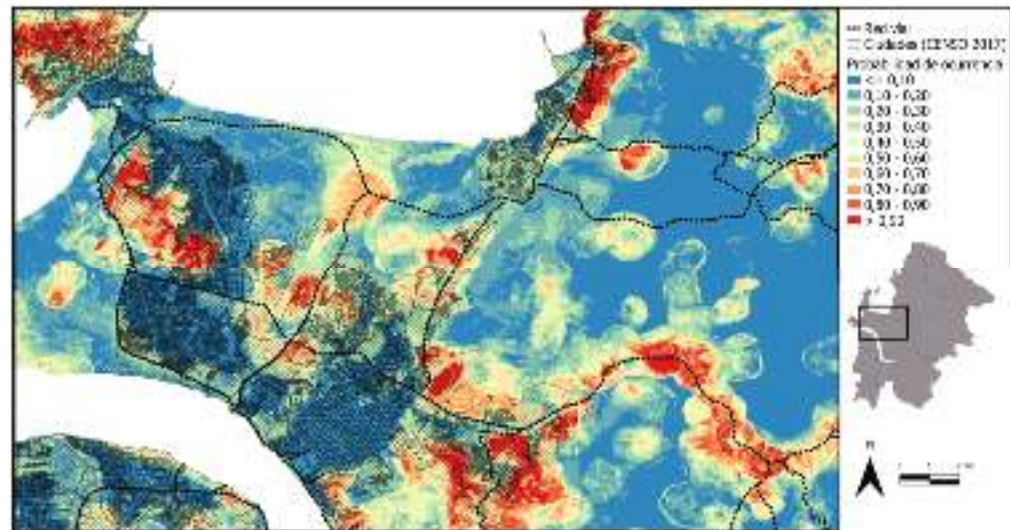
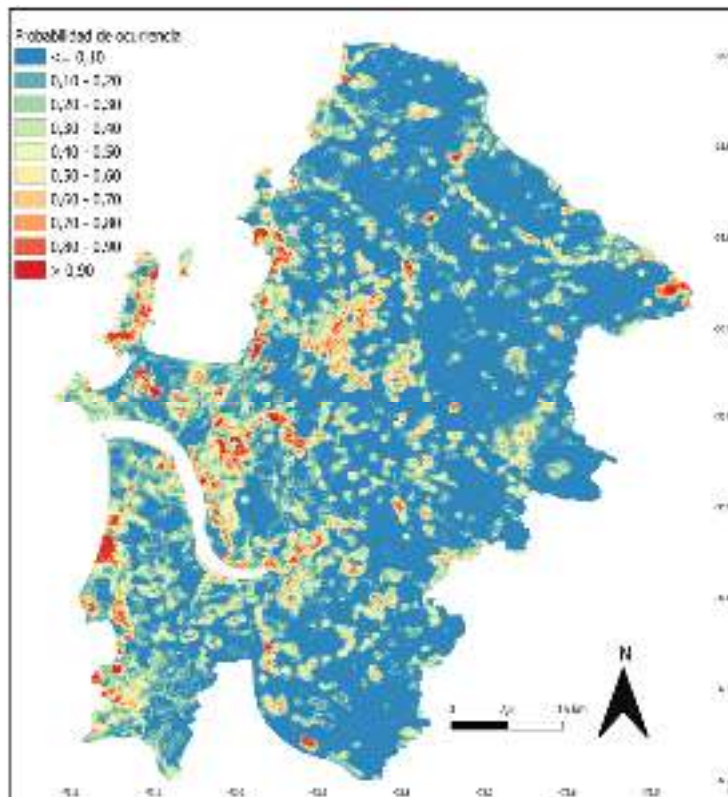
A

ROC Curve: AUC is the probability of the model making a correct classification. (97.8%)

B

Confusion matrix: shows the number of correct classifications per class

Wildfire occurrence: WUI Concepción



Areas around roads and around cities have a higher probability of fire occurrence



A Team
from
multiple
disciplines



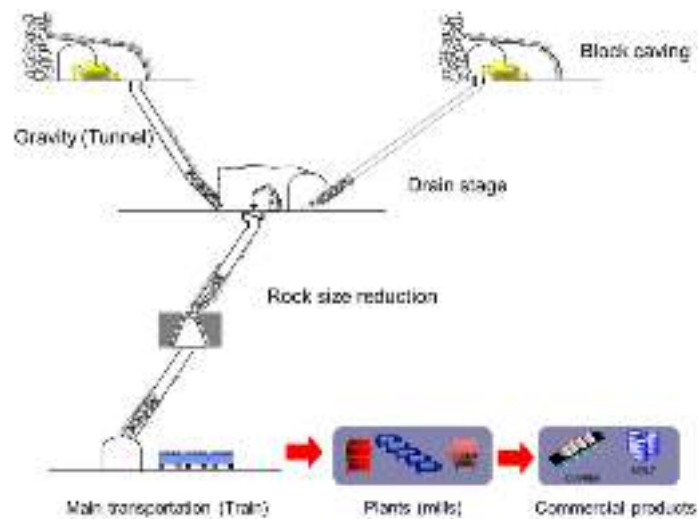
Mining

- Long Range planning . Rafael Epstein
- Now MIP models given advances in hardware and software
- Mine divided into blocks 30x30x30 meters.



Underground and Open pit

El Teniente



Chuquicamata



- Overall, 100 million dollars savings 2010.
- Collaboration with Alexandra Newman

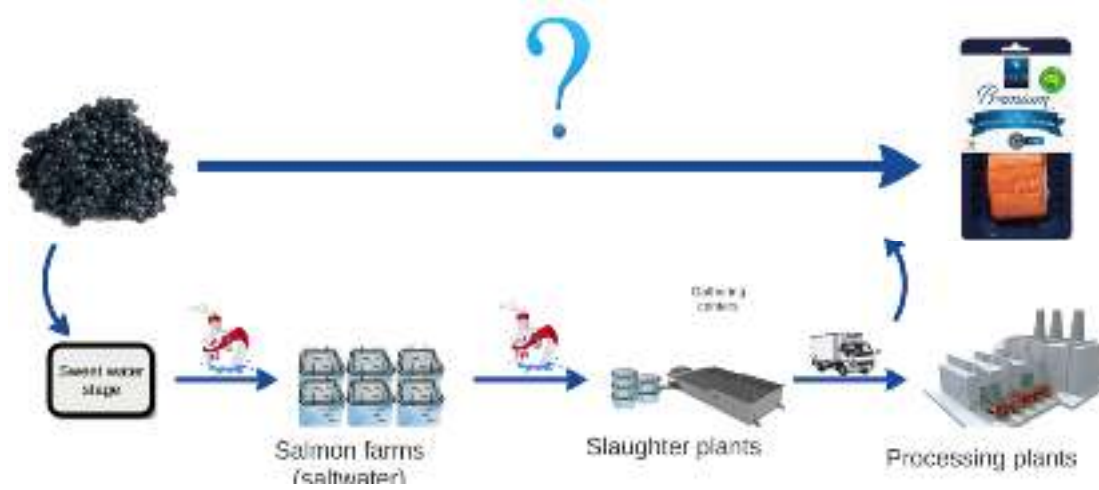


Salmon Industry

- Use Math programming to the logistics of the Salmon Farming Industry
- Two problems: Maritime and terrestrial
- MIP
 - Not very good due to time discretization
- Greedy heuristics work very well

The Salmon Logistics chain

- How to get from the eggs to fillet?



Conclusions

- Or in natural resources has been successful
- Changed nature of decision making in forestry, mining
- Led to important methodological research
- Incorporate new technologies: GIS, GPS, Satellite Information , Lidar, Drones, Data Science, Artificial Intelligence (machine learning, reinforcement learning)