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SCAPT

A Strategic Catchment Analysis and Planning Tool

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Cranfield University, UK

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AQUADAPT: Work Package One

Contract No. EVK1-CT-2001-00104

Aim: To generate knowledge supporting the strategic management of water resources in semi-arid environments at the catchment level under changing supply / demand patterns and water utilisation conditions.

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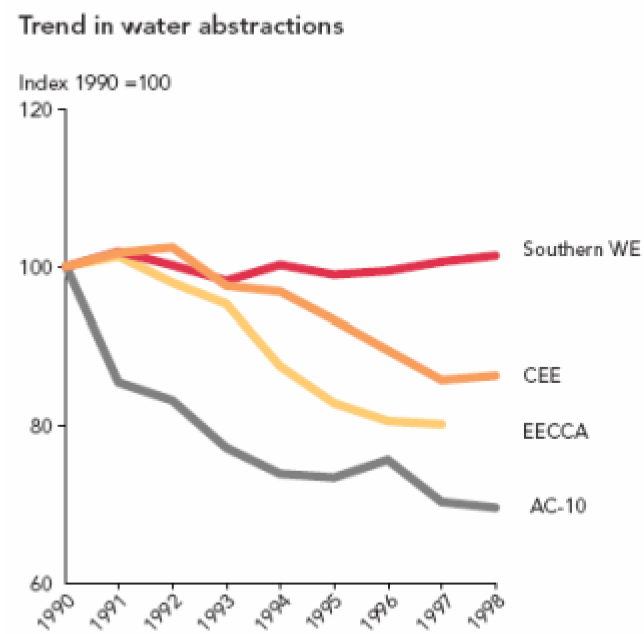
Context

- water challenges:
  - 31% of Europe's population live in countries using more than 20% of their annual water resource, indicative of high water stress
  - climate changes leading to droughts and low river flow/recharge plus increase in extreme events
  - water shortages grow esp. in Southern Europe where low water availability combines with increasing demand

- escalating conflicts:
  - water use and conservation
  - socio-economic developments
  - agricultural, industrial, domestic
  - environmental, leisure, amenity

- responses:
  - measures targeted at maintaining sustainable water levels and flows
  - integrated catchment management planning
  - Water Framework Directive



Source: European Environment Agency

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WFD

- Article 13: River Basin Management Plans
  - plan required for each catchment
  - general characteristics
  - statement of significant pressures
  - impacts of human activity on surface and groundwater
  - updated regularly (6 years)
- Article 14: Public Information and Consultation
  - active involvement of all interested parties
  - stakeholder engagement
  - participatory approach
  - public to receive overview of significant water management issues

Need for water resource management toolkits to help in decision making and information processes

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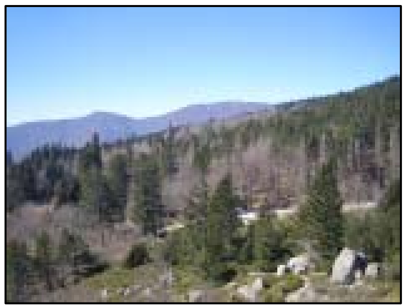
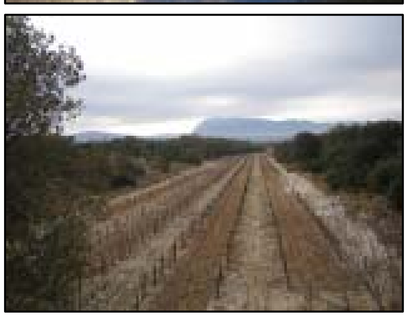
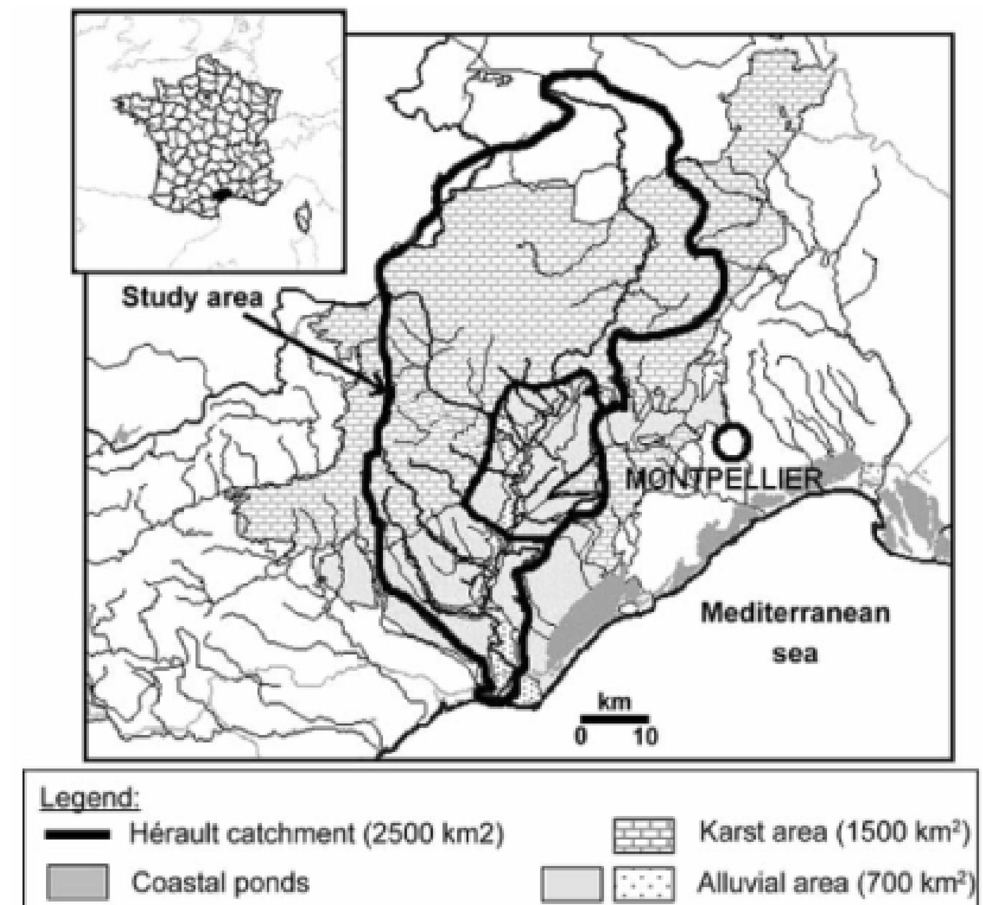
Study Area

- Hérault River, S.France
    - typical range of conflicts: farming/viticulture, potable water, tourism, leisure & amenity/fishing, population growth, environmental protection
    - undergoing rapid socio-economic changes







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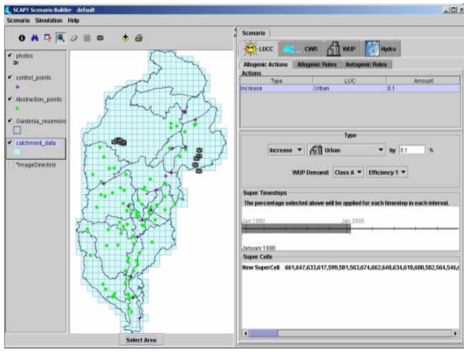
Spatial Catchment Analysis and Planning Tool



- aims to:
  - provide toolkit to aid water resource managers and planners
  - inform exploration of adaptive co-evolution
  - represent a transferable framework with initial implementation in Hérault
- estimates:
  - the impact of water-resource scenarios
  - allows scenario inter-comparisons to be made
- does not:
  - replace experts
  - provide analysis, prediction or explanation
    - research tool, not a full DSS

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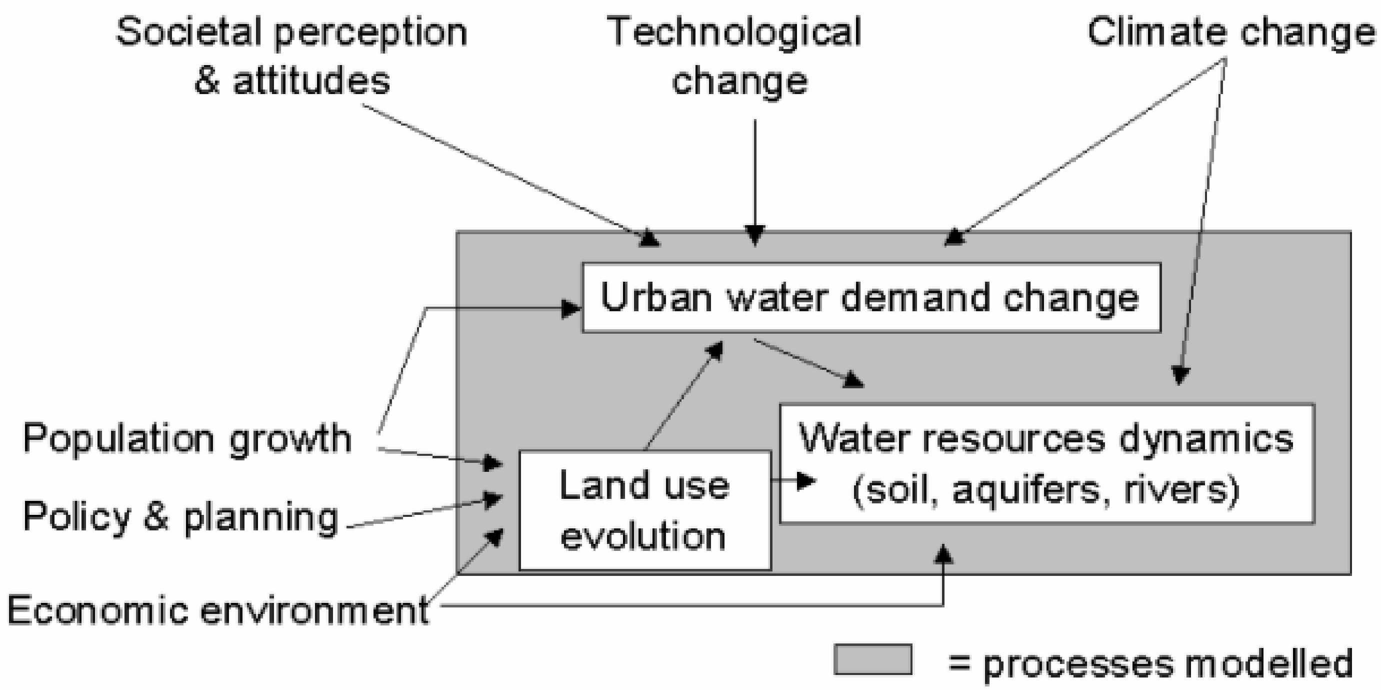
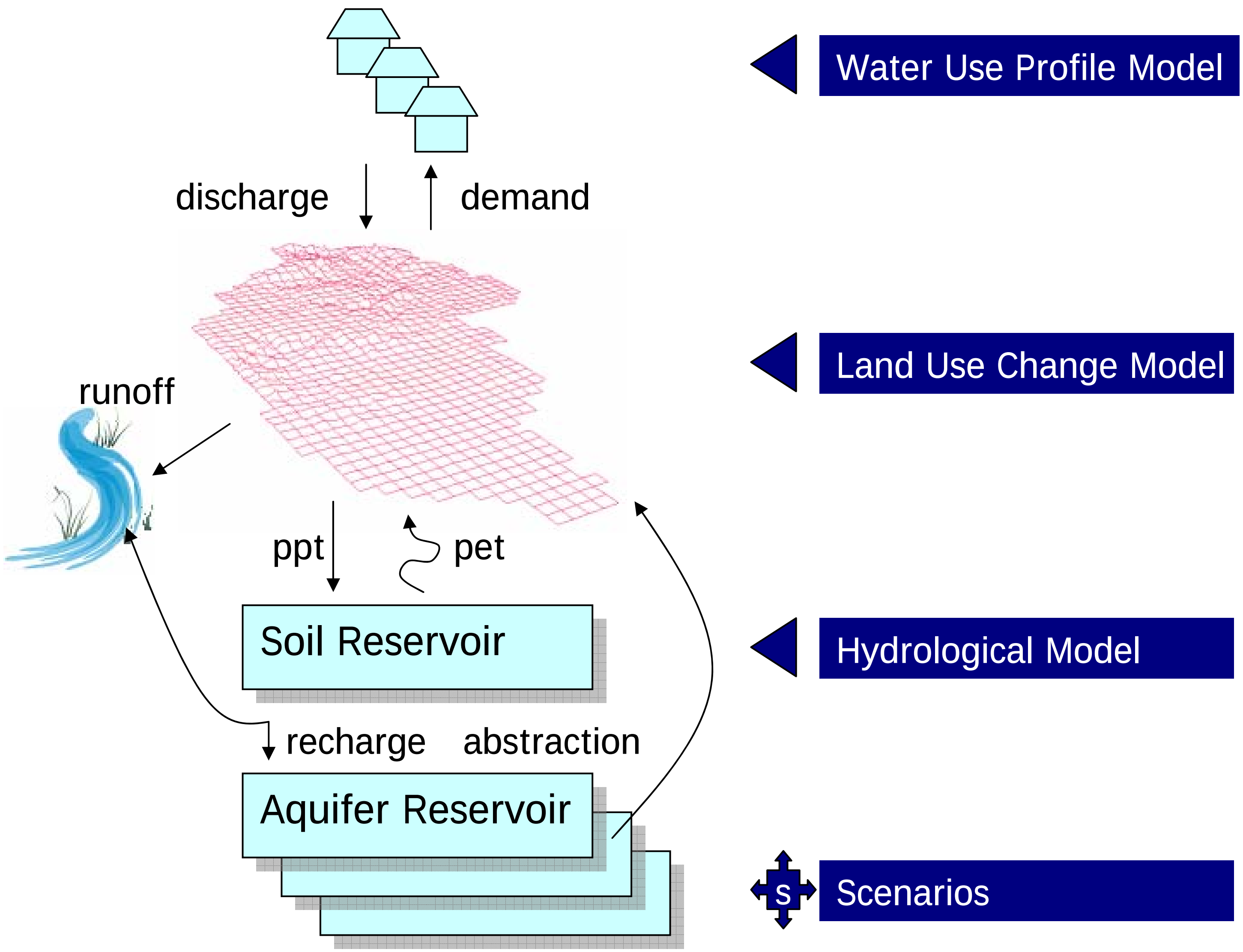
SCAPT Focus



SCAPT Model Components



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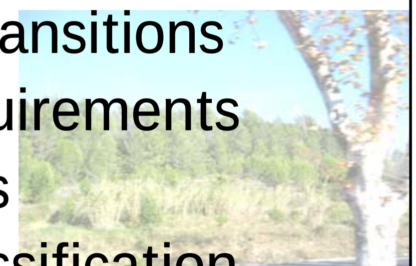
SCAPT Components

Hydrological: Runoff and Recharge
Residence time & Discharge
River levels
Abstractions & Irrigation

Land Use: Land Use Cover Transitions
Critical Water Requirements
Transition matrices
Geo-Ecological classification



Water Use Profile (WUP): Structures of Water-Dependent Processes
Micro-component simulations
Baseline and demand scenarios

Scenarios Possible futures, What-if?

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SCAPT Metrics

Gridsize: 2km x 2km cells

(749 cells) *[2,582 Km^2]*

Timestep: 1 month

For 20-30 years in future *(240-360 runs)*

A balance between long and short term catchment dynamics and cycles

Complexity: 360 x 749 = 269,640

14 Landuses = 3,774,960

x ‘n’ scenarios = !!!

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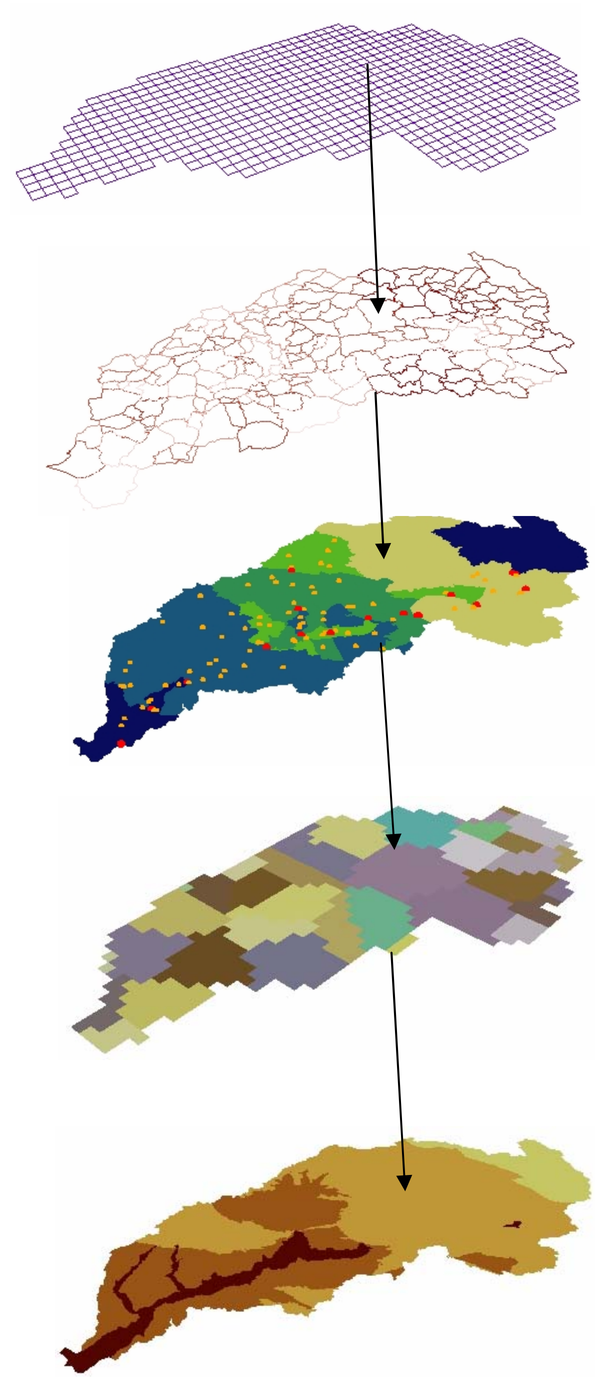
Data Organisation

- Grids
- Communes
- Abstraction Points
- Irrigation Areas
- Meteorological Stations
- Hydrological Subcatchments
- Aquifer Boundaries



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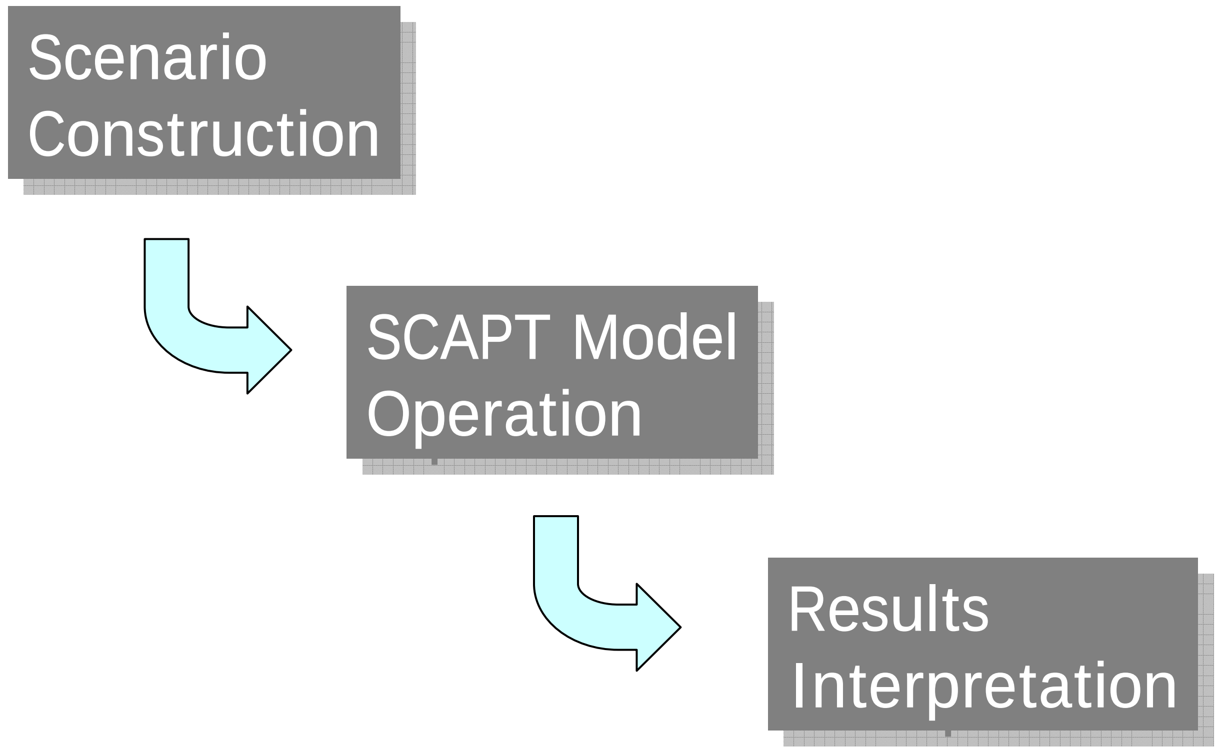
SCAPT Operation Sequence



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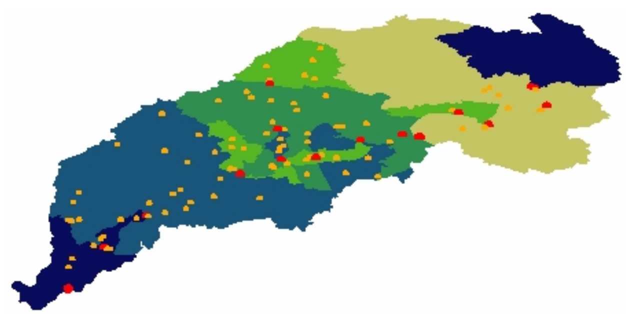
Hydrological Model



- Based on BRGM’s GARDENIA Model Principles
- Catchment divided into 23 subcatchments *(Gardenia Boxes)* controlled by gauging stations *(Control Points)*
- Each subcatchment is structured similarly
- Interactions between the subcatchments through net *contributions & losses*

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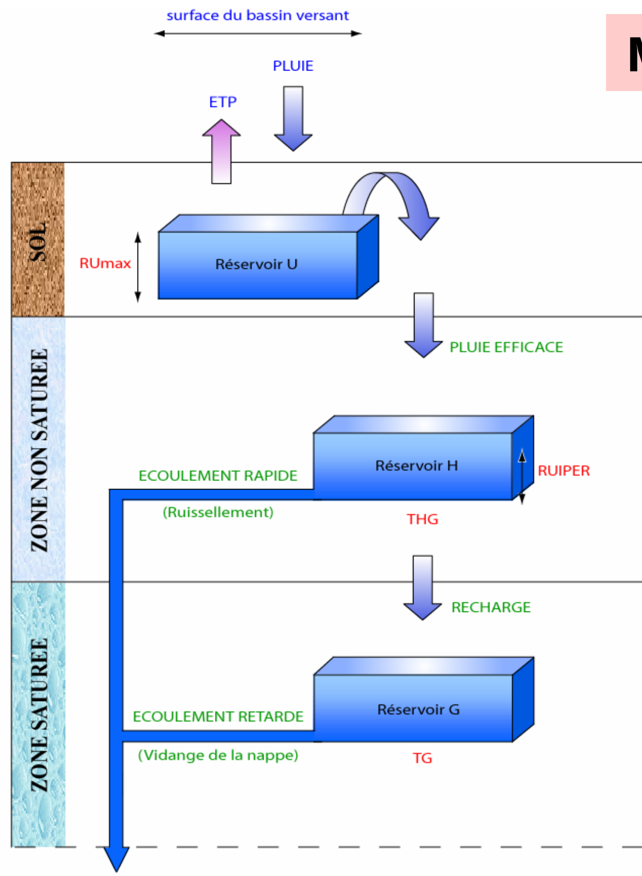
Principles of the GARDENIA model (Brgm)

Model outputs

Soil level
- Real evapotranspiration
- Efficient rain

Unsaturated zone
- Runoff
- Infiltration

Saturated zone
- Aquifer level
- Flow to the river



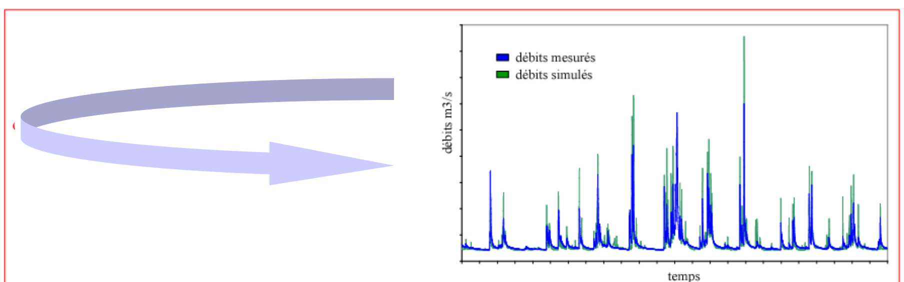
Model parameters

Soil level
- Soil water capacity

Unsaturated zone
- Water depth = switch
- Time of empting

Saturated zone
- Time of empting

Calculated flow to the river



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LUCC Model

- 14 landuse classes from SPOT
- Three types of landcover:
  - Autogenic:
    - Grassland
    - Garrigue
    - Forest
    - Abandoned Vineyard
  - Allogenic:
    - Vineyard
    - Dense Vineyard
    - Sparse Vineyard
    - Arable Agriculture I (Summer)
    - Arable Agriculture II (Winter)
    - Suburban
    - Urban
    - Abandoned Urban
  - Miscellaneous:
    - Water
    - Roads
    - Unclassified
- Critical Water Requirements for autogenic landuse

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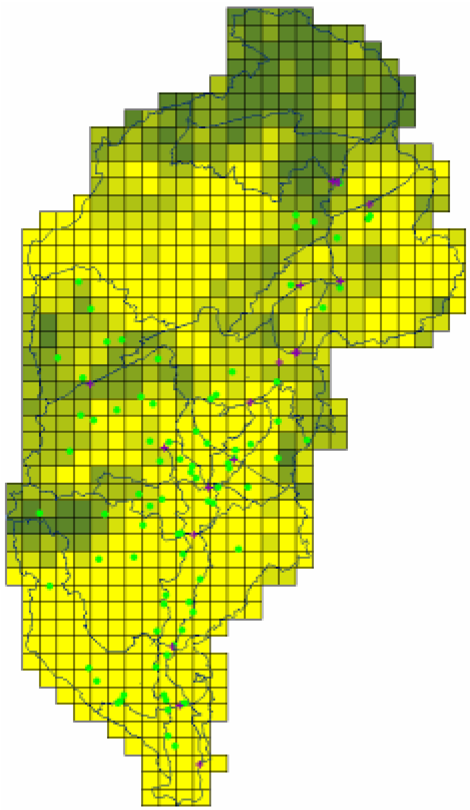
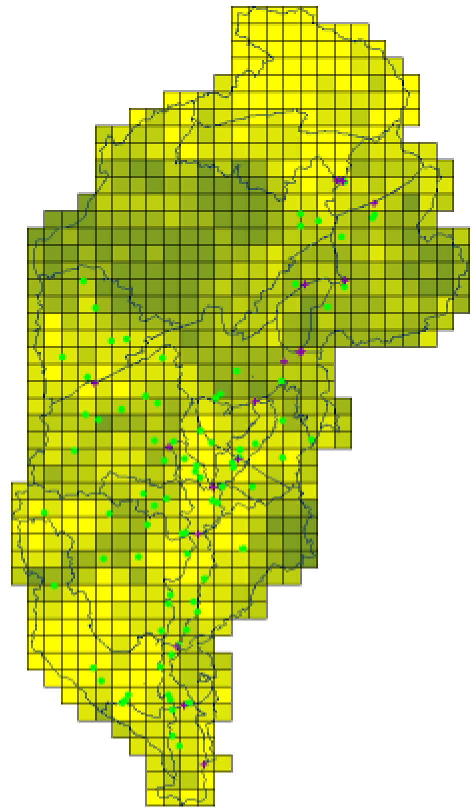
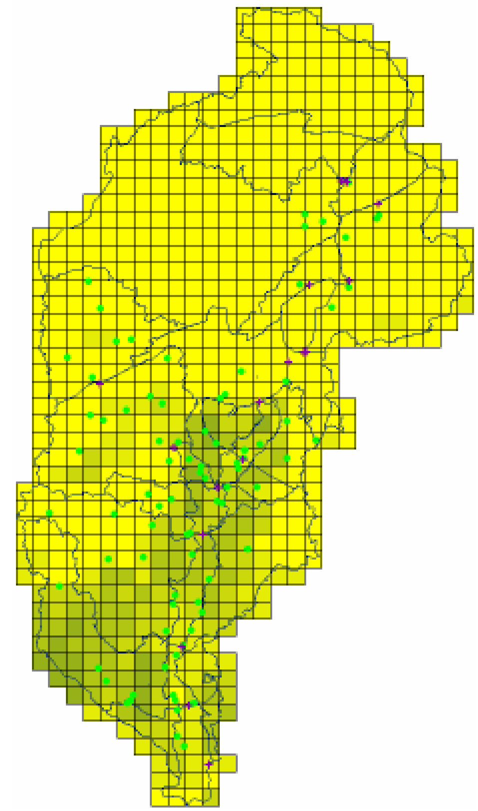
LUCC Distributions



LUCC12 Forest



LUCC11 Garrigue



LUCC1 Vineyard

Autogenic (LUCC12 Forest, LUCC11 Garrigue)

Allogenic (LUCC1 Vineyard)

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LUCC Model Operation

- Each gridcell has 14 landuse %'s ($\sum$=100)

- Internal 'Autogenic' change
  - Represent natural processes
  - Transition matrices
    - Succession
      (direction of change & duration of change)
    - Constraints
      (geomorphology & critical water requirements)

- External 'Allogenic' change
  - Represent planning decisions
  - Scenario driven
    - Additive and subtractive
    - Target and avoid
    - Extreme events (e.g. fire)

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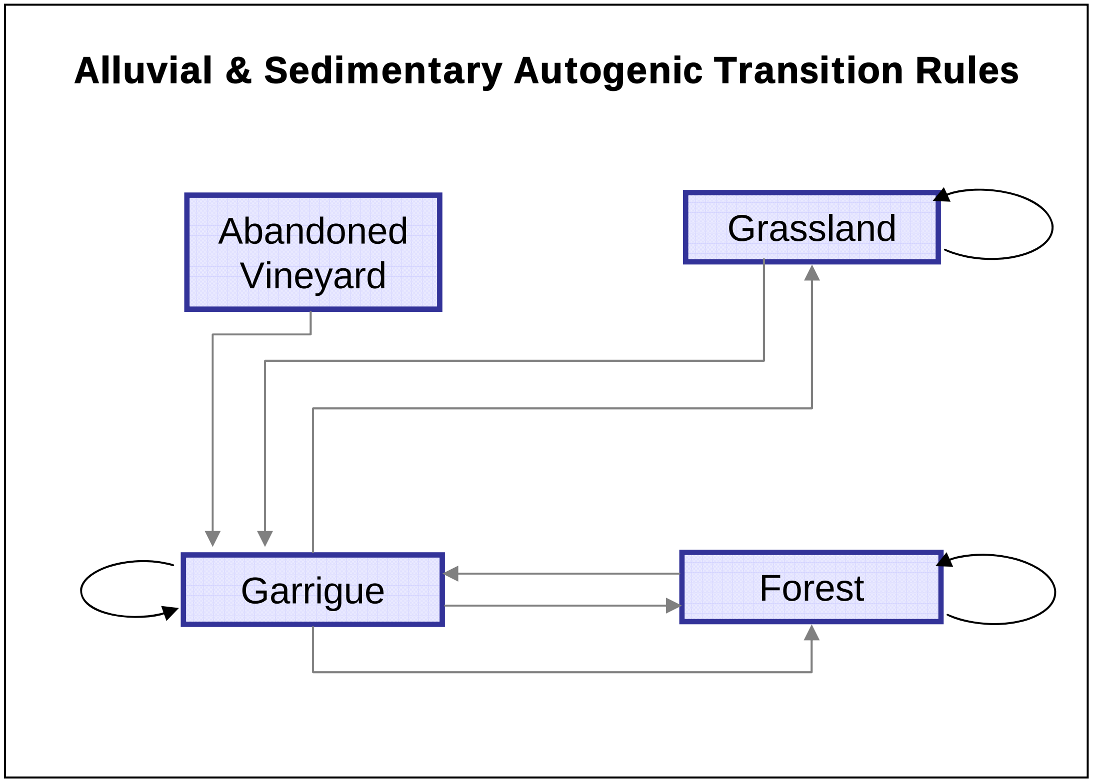
LUCC Model

Example Autogenic Transition Rules



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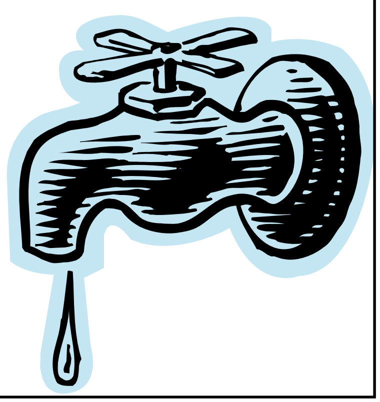
WUP: Urban Demand

- Specific Commune Census Data
- Hérault Questionnaire responses
- Simulation of Population Demand *per commune*
  - Spatial patterns of water demand
  - Urban Land Cover % from LUCC
  - Urban demand cover
- Transferred to Grid
  - Volumetric basis
  - WUP Scenario matrix



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Household Water Micro-component Model

CATEGORY	VARIABLE
Percentage of Irrigation by:	Hose Watering Can Other
Volume per use for :	Hose Watering Can Other
Average incidence of:	Toilet Flush Shower Bath
Market Penetration of	Washing Machine Dishwasher Shower Sink use Bath

CATEGORY	VARIABLE
Efficiencies	W.C. Dual Flush Equipped Equipped and Use Small Flush Ratio Efficiencies employed
Washing Machine And Dishwasher	Old to New Ratio
Garden	Number of households Percentage of households Percentage of those that irrigate Incidence (PW) Irrigation
Swimming Pool	Percentage of households Size of pool Topping up of swimming pool

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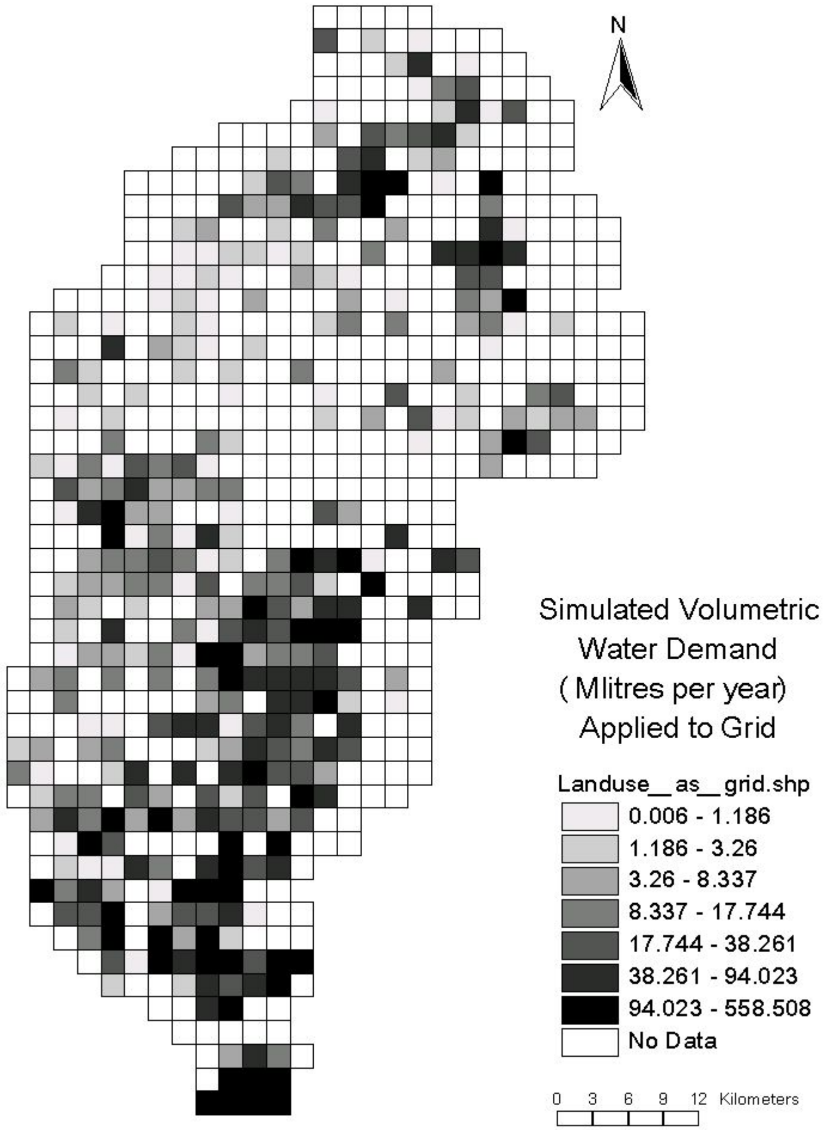
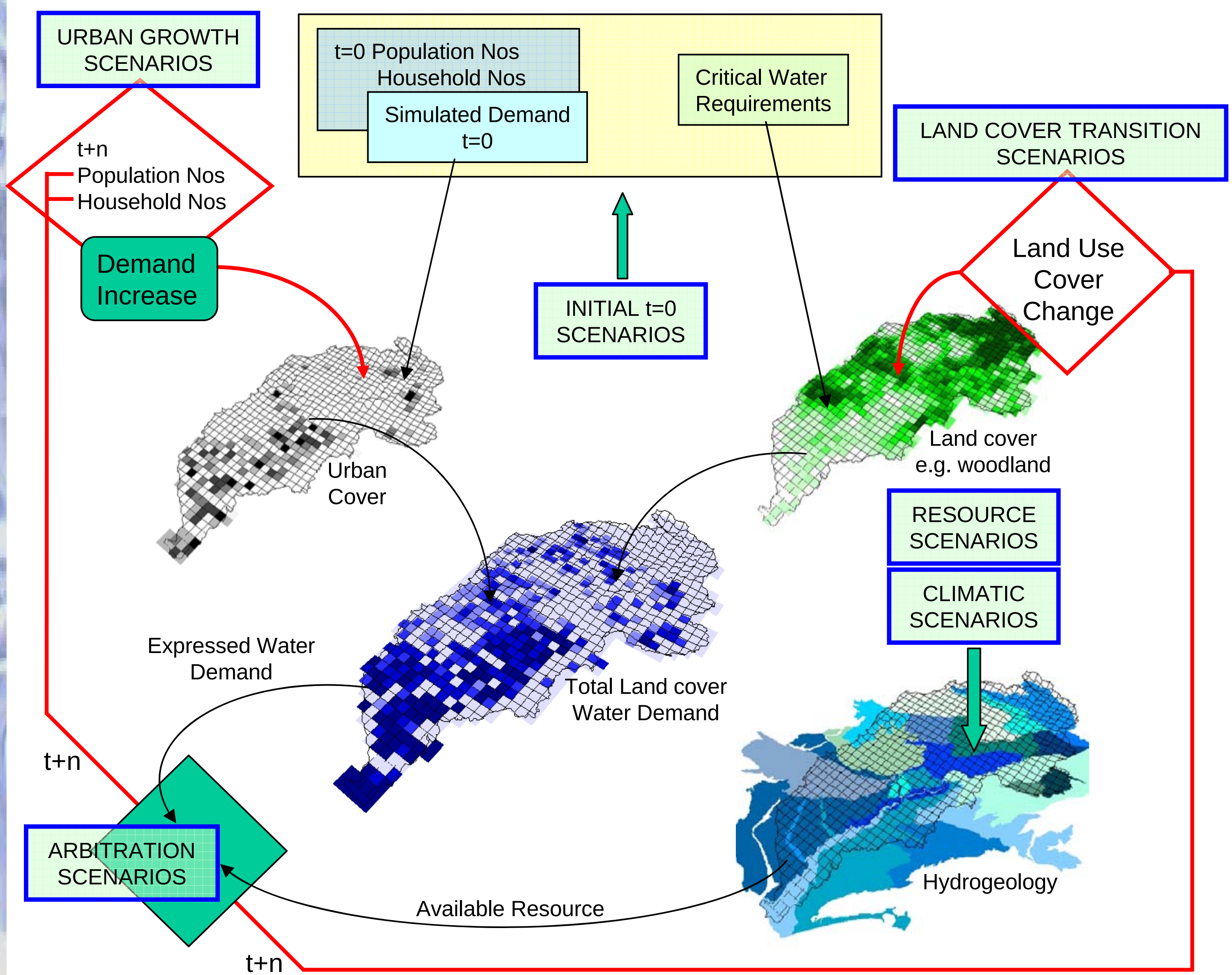
Urban demand Grid 2x2km



SCAPT Model Structure

Stitching everything together



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SCAPT Scenario Themes

- Volitional and Directed change in household water use
- Volitional indoor water uses
- Demographic Change
- Land Use Change
- Leisure and Amenity Use of Natural Resources
- Climate Change

Set through Parameters & Action Rules

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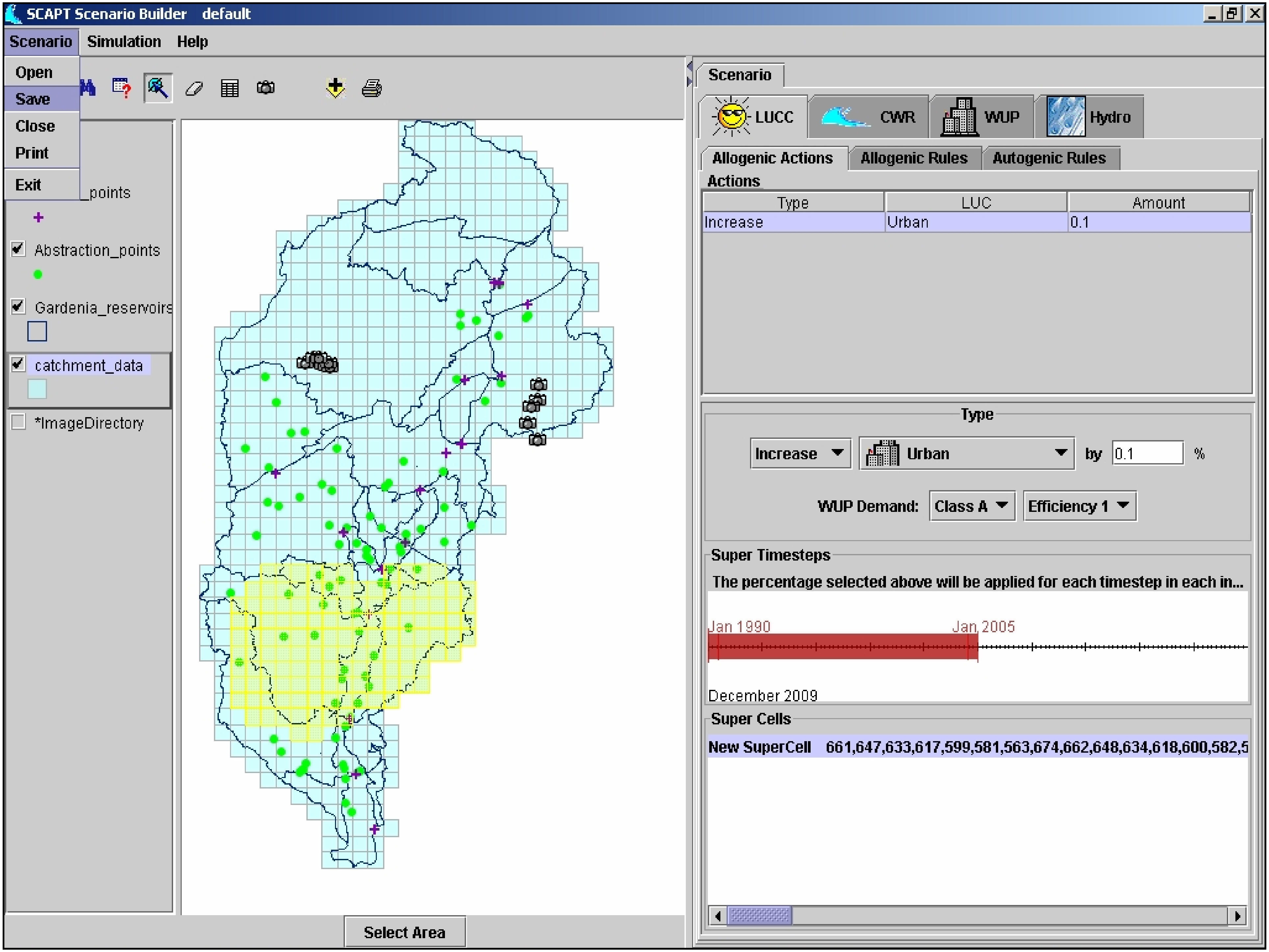
Scenario Builder – Mechanisms

Scenario Builder

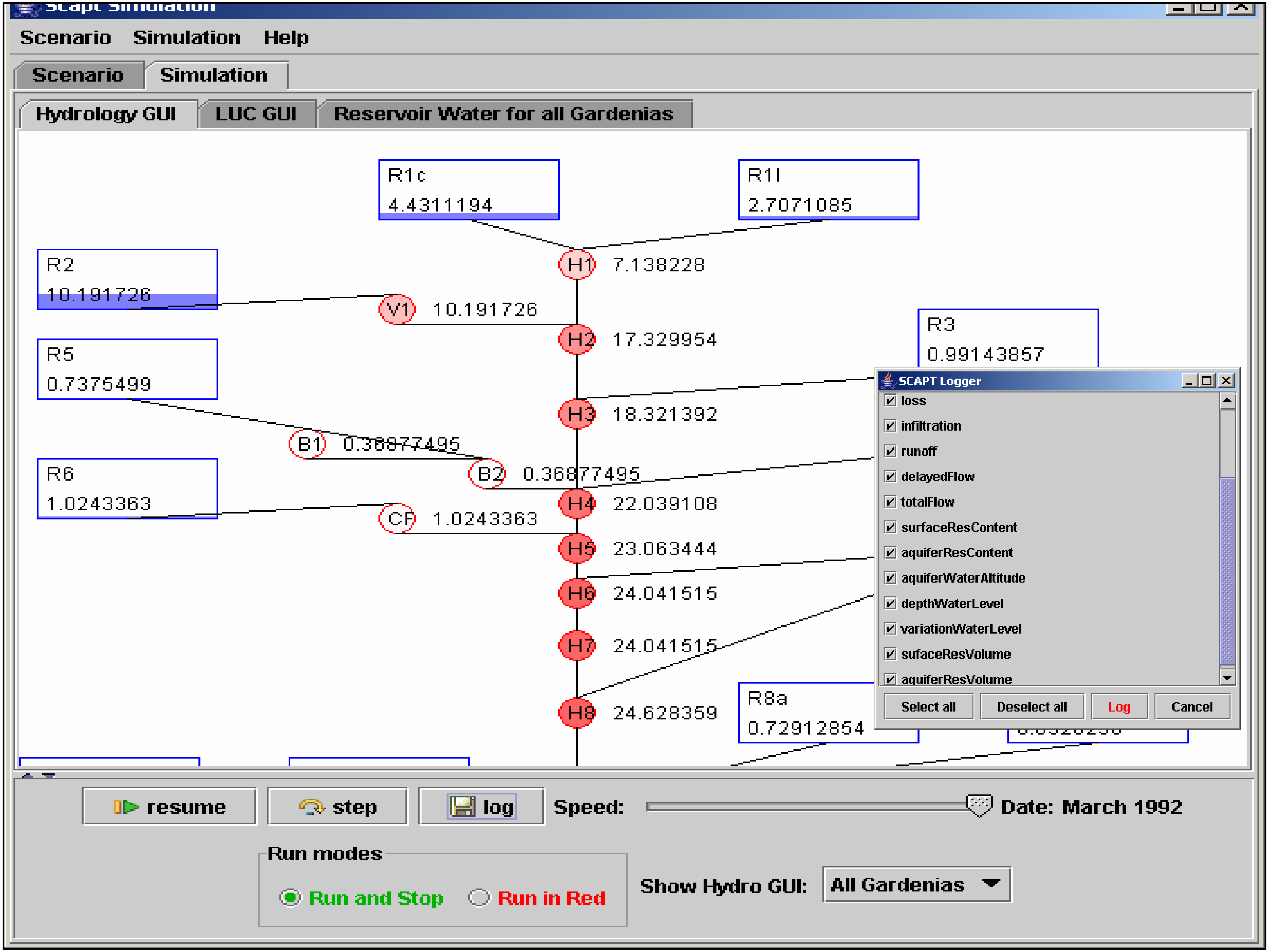
For Land Use Cover Change (LUCC)
Specify Allogenic changes
Specify Autogenic transitions
Specify Critical Water Requirements

For Water Use Profiles (WUP)
Specify different WUPs
Indicate urban demand patterns
Specify urban growth scenarios

For Hydrology
Set initial parameter tables and rules
Climate change perturbations
Specify abstraction & irrigation scenarios



SCAPT Scenario Builder default
Scenario
Simulation
Help
Open
Save
Close
Print
Exit
_points
Abstraction_points
Gardenia_reservoirs
catchment_data
*ImageDirectory
Select Area
Scenario
LUCC
CWR
WUP
Hydro
Allogenic Actions
Allogenic Rules
Autogenic Rules
Actions
Type
LUC
Amount
Increase
Urban
0.1
Type
Increase
Urban
by
0.1
%
WUP Demand:
Class A
Efficiency 1
Super Timesteps
The percentage selected above will be applied for each timestep in each in...
Jan 1990
Jan 2005
December 2009
Super Cells
New SuperCell 661,647,633,617,599,581,563,674,662,648,634,618,600,582,5


Scenario
Simulation
Help
Scenario
Simulation
Hydrology GUI
LUC GUI
Reservoir Water for all Gardenias
R1c
4.4311194
R1l
2.7071085
R2
10.191726
H1
7.138228
V1
10.191726
H2
17.329954
R3
0.99143857
R5
0.7375499
H3
18.321392
B1
0.36877495
B2
0.36877495
R6
1.0243363
H4
22.039108
CF
1.0243363
H5
23.063444
H6
24.041515
H7
24.041515
H8
24.628359
R8a
0.72912854
SCAPT Logger
loss
infiltration
runoff
delayedFlow
totalFlow
surfaceResContent
aquiferResContent
aquiferWaterAltitude
depthWaterLevel
variationWaterLevel
sufaceResVolume
aquiferResVolume
Select all
Deselect all
Log
Cancel
resume
step
log
Speed:
Date: March 1992
Run modes
Run and Stop
Run in Red
Show Hydro GUI:
All Gardenias

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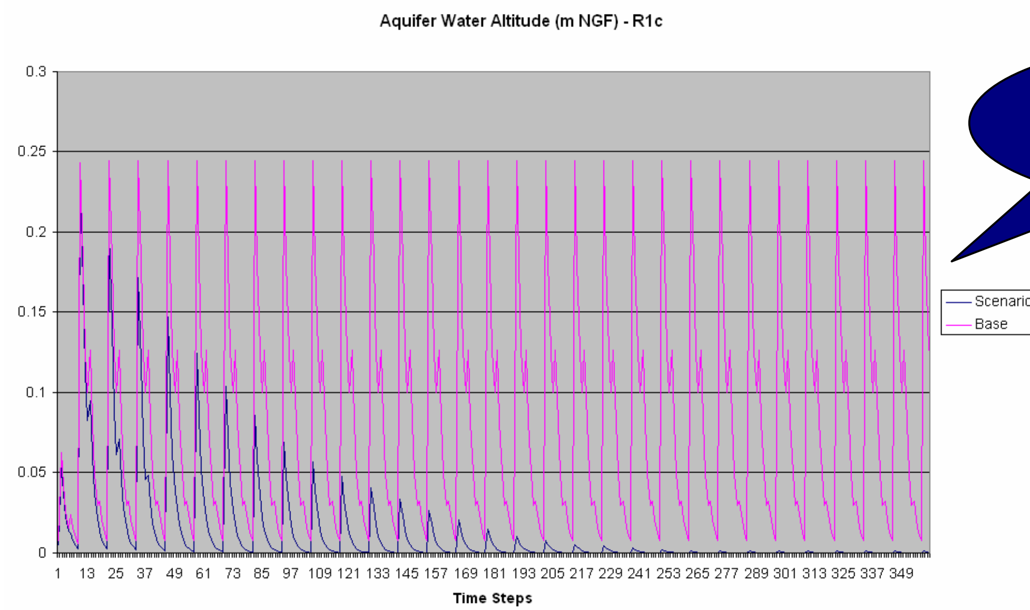
Example scenario...

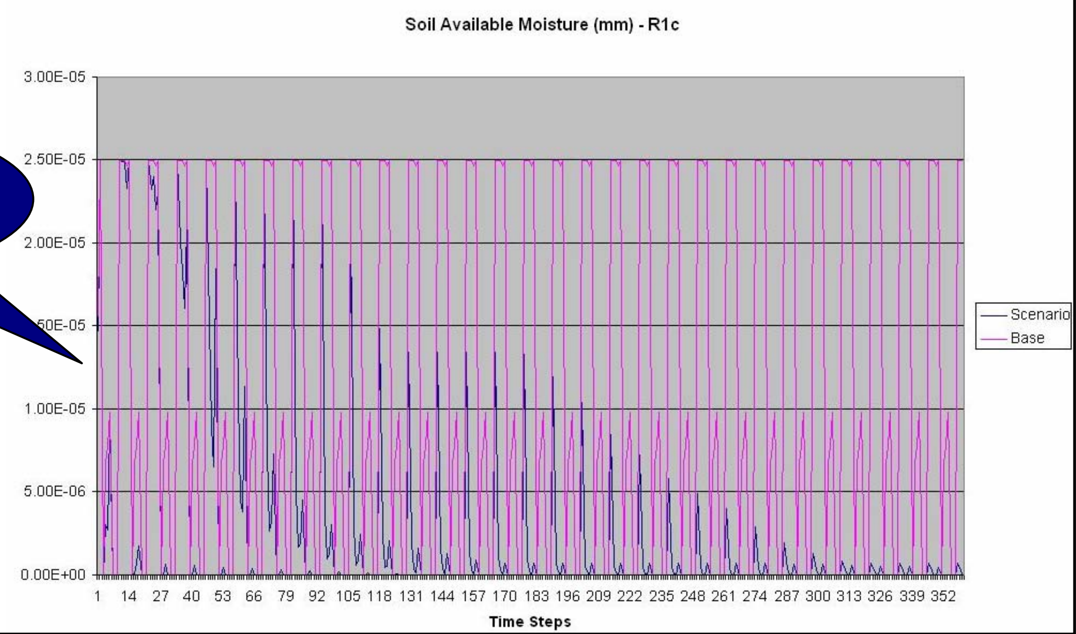
Decreasing rain



Dec. Aquifer Water

RainDecrease:
Base Scenario
Rain Factors -1% for Jan to Dec

Falling Soil Moisture



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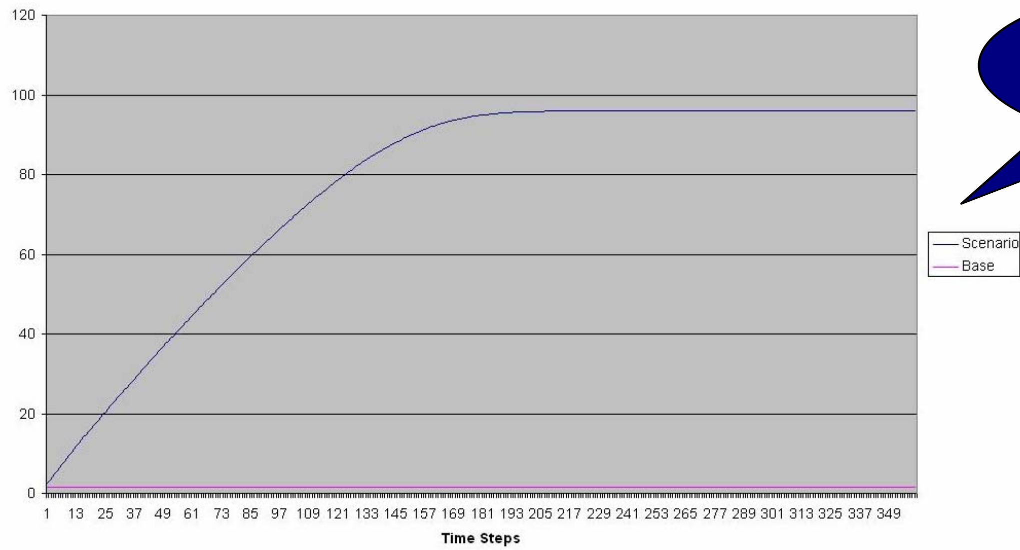
Example scenario...

Increasing population

Urban (%) - Average LUC values along time for whole catchment

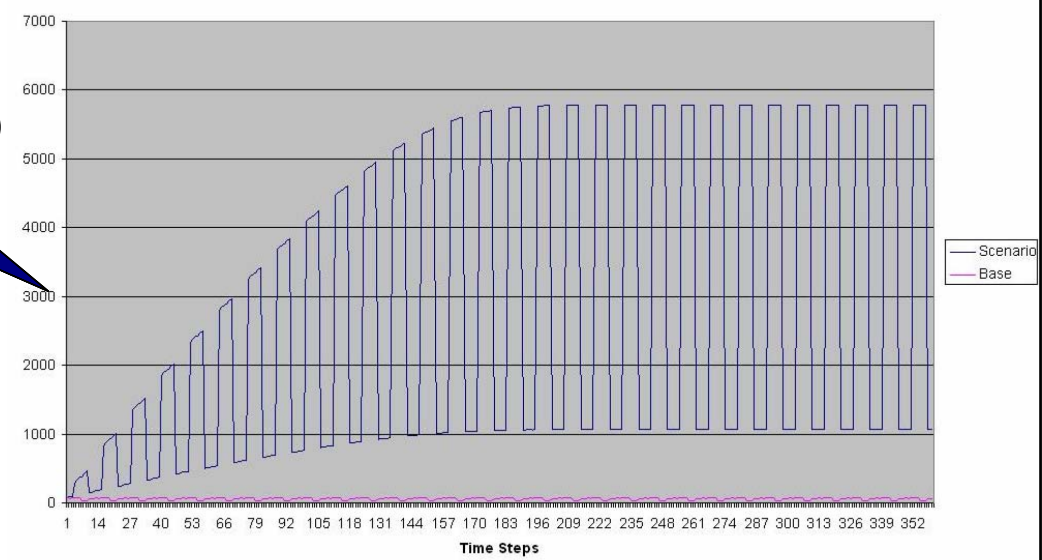


Popn. Increases

UrbanIncrease:
Base Scenerio
Sample WUP classes
Action: Increase Urban by 1%, Class A, efficiency 2 over the whole of the Catchment
Allogenic Probalities - equal % for all land uses

Water Demand (mm) - Average Water Demand values along time for whole catchment

Inc. Water Demand



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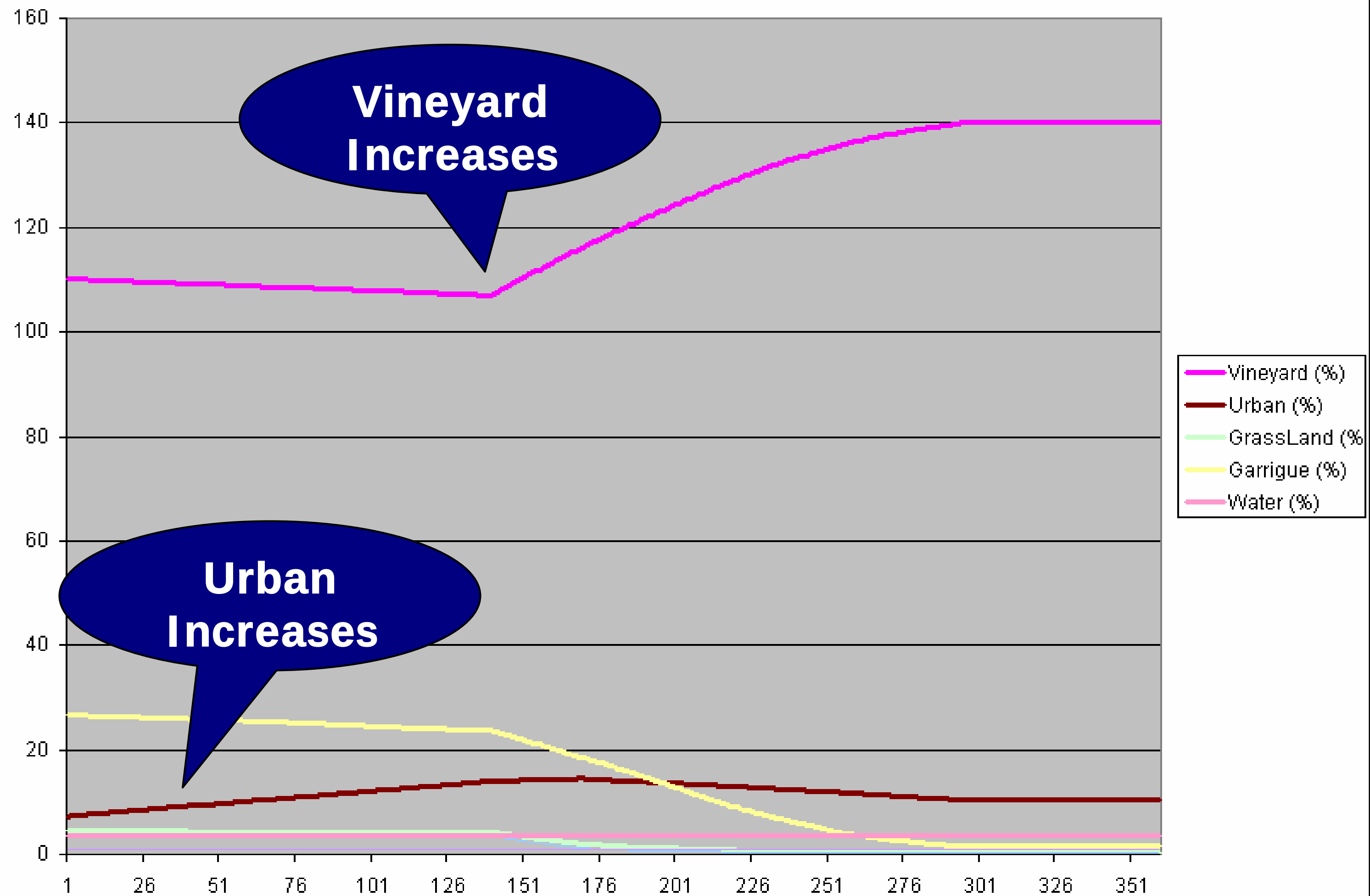
Example scenario…

Multiple Changes in Landuse Classes

Alluvial cells:
Urban +0.5% Jan 1990 – Feb 2004
Vineyard +0.5% Sep 2001 – July 2014



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SCAPT Approach

Benefits of Java and Object-Oriented design:

- Generic Modelling Framework
- Flexible Architecture
- Modular Design
- Intiuitive GUI
- Portability
- Self-documenting
- GIS Integration

Framework can accommodate new components that could be integrated with existing ones

Framework could be applied to other catchments

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SCAPT…

Inter-disciplinary framework

Formal expression of

- catchment dynamics
- catchment inter-relationships
- temporal and spatial patterns

Scenarios addressing **socio-economic**, **technological** and **environmental** issues

Revealing **sustainable patterns** of water resource usage over time, locally and at catchment scale

Novel implementation ‘Java’ computer language - OO

Informing search for **adaptive co-evolution**

Basis for an **institutional WFD DSS** tool ...