

# Dynamic Ecosystems Floodplain Model

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MSc Spatial Decision Support Systems Geoinformation



# Where are we going?

- Objective
- Floodplain ecosystems
  - Importance
  - Modeled phenomena
  - Terms
- Model requirements
- Floodplain modeling procedure
  - Components overview
  - Concept & implementation
  - Software
  - Package
  - Outlook
- Floodplain modeling & SDSS



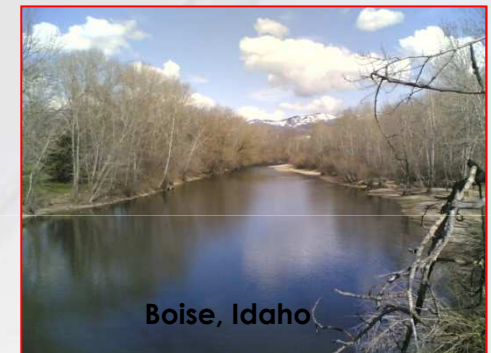
# Objective

- Computer implementation of:
  - Simulation models (Two Models)
  - Generic for riparian ecosystem
  - Static, initial floodplain landscape model
  - Dynamic floodplain model:
    - Simulates landscape evolution
    - Vegetation response to variables determine by discharge & morphology



# Importance of riparian ecosystems

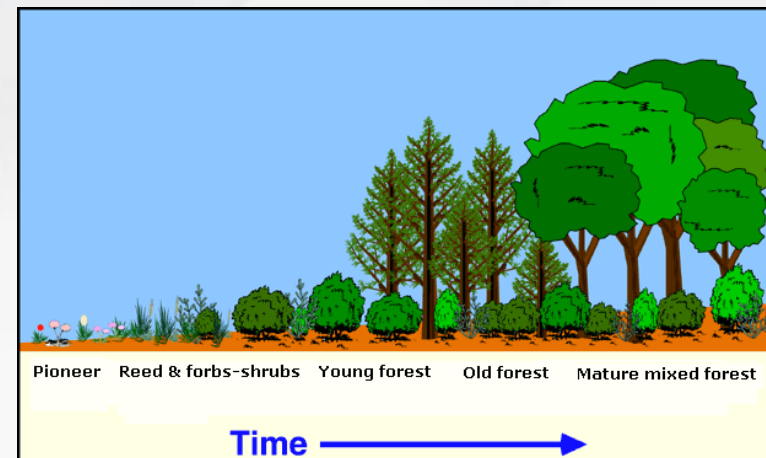
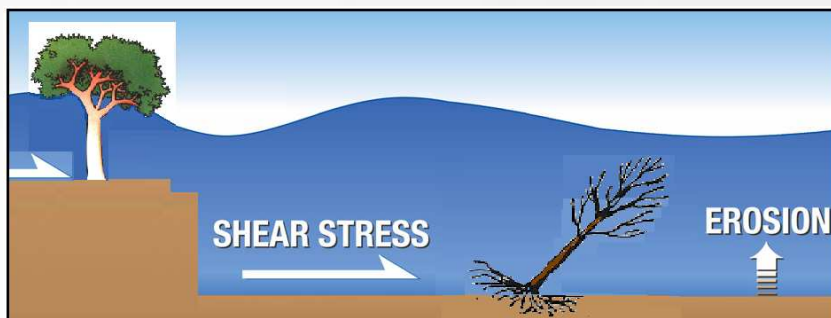
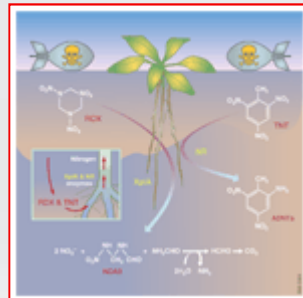
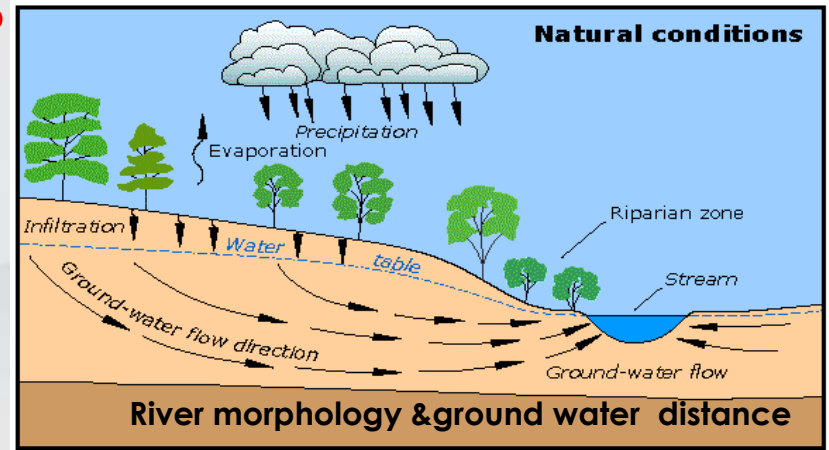
- Support of niche species
- Support food webs
- Support birds migration
- Biodiversity
- Cultural heritage
- Water quality
- Impacts wide spread
- International nature restoration-protection laws
  - Assessing tools



# Floodplain ecosystems

## Considered phenomena

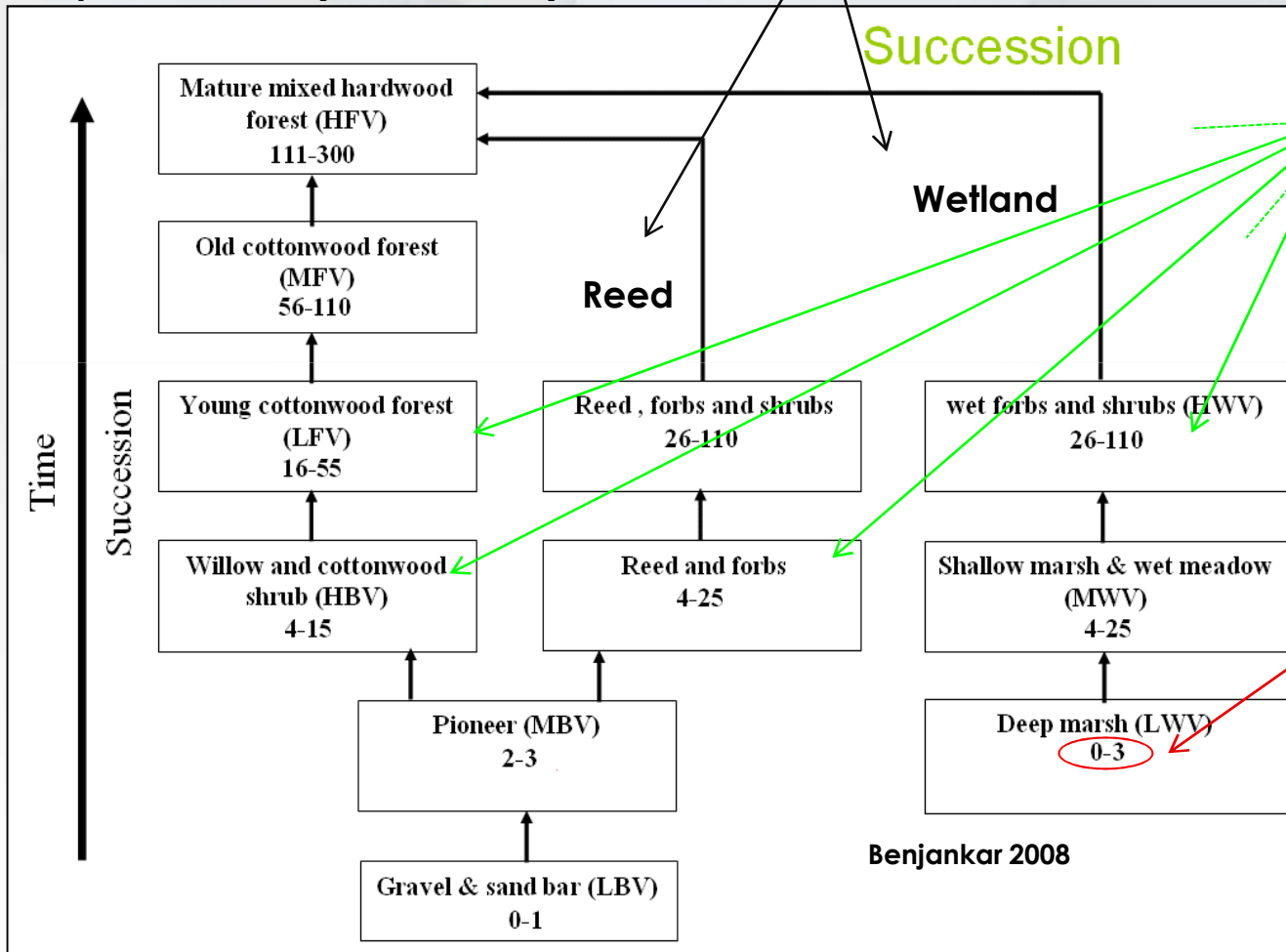
- Recruitment
  - Colonization sites
  - Groundwater level
  - Scour disturbance (flow by the shore)
- Shear stress
- Flood duration (physiological stress)
- Time



# Terms: succession series, cover types

## Succession Series (different vegetation kinds)

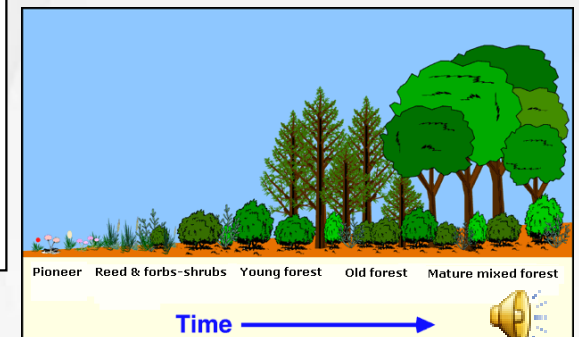
Riparian Forest (Cottonwood)



Cover Types (phases)

Age range  
(phase time span)

Benjankar 2008



# Requirements of the model

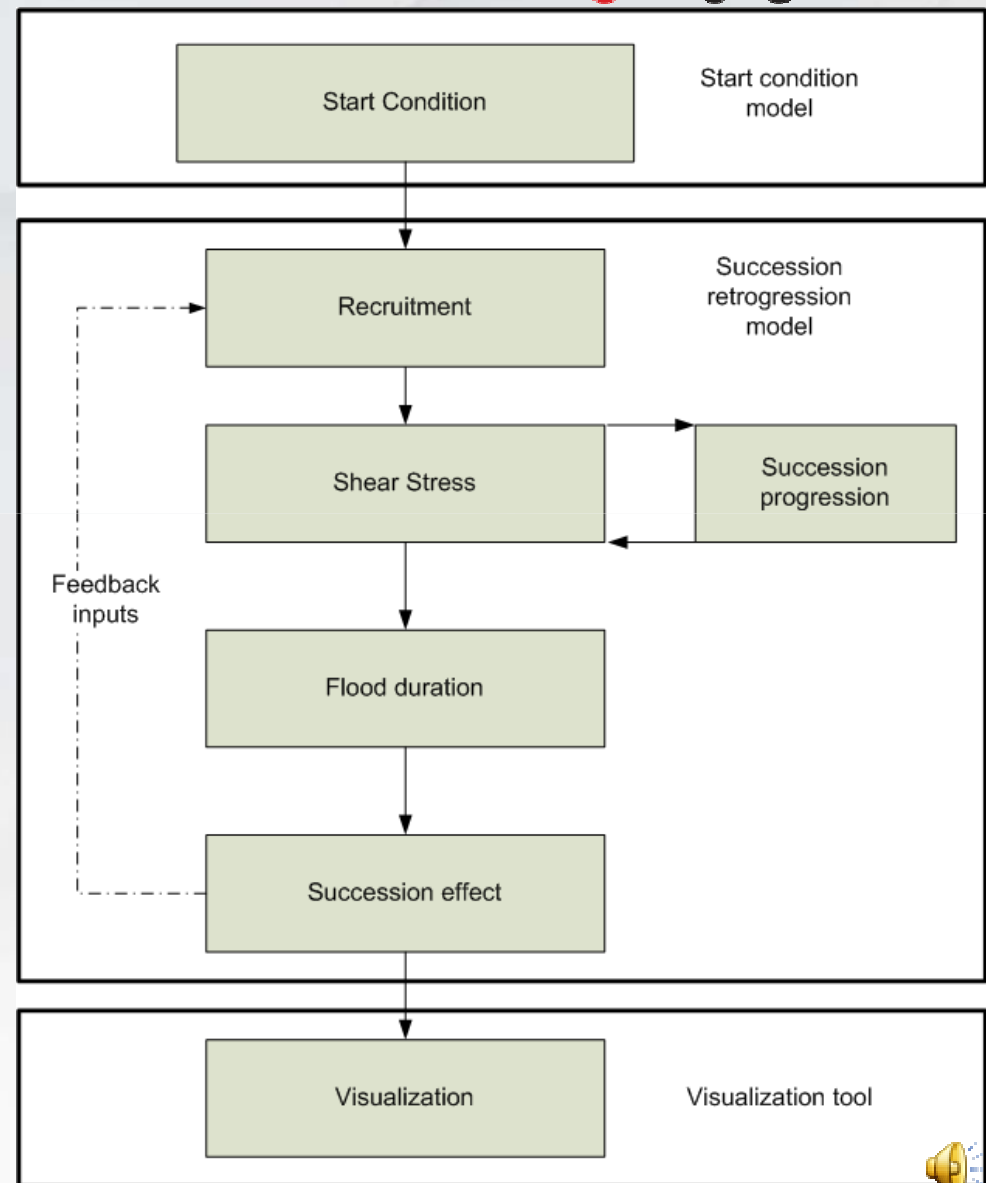
- Spatial referenced inputs-outputs (Maps)
- Model set on three succession series
- Record of cover types areas (additional , non spatial output)
- Well documented
- Results displayed with user defined color legend



# Modeling procedure components

- Start condition model:
  - Defines extents of the starting succession stands
  - Assigns minimum ages \* of the stands in the study area
- Succession retrogression model:
  - Dynamic
  - Evaluates evolution & spatial distribution of vegetation
  - Yearly inputs
  - Made by four submodels
- Visualization tool:
  - Re-displays succession retrogression outputs with a unified legend

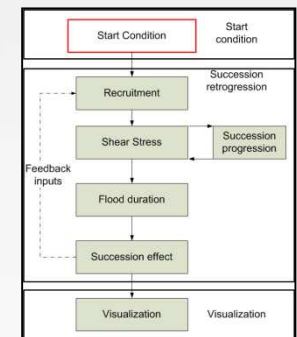
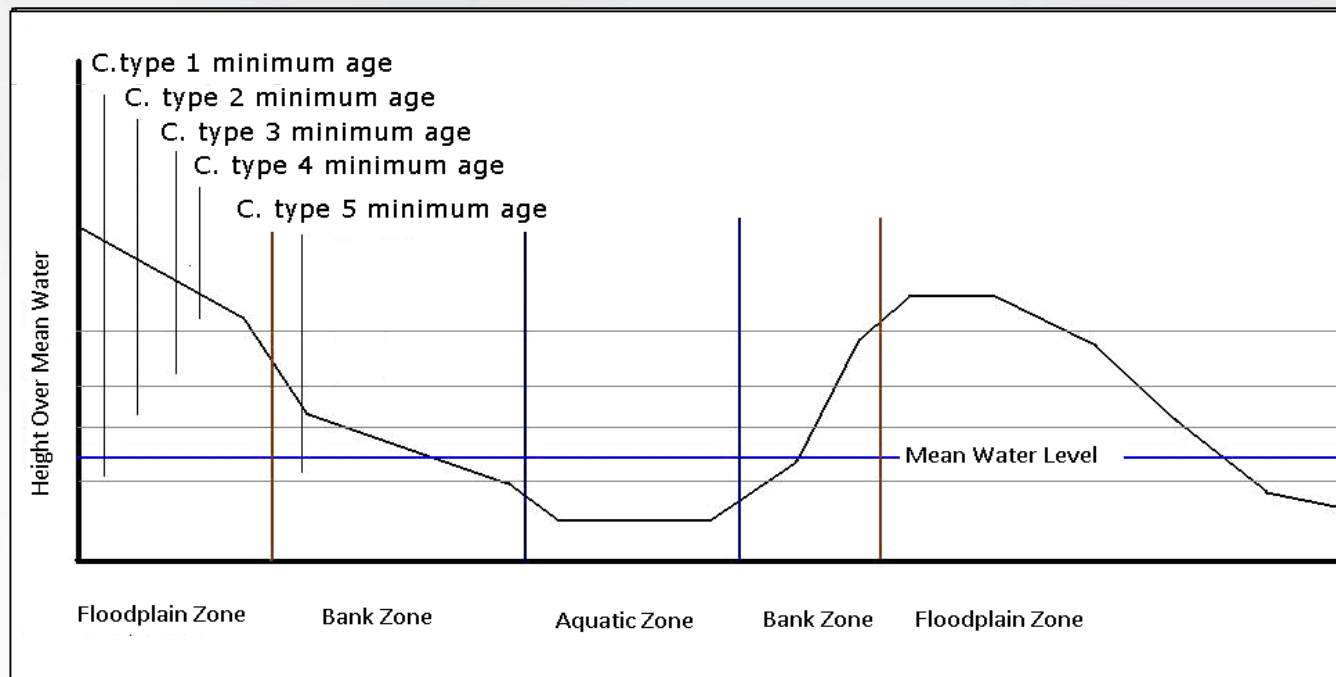
\*minimum number of years that, in natural conditions, are necessary to reach that stand status (height, resistance, shape...)



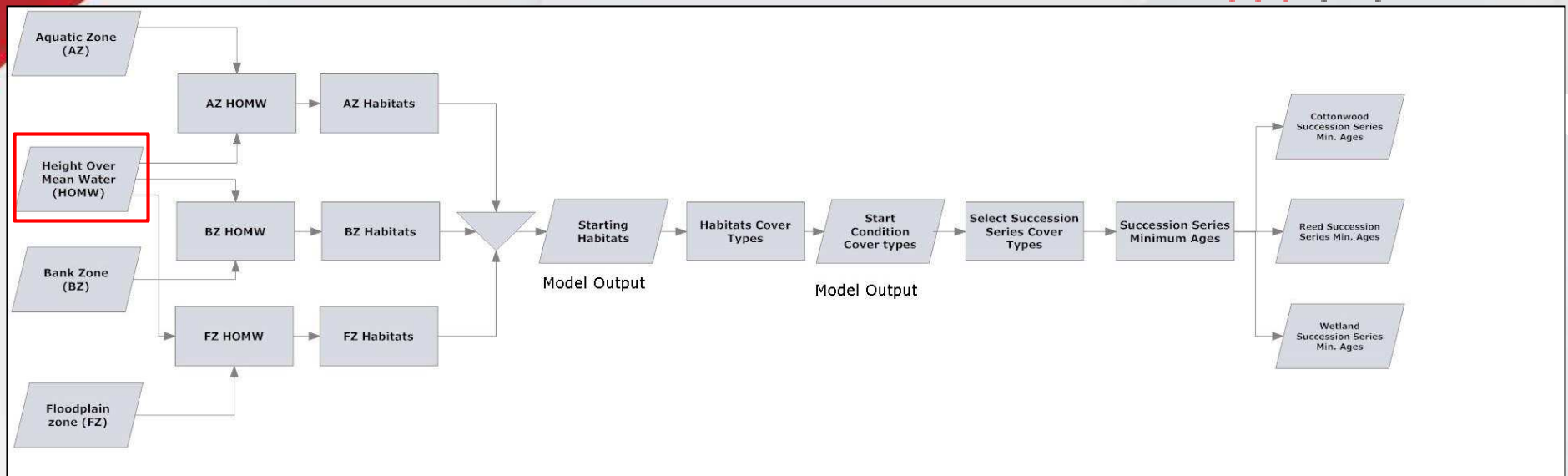


## Start condition

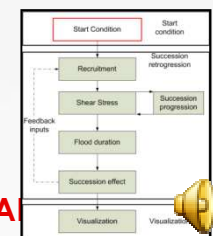
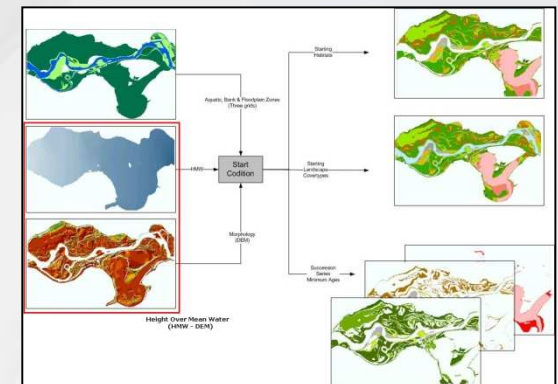
- Defines initial habitat conditions and related landscape
  - Height over mean water level
  - Zone where heights are measured (aquatic, bank or floodplain zone)
- Tuple height-zone defines a unique habitat
- Each habitat has a unique cover type
- Each cover type has a minimum age



# Start condition implementation



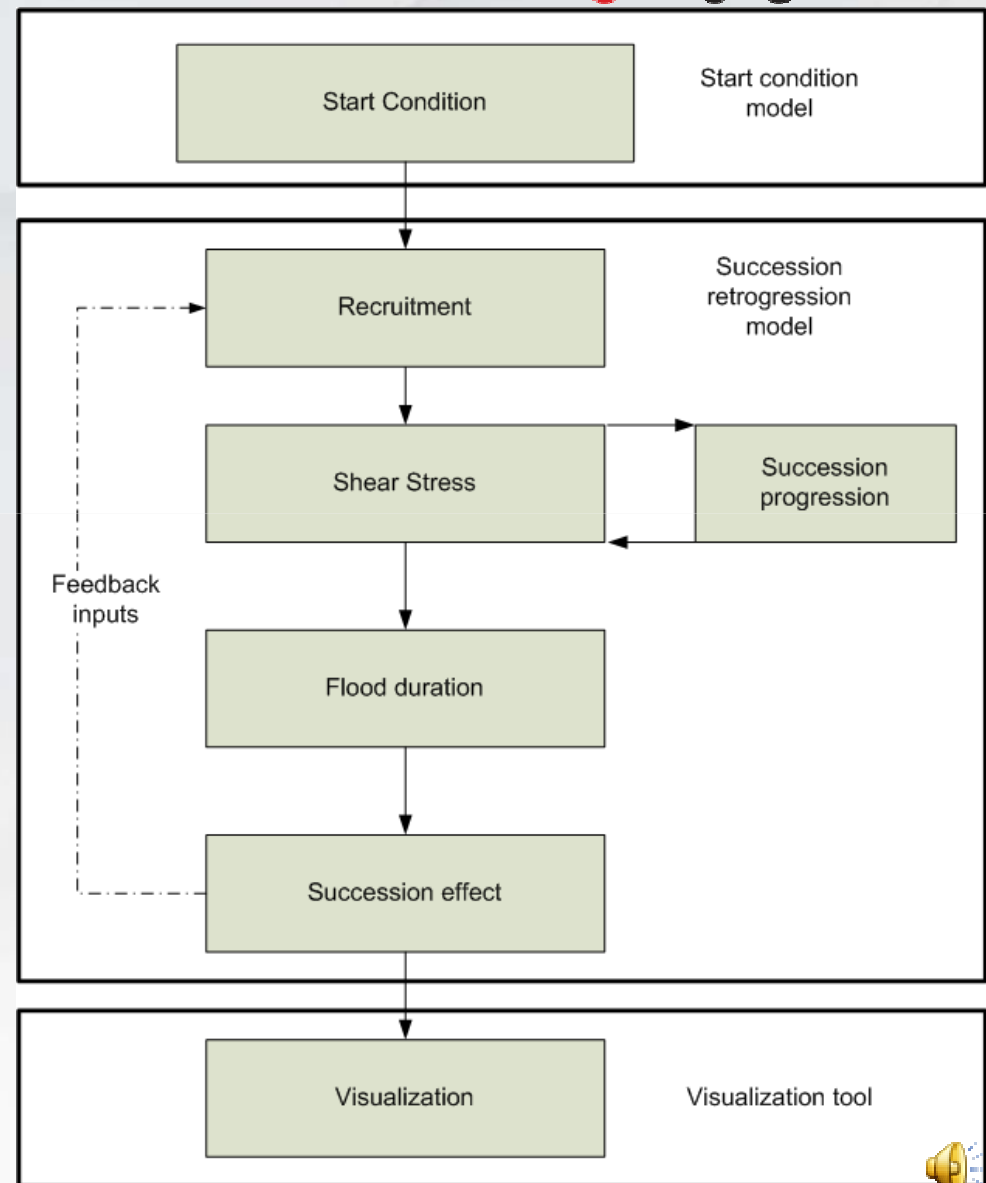
Input Grids	Parameters	Output Grids
<ul style="list-style-type: none"> <li>Height over mean water</li> <li>Morphology (DEM)</li> <li>Aquatic zone</li> <li>Bank zone</li> <li>Floodplain zone</li> </ul>	<ul style="list-style-type: none"> <li>Heights over mean water of the bank zone habitats</li> <li>Heights over mean water of the floodplain zone habitat</li> <li>Reclassification from initial habitats to cover types</li> <li>Cover types minimum age</li> </ul>	<ul style="list-style-type: none"> <li>Start condition landscape</li> <li>Initial habitats</li> <li>succession minimum ages</li> <li>Reed succession minimum age</li> <li>Wetland succession minimum age</li> </ul>



# Modeling procedure components

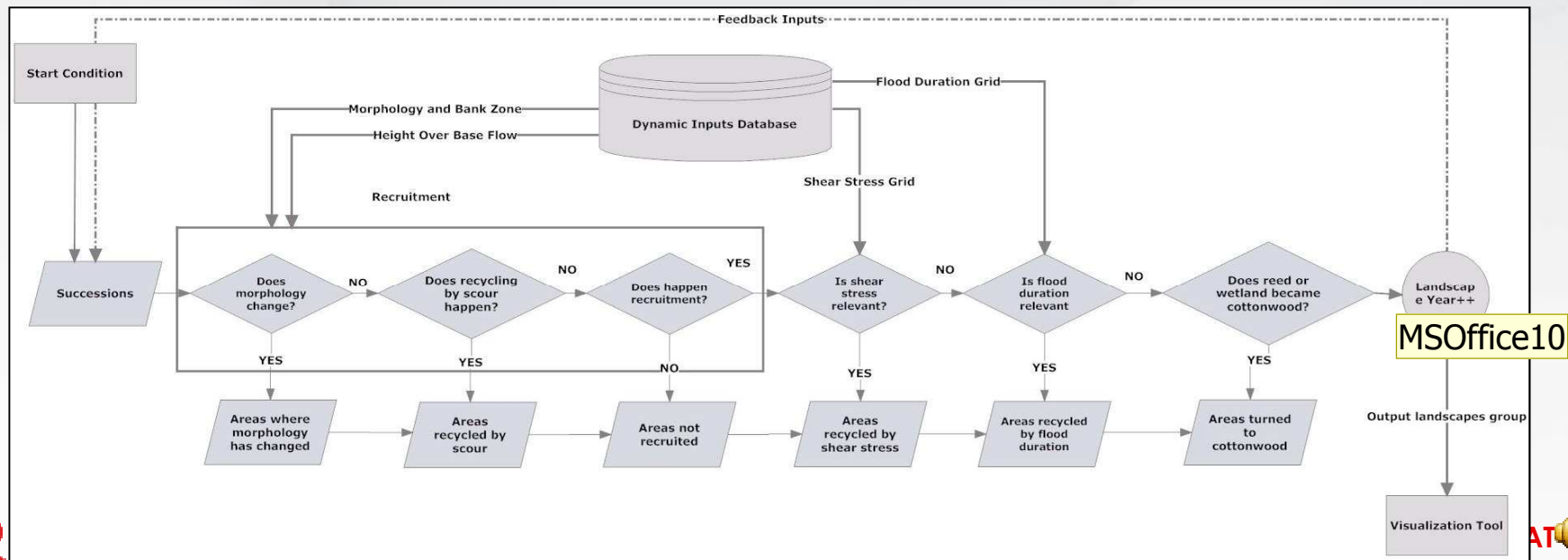
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\*minimum number of years that, in natural conditions, are necessary to reach that stand status (height, resistance, shape...)



# Succession retrogression model

- **Dynamic: inputs-feedback variables**
- **Can be different for each simulated year**
- **File paths stored in a database**
- **Based on hard thresholds & Boolean evaluations**
- **Dynamic inputs:**
  - Morphology (DEM) & Bank zone
  - Height over base flow (approx. soil moisture and scour disturbance)
  - Mechanical disturbance (Shear stress)
  - Physiological flooding stress (Flood duration)



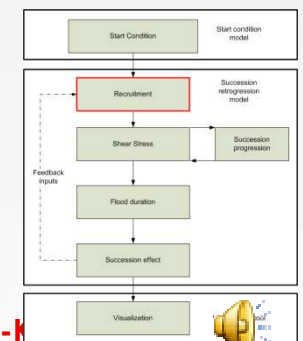
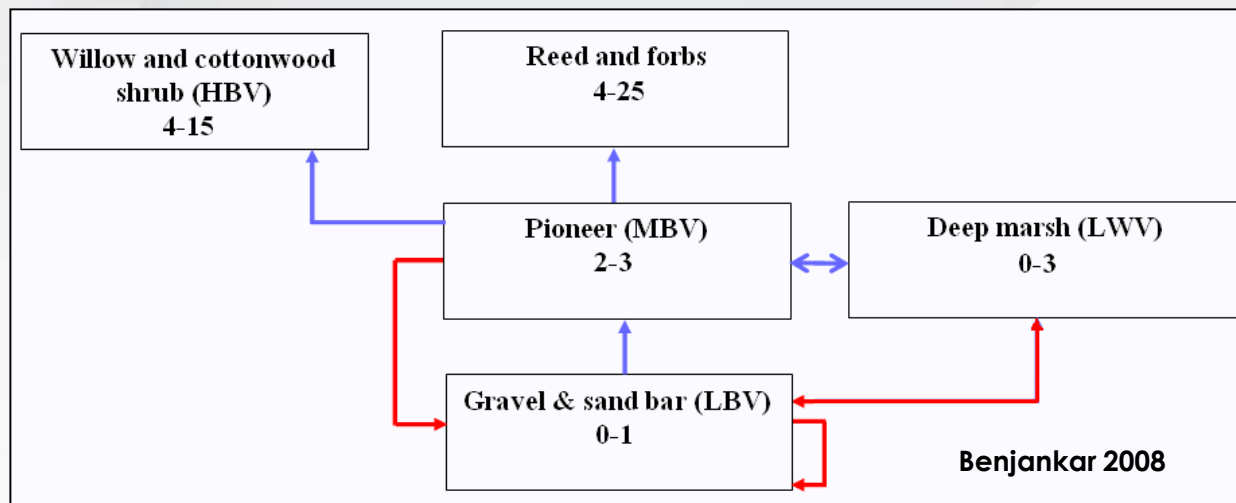
**Slide 12**

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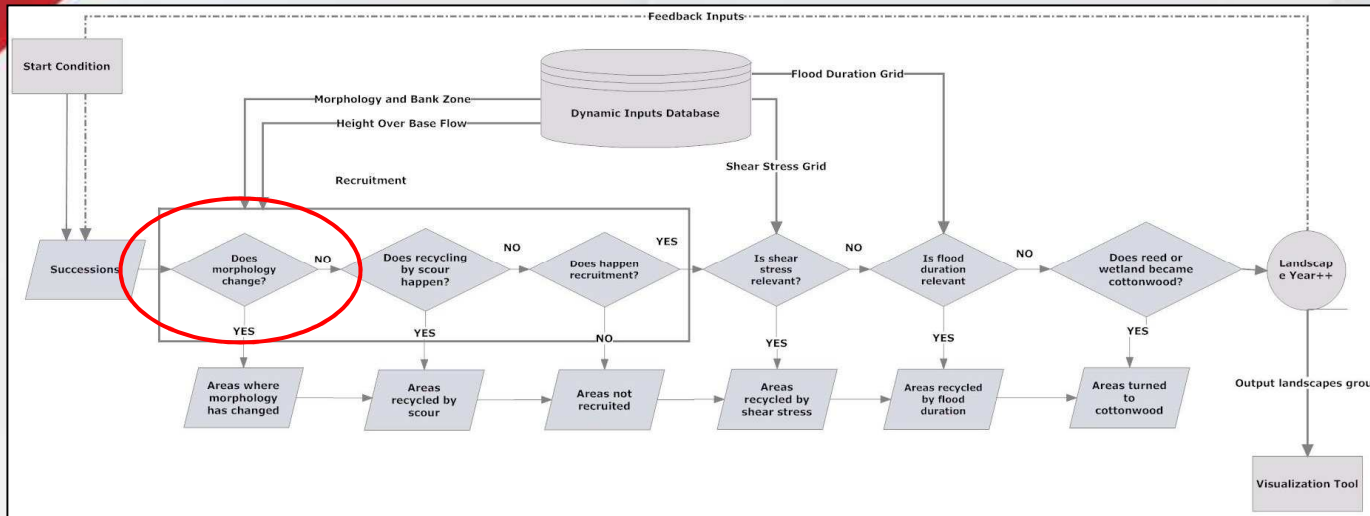
**MSoftware10** how to classify this (morphology vs hydrology)?  
, 9/16/2008

# Recruitment submodel rules

- Verifies changes in morphology
- Vegetation renewal, scour disturbance:
  - Occur only on open bar
  - Height Over Base Flow (HBF), Bank Zone, Morphology
- Reed & cottonwood share pioneer phase
- Fate of shared pioneer depends by HBF at 3<sup>rd</sup> year



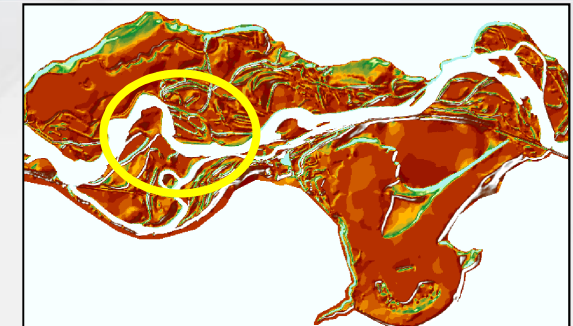
# Succession retrogression evaluations



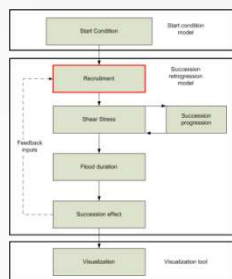
DEM Year n

## Recruitment Morphology Check:

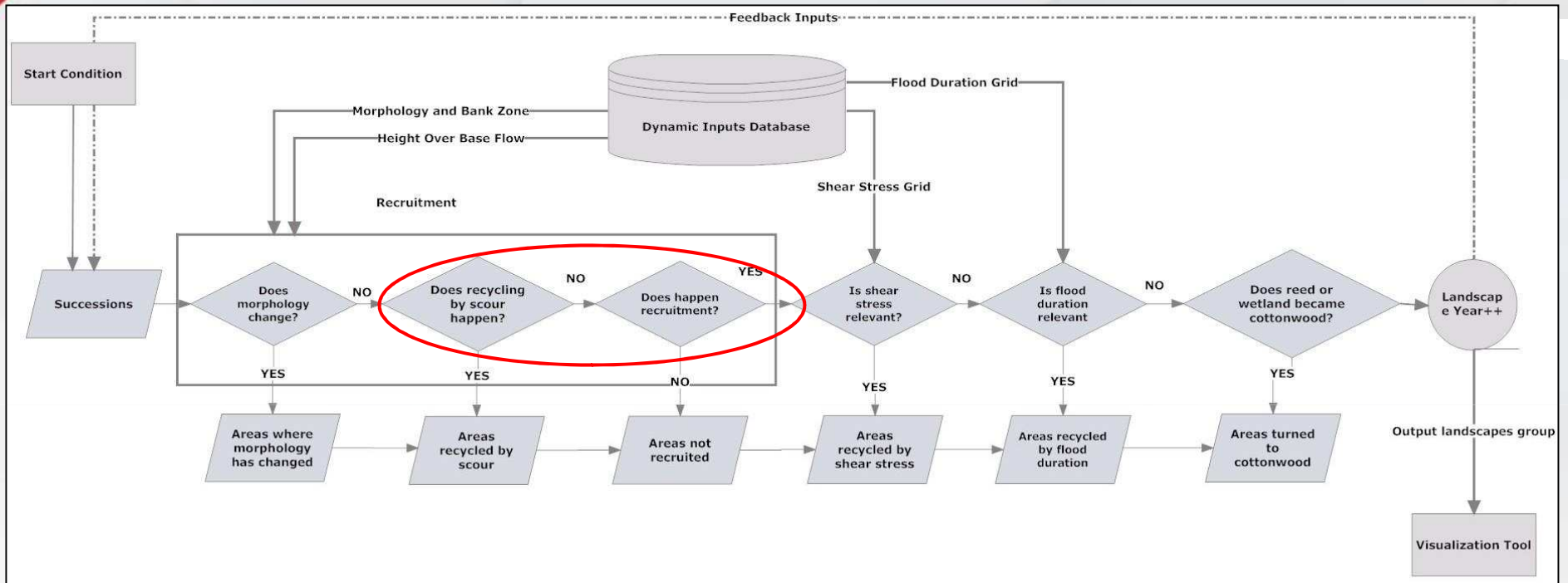
- New land → potentially colonizable
- Land to water → loss of cover types



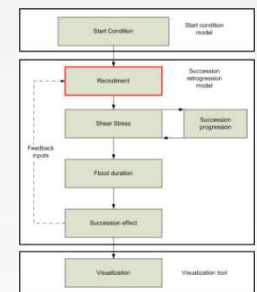
DEM Year n+1



# Succession retrogression evaluations

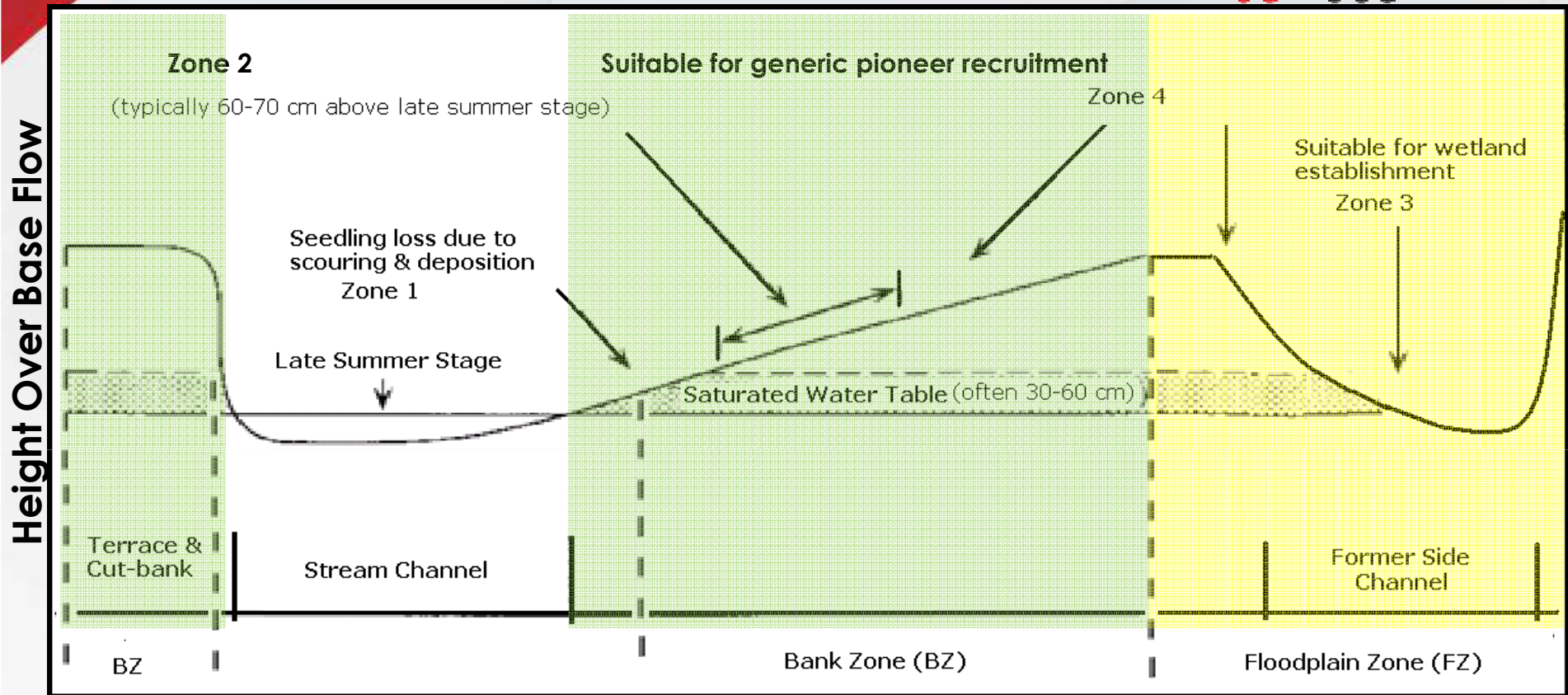


**Recruitment: vegetation renewal, seedling disruption (scour)**

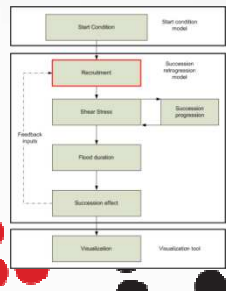




# Recruitment rules II-Renewal, Disruption



Adapted from Mahoney & Rood, 1998

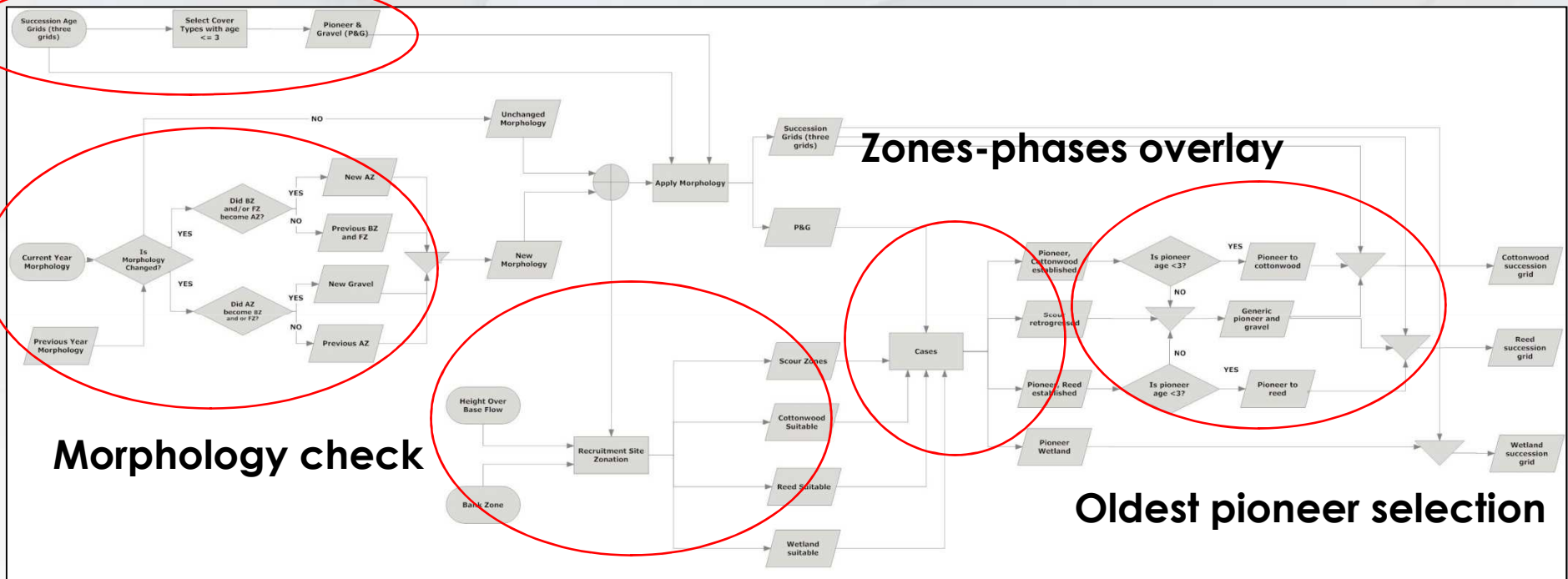


		Height Over Base Flow		
Bank Zone	Disruption		Cottonwood	
		Reed		Reed
Floodplain zone	Wetland	Reed		

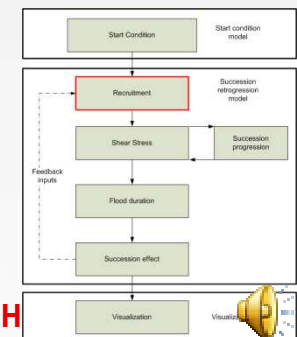
After 3<sup>rd</sup> Year

# Recruitment submodel implementation

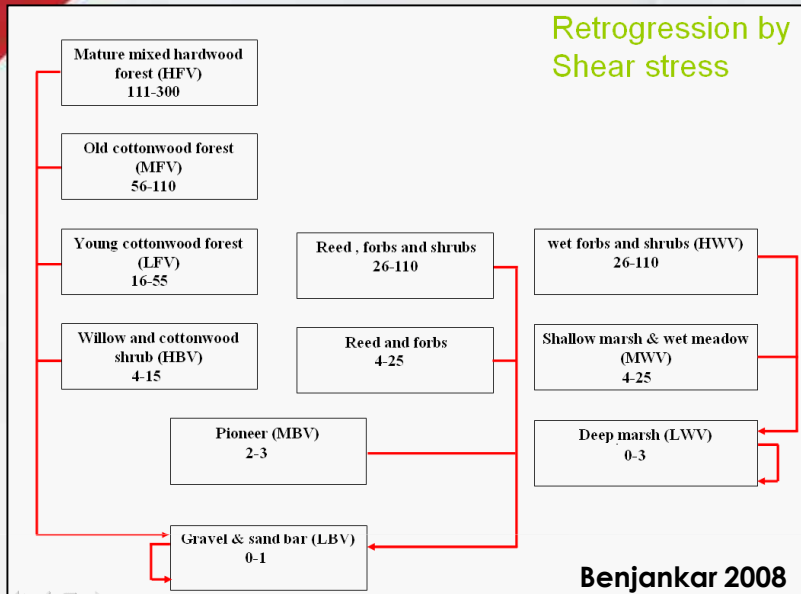
## Pioneer phases selection



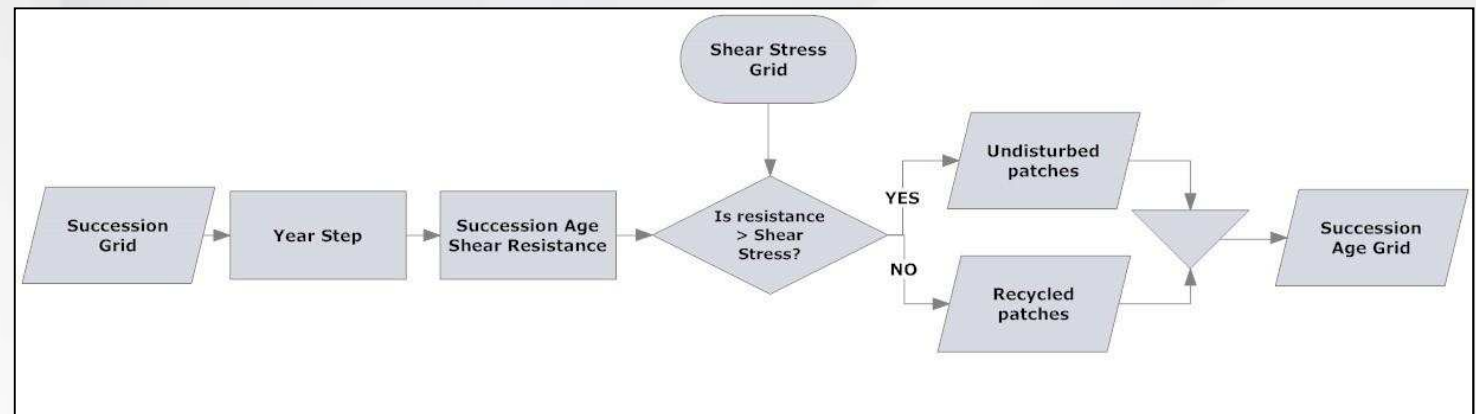
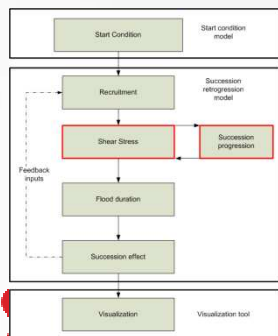
## Zones division



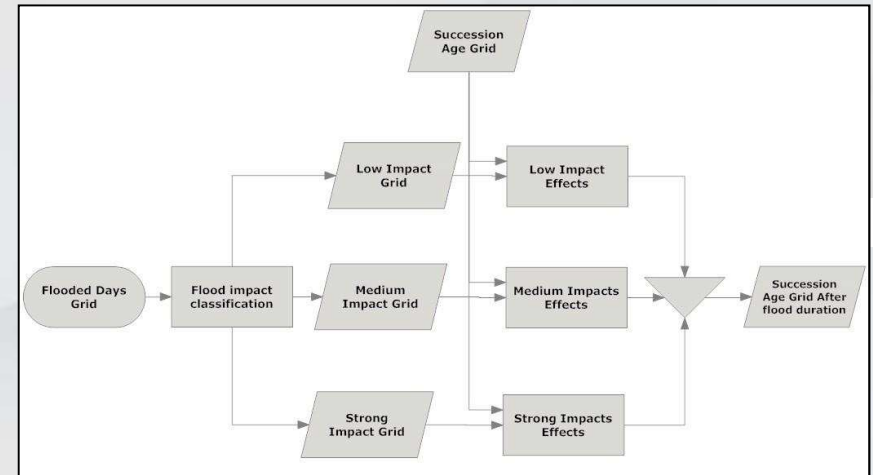
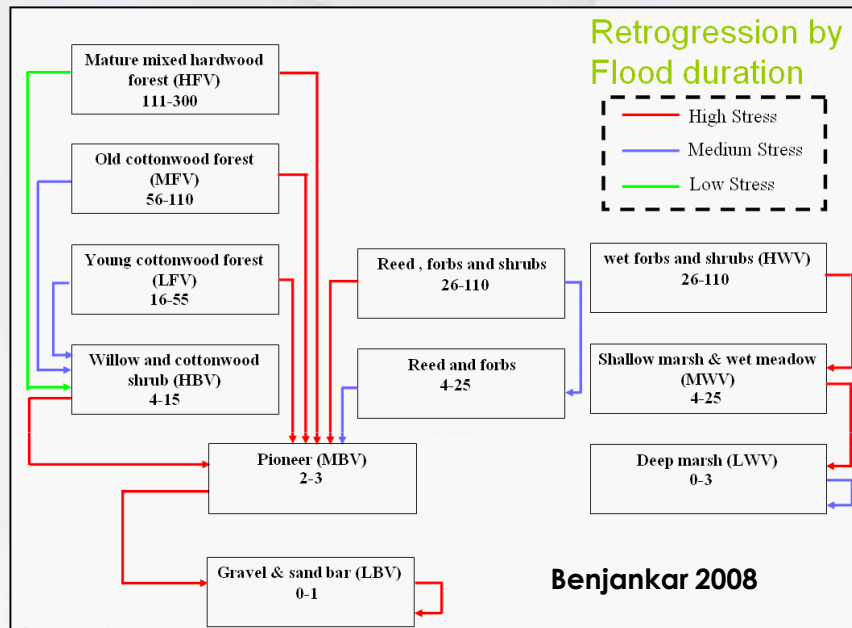
# Shear stress submodel



- Causes total recycling
- Add one (year) to succession ages
- Reclass ages to mechanical resistance
- Resistance VS. shear grid of the year



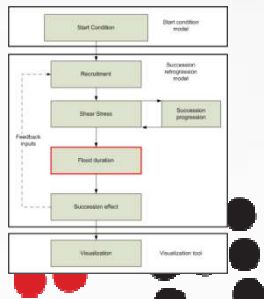
# Flood duration submodel



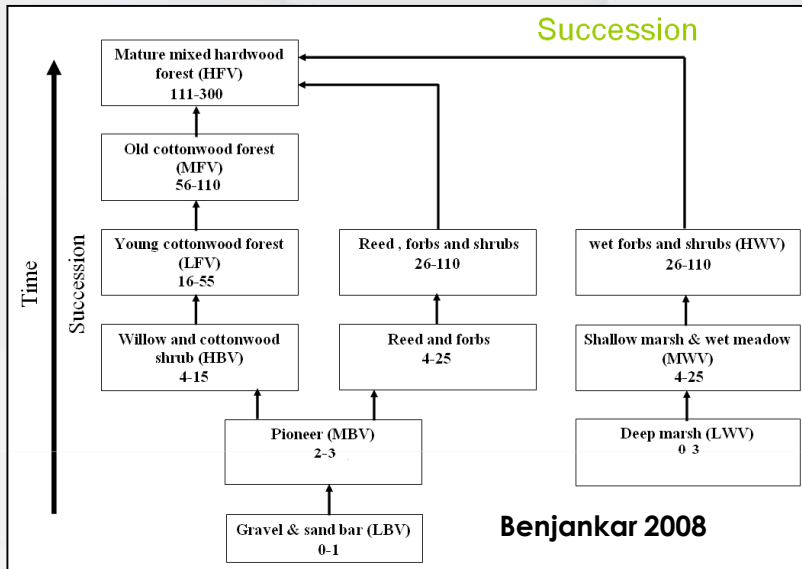
- Total or partial recycling
- Reclass flood grid to impacts
- Check where succession overlays impact grid
- Reclass accordingly

Range of flooded days	Impact severity
90 - 119	Low stress
120 - 150	Medium stress
150 - 366	High stress

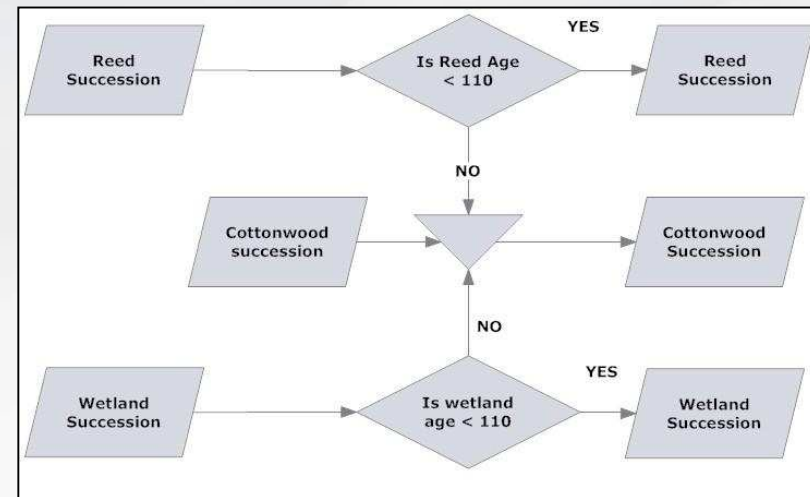
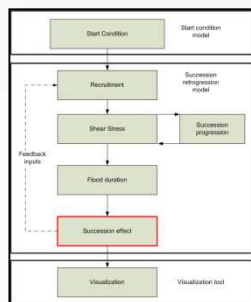
Example of impact intensity classification



# Succession progression effect

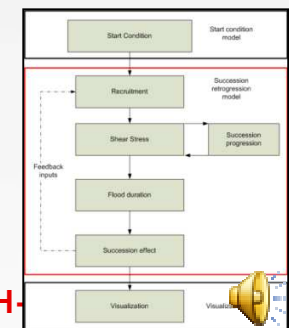
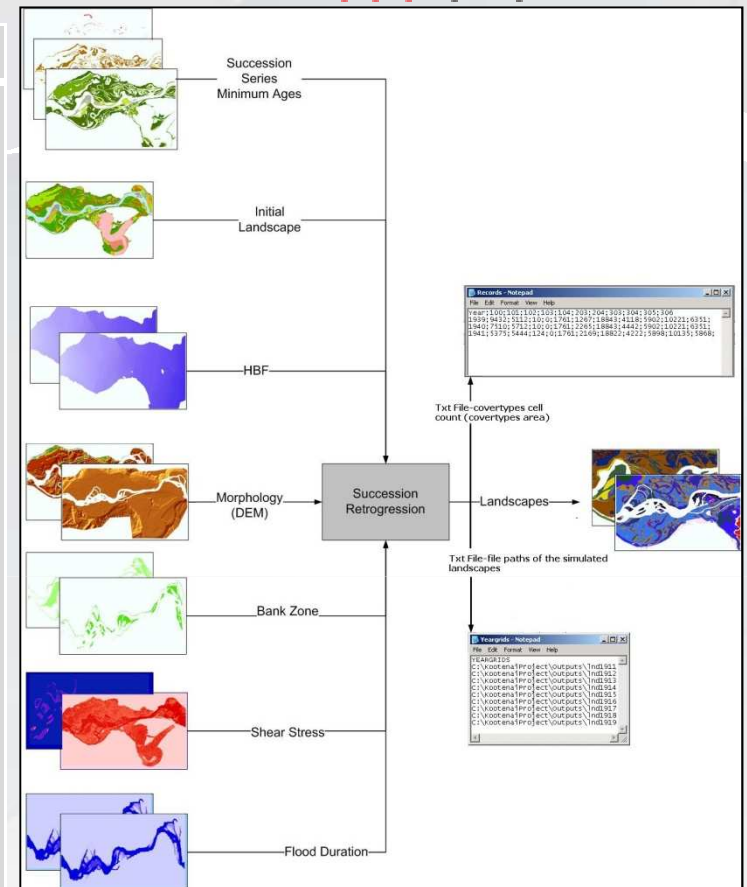


- Perform age check on reed & wetland
- If old enough become cottonwood (forest series)



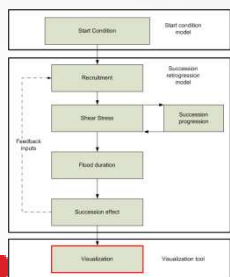
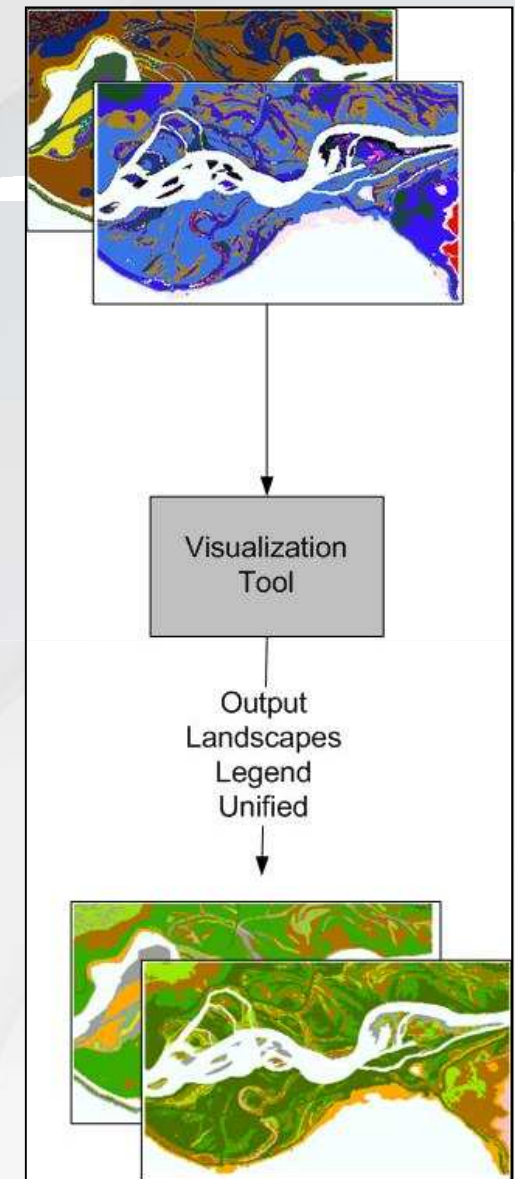
# Succession-retrogression, elements

Inputs	Parameters	Outputs
<ul style="list-style-type: none"> <li>• succession minimum ages</li> <li>• Reed succession minimum ages</li> <li>• Wetland succession minimum ages</li> <li>• Start condition landscape</li> <li>• Height over base flow</li> <li>• Bank zone</li> <li>• Morphology</li> <li>• Shear stress</li> <li>• Flood duration</li> </ul>	<ul style="list-style-type: none"> <li>• Heights over mean water range for the scour disturbance</li> <li>• Heights over mean water within the range suitable for establishment of cottonwood succession from generic pioneer phase</li> <li>• Heights over mean water within the range suitable for wetland recruitment</li> <li>• Successions age classes shear stress resistance (three parameters set)</li> </ul>	<ul style="list-style-type: none"> <li>• Landscape of the study site for each simulated year</li> <li>• File storing the number of cells for each grid code of each simulated landscape</li> <li>• File storing the file path of the simulated year output</li> </ul>

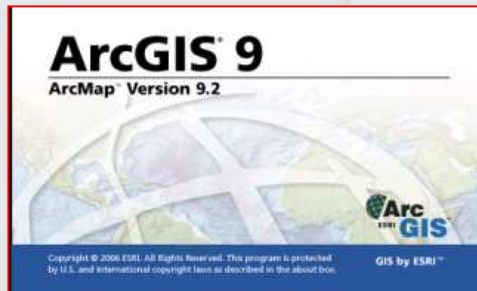


## Visualization tool

- Re-display results of succession retrogression
- Requires some manual operations

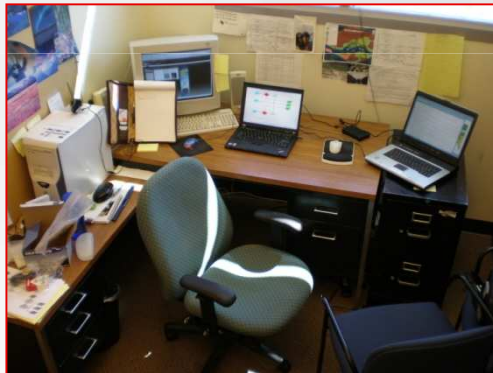


# Software



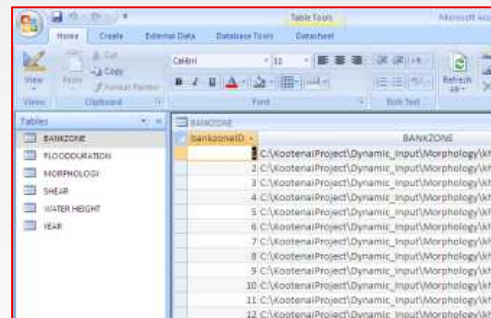
## •ArcGis 9.2

- Model builder
- Spatial analyst extension
- Geoprocessing sequencing
- Provides interface



## •Python 2.4

- PythonWin ext.
- Dynamic data passing
- Naming and records
- Custom geoprocessing

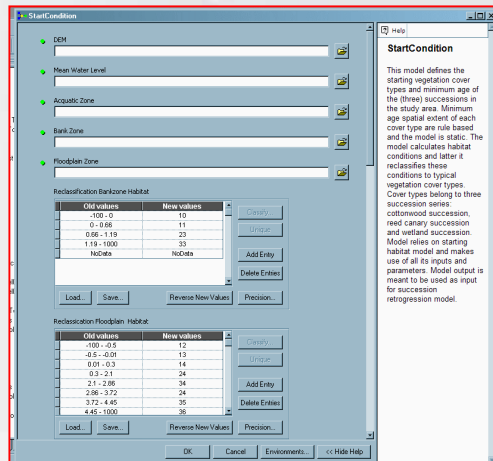


- MS Access
- Dynamic inputs storage
- Popular



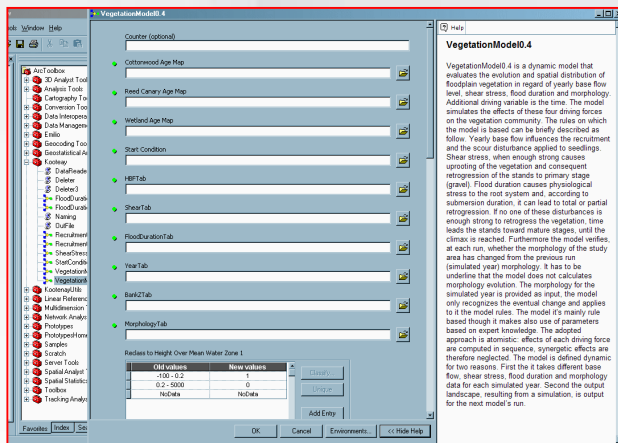


# Model Package Interfaces & toolboxes

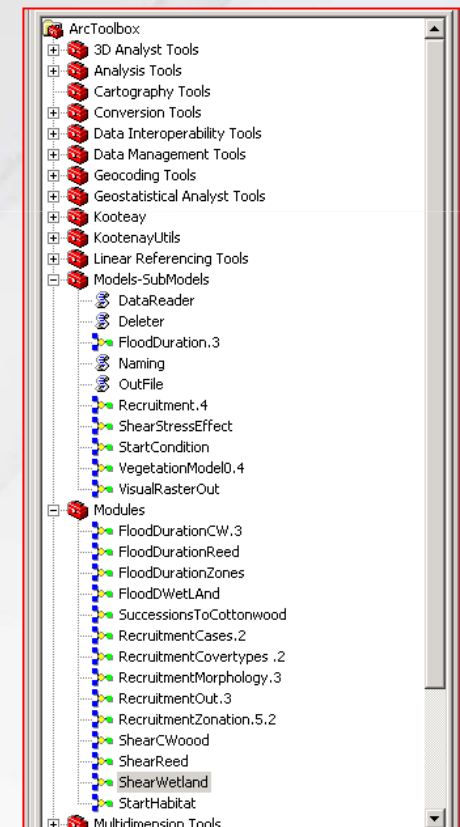


Start Condition

- Accessible from custom tbx.
- Select input grids
- Select output storage location
- Set parameters value
- Set number of iterations
- Aid user



Succession retrogression



Custom toolboxes



# Model Package

## Documentation & Help files



Documentation htm

chm Help file

Folder system

**ArcGIS**

### Model Documentation Contents

**Description**

- [Introduction](#)
- [Concept and Logic](#)
- [Architecture](#)

**System Requirements and Model Use**

- [User manual](#)

**Technical Documentation**

- [Start Condition Model](#)
- [Start Habitat](#)
- [Succession Retrogression Model](#)
- [Recruitment](#)
- [Shear Stress](#)
- [Flood Duration](#)
- [Succession](#)
- [Visualization](#)

**Appendix**

- [Consistency Table](#)
- [Database Documentation](#)

**ArcToolbox**

### VegetationModel0.4

**Author**  
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University Of Idaho, 322 E. Front street, Boise, Idaho www.uhome.uidaho.edu.

**In collaboration with:**  
Umweltbüro, Bahnhofstrasse 39, A-9020 Klagenfurt, Austria. www.umweltbuero-klagenfurt.at

**Abstract**  
VegetationModel0.4 is a dynamic model that evaluates the evolution and spatial distribution of floodplain vegetation in regard of yearly base flow level, shear stress, flood duration and morphology. Additional driving variable is the time. The model simulates the effects of these four driving forces on the vegetation community. The rules on which the model is based can be briefly described as follow: yearly base flow influences the recruitment and the scour disturbance applied to seedlings. Shear stress, when enough strong causes uprooting of the vegetation and consequent retrogression of the stands to primary stage (gravel). Flood duration causes physiological stress to the root system and, according to submersion duration, it can lead to total or partial retrogression. If no one of these disturbances is enough strong to retrogress the vegetation, time leads the stands toward mature stages, until the climax is reached. Furthermore the model verifies, at each run, whether the morphology of the study area has changed from the previous run (simulated year) morphology. It has to be underline that the model does not calculate morphology evolution. The morphology for the simulated year is provided as input, the model only recognizes the eventual change and applies to it the model rules. The model it's mainly rule based though it makes also use of parameters based on expert knowledge. Driving forces are applied in abiotic fashion: effects of each driving force are computed in sequence, synergetic effects are therefore neglected. In addition the model adopts a Boolean approach and relies on hard thresholds. The model is defined dynamic for two reasons. First the it takes different base flow, shear stress, flood duration and morphology data for each simulated year. Second the output landscape, resulting from a simulation, is output for the next model's run.

**Model Parameters**

Expression	Explanation	Data Type-Values
Counter (Required)	Number of times the model will iterate	Integer, model variable. Value: [1 -...]
Cottonwood Age Map (Required)	Cottonwood succession map (expressed in stands ages). Output from Starting Condition Map	Raster Dataset, model Input. Value: [0-111]

My Computer

Preload (C:)

- FloodplainDynamicModel
  - Database
  - Documentation
  - Dynamic Input
    - Flood\_grids
    - HBF\_grids
    - Morphology
    - Shear\_grids
  - info
  - Infotables
  - Initial\_Dataset
  - Legends
  - Outputs
  - pythons
  - SQLExpressions

- Models-submodels-modules description
- Data types
- Parameters value range-consistency
- Model use
- Folder system contents
- Database model



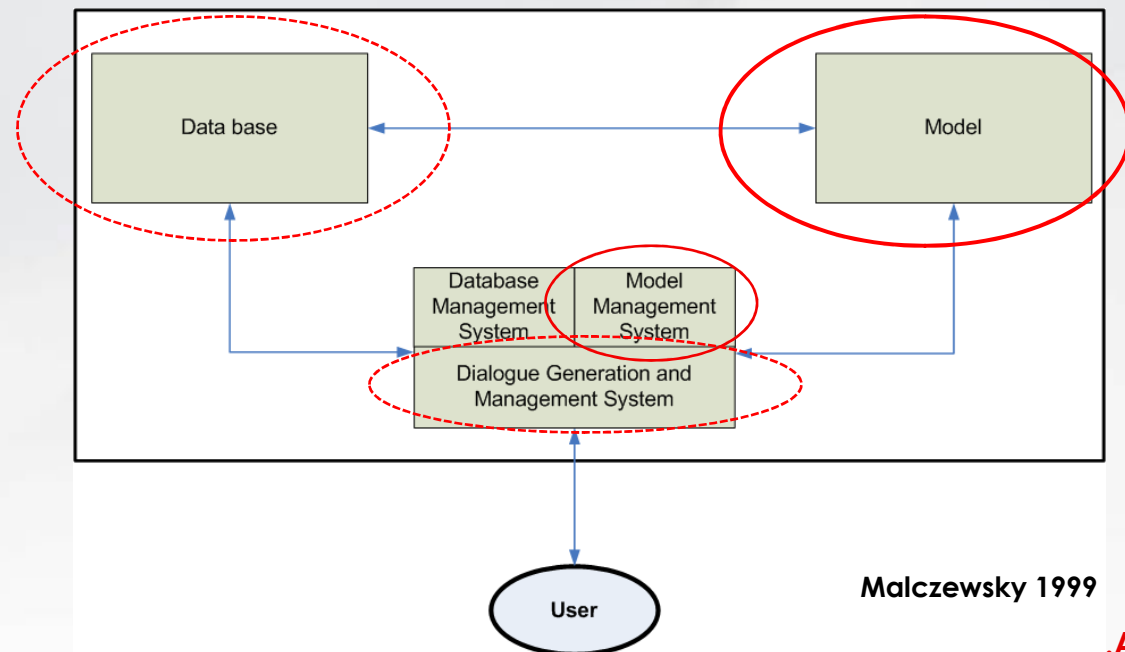
## What can be better done

- Better DBMS (RDB compliant, manage scenarios)
- Integration with hydraulic software
- Mutually excluding solutions
- Increase decision space exploration capabilities
- Shorter the time required to assess different discharges



## ...what about SDSS?

- Database, model, GUI, User
- Support for (spatial) semistructured problems
  - Explore solution space (alternatives)
  - Support different decision making styles (decision maker preferences)



Malczewsky 1999



## Where have we been?

- Ecological & cultural river ecosystem importance
- Development of dynamic, general, spatial, process based Model
- Fulfill objectives & requirements
- Maybe not a full SDSS...

**...BUT:**



# Dynamic Ecosystems Floodplain Model

- Brand new in floodplain modeling
- Valuable assessing tool
- Room for improvements



# QUESTIONS?

Thank you, have a nice day 😊

