

Modeling Ecological Population Dynamics

Ecology is the study of patterns in nature, of how those patterns came to be, how they change in space and time, why some are more fragile than others (Kingsland, Modeling Nature).

Will improved understanding and enhanced predictive capabilities lead to better ecological stewardship?

photo by Greg Bedinger/LightHawk

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Types of Models – Diverse!

Models are...	Conceptual	Biophysical	Mathematical
The model is...	A conceptual description of systems behavior	A scaled reproduction of a real system	Built by coupling of functions, rules, and equations
Elements of models are	Premises, relationships, conclusions	Physical objects	Mathematical and state variables
...with the plausibility check	Conclusions tested for well-known situations	An experiment in a well-known environment is performed	Model behavior is analyzed using different methodologies (stability and sensitivity analyses)
A simulation is...	A mental experiment	A physical measurement given a boundary condition	A numerical solution of equations of rules given initial and boundary conditions
“System” encompasses	Definition of components, interactions, and system boundaries		<i>(Jorgensen, 2011, Handbook of eco-models)</i>

Razorback Sucker Model

```

graph TD
    A[Upstream of Floodplains] -- Floods --> B[Creation and Maintenance of Gravel Bars]
    B -- Floods --> C[Razorback In Channel Larvae, Juveniles, Adults]
    C -- Spawning Gut (April-late May) --> D[Razorback Reproduction]
    D -- Spawning Gut --> E[Inundated Floodplains/Floodplain Wetlands]
    E -- Organic Matter (eg. Inverte and detritus) --> F[Nursery Areas]
    F -- Calm, warm water --> G[Backwater Pool Habitat]
    G -- Flood Recession --> H[Isolated by Low Flows (late summer-winter)]
    H -- Connected by Floods and High Flow Pulses (spring and periodic throughout year) --> I[Non-Native Predators (In Channel)]
    I -- Floods --> A
    
```

Washington University photo

% Application	2001-10
Dynamic biogeochem	30.8
Steady state biogeochem	1.8
Pop. dynamics	24.2
Spatial models	19.9
Structurally dynamic	8.2
IBMs and CA	5.9
ANN and AI	5.4
Fuzzy logic	1.8
Ecotoxicology	2.0

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...Applications and Related Tools

	<u>Level of detail</u>	<u>Uses of eco-models</u>	<u>Other Software</u>
EFM and GeoEFM	1) Statistics ↓	Water allocation NEPA assessments	IHA, HIP/HAT, HEFR, R, EcoModeller, ...
	2) Habitat ↓	River restoration Conservation plans	HEP, IFIM, MesoHABSim, CASiMiR, EDT, HSiS, ...
EFMSim	3) Populations	ESA consultations	LANDIS, SALMOD, EDYS, HexSim, ...

Week in review

Topic:	Data/Stats/Time Series Analysis	... Habitat Mapping and Functionality	... Populations
Technology:	DSSVue/IHA/EFM and EFM Plotter	... EFM and GeoEFM + RAS and RAS Mapper	... EFMSim
Easy to forget:	RPT = Software to help make alternatives ... goal setting and formulation - not analyses		

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Modeling Sequence

```

graph TD
    subgraph Layers
        P[PARCELS]
        Z[ZONING]
        T[TOPOGRAPHY]
        W[WETLANDS]
        D[DEMOGRAPHICS]
        L[LAND COVER]
        I[IMAGERY]
        R[RASTERMAP]
        TURF[TURF Image]
    end

    subgraph Sequence
        SA[Study Area] --> L[Layouts] --> D[Data] --> V[Variables] --> C[Communities] --> R[Rules] --> S[Simulation]
    end

    subgraph Map
        M[Map of river system]
    end

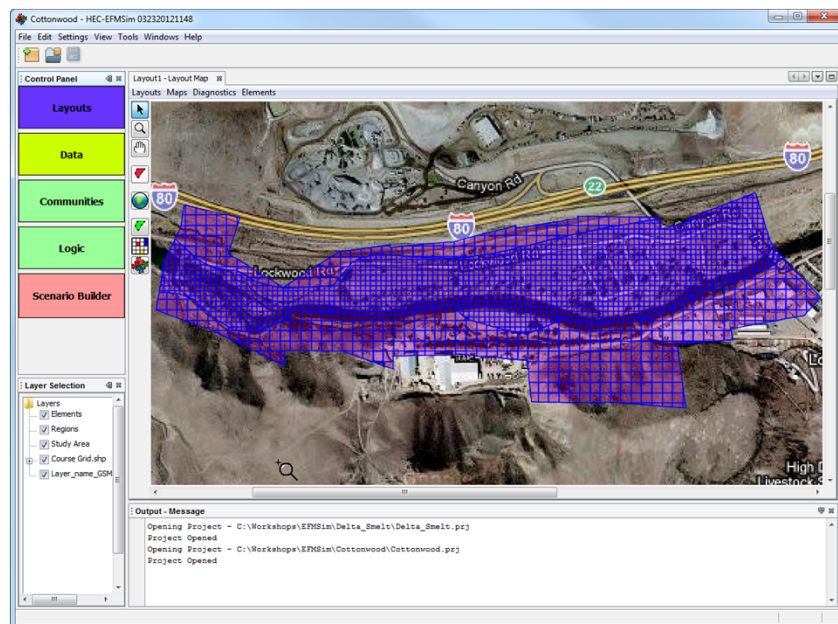
    SA --- M
    L --- M
    D --- M
    V --- M
    C --- M
    R --- M
    S --- M

    SA --- Note[These already done for today's workshop.]
    L --- Note

    S --- Note2[Animations of ecosystems...dynamic in time and space]
    
```

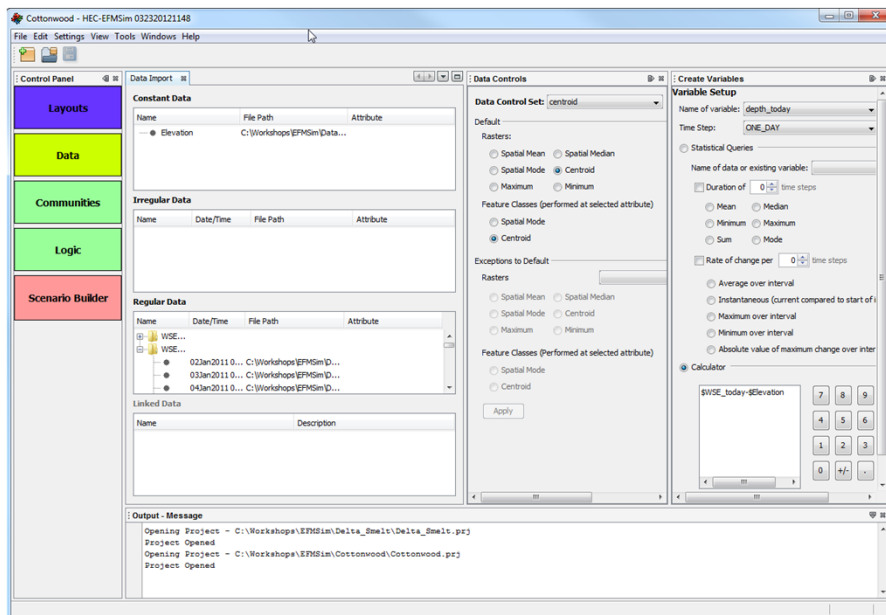
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Components (Layouts)



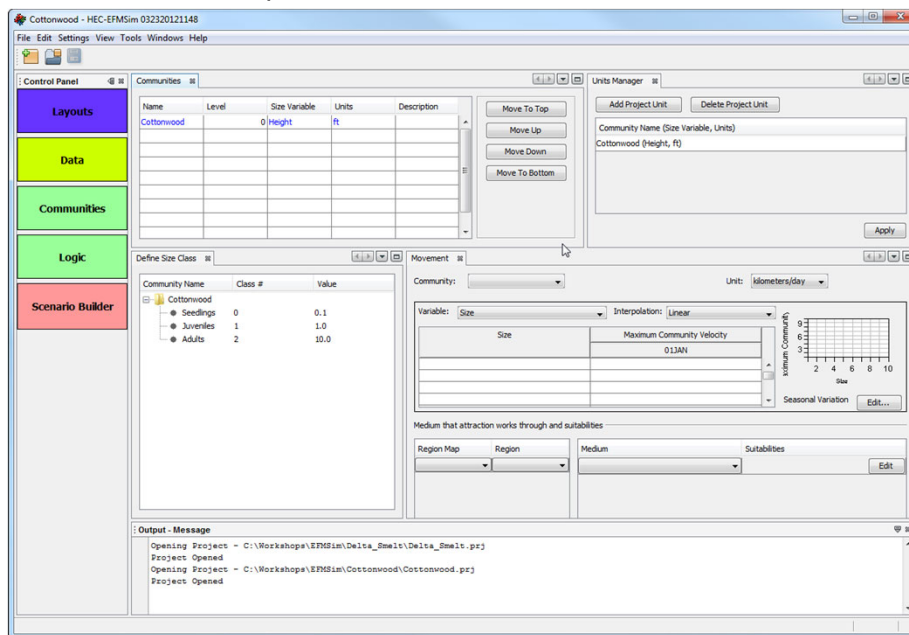
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Components (Data and Variables)



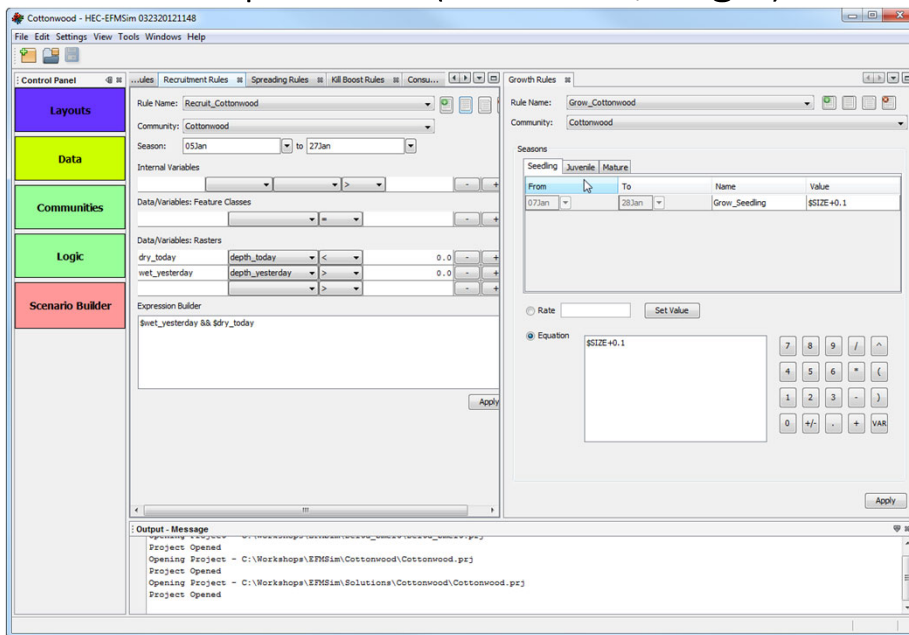
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Components (Communities)



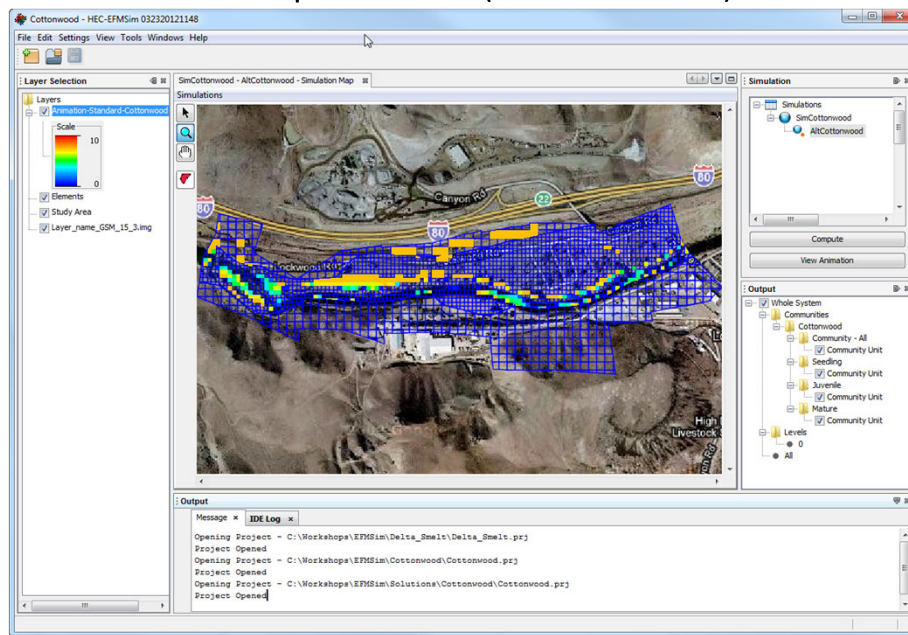
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Components (Rules...ie, Logic)



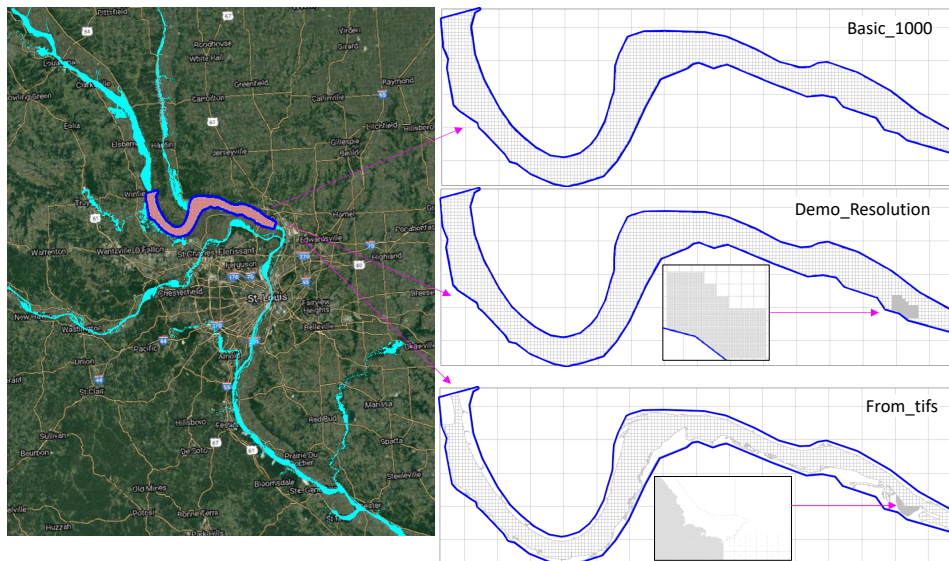
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Components (Simulation)



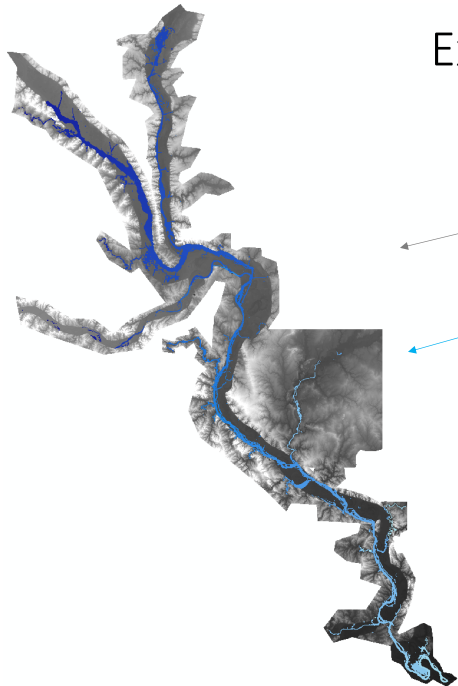
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Example - Mississippi River - Layouts



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Example - Mississippi River - Data



Terrain
2m (4.4GB)

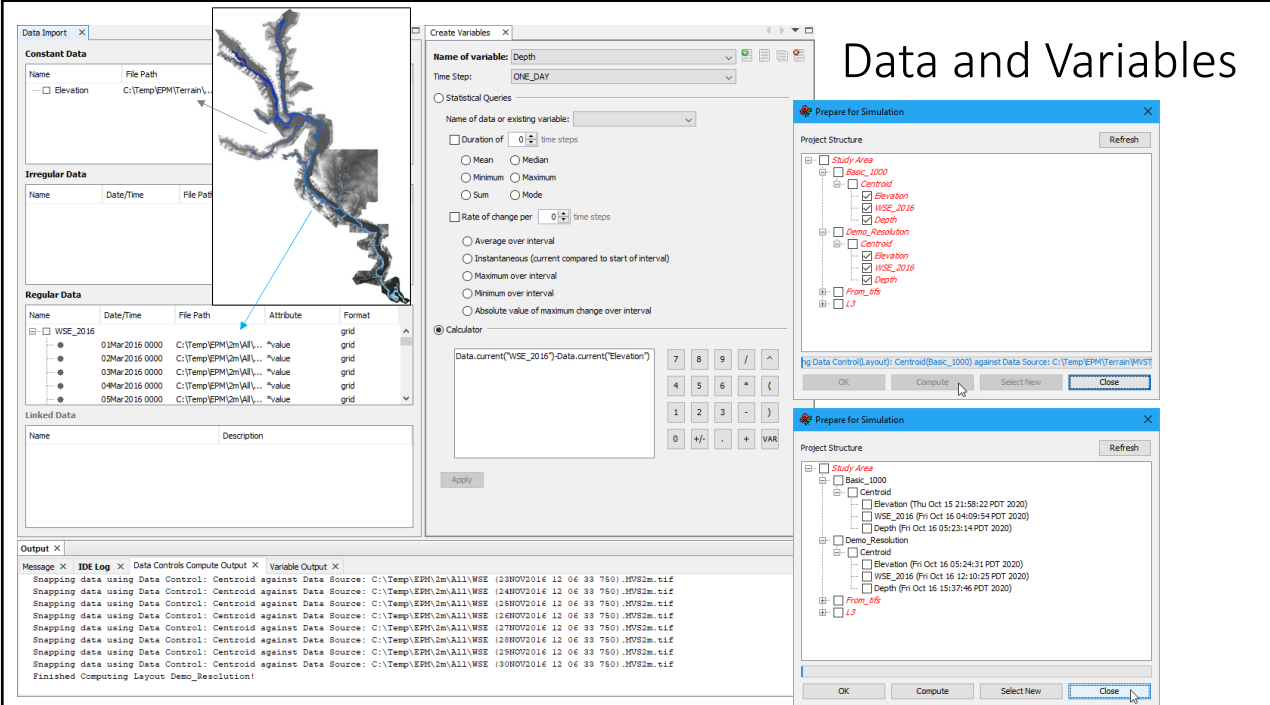
Water surface elevations (WSE)
01Mar2016 to 30Nov2016
275 days
165GB (~0.6GB/day)

2m resolution for Miss River
309M cells

01Apr2016 shown in image
(blue)

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Data and Variables



Data Import

Constant Data

Name	File Path
<input type="checkbox"/> Elevation	C:\Temp\EPM\Terrain\...

Irregular Data

Name	Date/Time	File Path
WSE_2016	01Mar2016 00:00	C:\Temp\EPM\2m\All\...value
	02Mar2016 00:00	C:\Temp\EPM\2m\All\...value
	03Mar2016 00:00	C:\Temp\EPM\2m\All\...value
	04Mar2016 00:00	C:\Temp\EPM\2m\All\...value
	05Mar2016 00:00	C:\Temp\EPM\2m\All\...value

Regular Data

Name	Date/Time	File Path	Attribute	Format
WSE_2016	01Mar2016 00:00	C:\Temp\EPM\2m\All\...value	grid	grid
	02Mar2016 00:00	C:\Temp\EPM\2m\All\...value	grid	grid
	03Mar2016 00:00	C:\Temp\EPM\2m\All\...value	grid	grid
	04Mar2016 00:00	C:\Temp\EPM\2m\All\...value	grid	grid
	05Mar2016 00:00	C:\Temp\EPM\2m\All\...value	grid	grid

Linked Data

Name	Description

Create Variables

Name of variable: Depth

Time Step: ONE_DAY

Statistical Queries

Name of data or existing variable:

Duration of 0.5 time steps

Mean Median

Minimum Maximum

Sum Mode

Rate of change per 0.5 time steps

Average over interval

Instantaneous (current compared to start of interval)

Maximum over interval

Minimum over interval

Absolute value of maximum change over interval

Calculator

Data: current("WSE_2016")-Data:current("Elevation")

Apply

Prepare for Simulation

Project Structure

- Study Area
 - Basic_1000
 - Centroid
 - Elevation
 - WSE_2016
 - Depth
 - Demo_Resolution
 - Centroid
 - Elevation
 - WSE_2016
 - Depth
 - From_016
 - L3

Data Control [Layout]: Centroid\$Basic_1000 against Data Source: C:\Temp\EPM\Terrain\WSE

OK Compute Select New Close

Prepare for Simulation

Project Structure

- Study Area
 - Basic_1000
 - Centroid
 - Elevation (Thu Oct 15 21:58:22 PDT 2020)
 - WSE_2016 (Fri Oct 16 04:09:54 PDT 2020)
 - Depth (Fri Oct 16 05:23:14 PDT 2020)
 - Demo_Resolution
 - Centroid
 - Elevation (Fri Oct 16 05:24:31 PDT 2020)
 - WSE_2016 (Fri Oct 16 12:10:25 PDT 2020)
 - Depth (Fri Oct 16 15:37:46 PDT 2020)
 - From_016
 - L3

OK Compute Select New Close

Output

Message X IDE Log X Data Controls Compute Output X Variable Output X

Snapping data using Data Control: Centroid against Data Source: C:\Temp\EPM\2m\All\WSE (138092016 12 06 33 750).MYS2m.tif

Snapping data using Data Control: Centroid against Data Source: C:\Temp\EPM\2m\All\WSE (148092016 12 06 33 750).MYS2m.tif

Snapping data using Data Control: Centroid against Data Source: C:\Temp\EPM\2m\All\WSE (158092016 12 06 33 750).MYS2m.tif

Snapping data using Data Control: Centroid against Data Source: C:\Temp\EPM\2m\All\WSE (168092016 12 06 33 750).MYS2m.tif

Snapping data using Data Control: Centroid against Data Source: C:\Temp\EPM\2m\All\WSE (178092016 12 06 33 750).MYS2m.tif

Snapping data using Data Control: Centroid against Data Source: C:\Temp\EPM\2m\All\WSE (188092016 12 06 33 750).MYS2m.tif

Snapping data using Data Control: Centroid against Data Source: C:\Temp\EPM\2m\All\WSE (198092016 12 06 33 750).MYS2m.tif

Finished Computing Layout Demo_Resolution!

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Communities and Logic (Ecology)

Arrowhead (*Sagittaria* spp.)
 Yellow nutsedge (*Cyperus esculentus*)
 Walter's millet (*Echinochloa walteri*)
 Nodding smartweed (*Polygonum lapathifolium*)

...plus Mallards, Geese, Swans

**Recruit and grow, 01Apr - 30Sep
 **Recruit on newly exposed or shallow (< 3") areas

Different grow rates
 Different max size

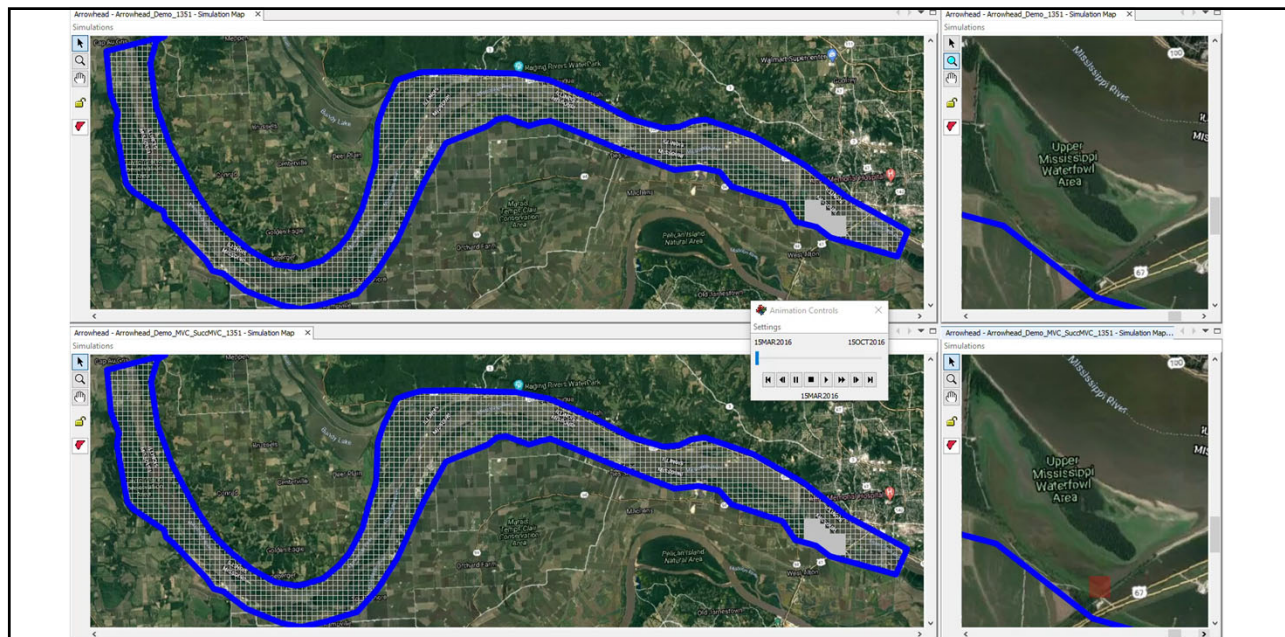
**Lost if overtopped

Name	Level	Size Variable	Size Units	Description
Arrowhead	0	height	feet	perennials
Nutsedge	0	height	feet	perennials
Millet	0	height	feet	annuals
Smartweed	0	height	feet	annuals

Community Name	Size Class Index	Size Class Lower Limit
Arrowhead		
● Juvenile	0	0.25
● Adult	1	3.0
● Mature	2	3.75
● Max	3	4.0
Nutsedge		
Millet		
Smartweed		



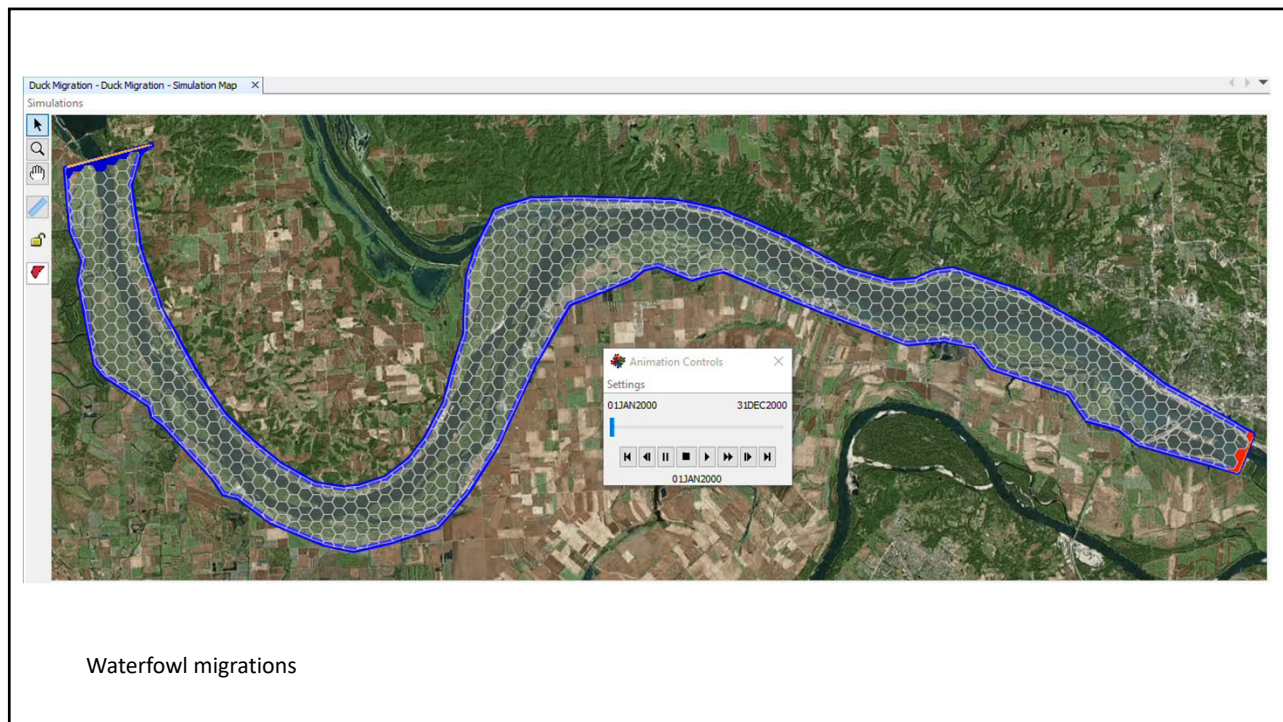
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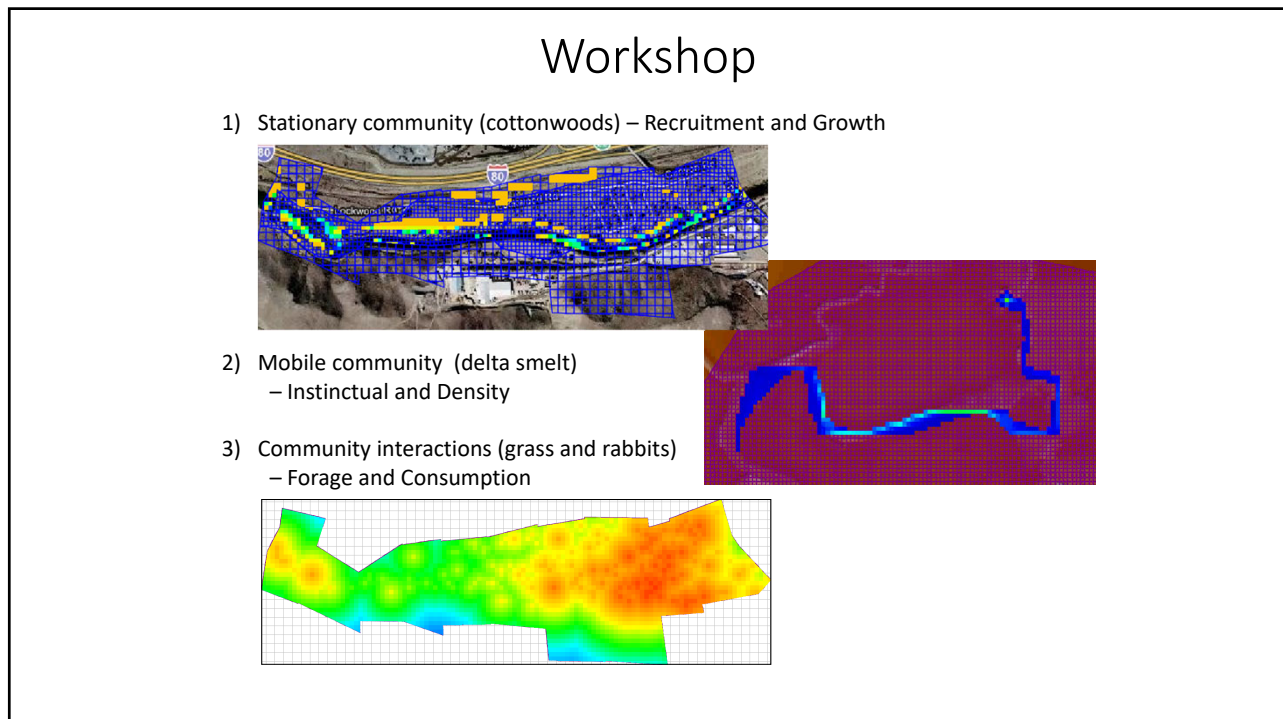
Top windows: Arrowhead – Recruitment (newly shallow or exposed soil) and growth (constant per size class)

Bottom windows: Arrowhead – Recruitment, growth, and overtopping (stage > size triggers succession)

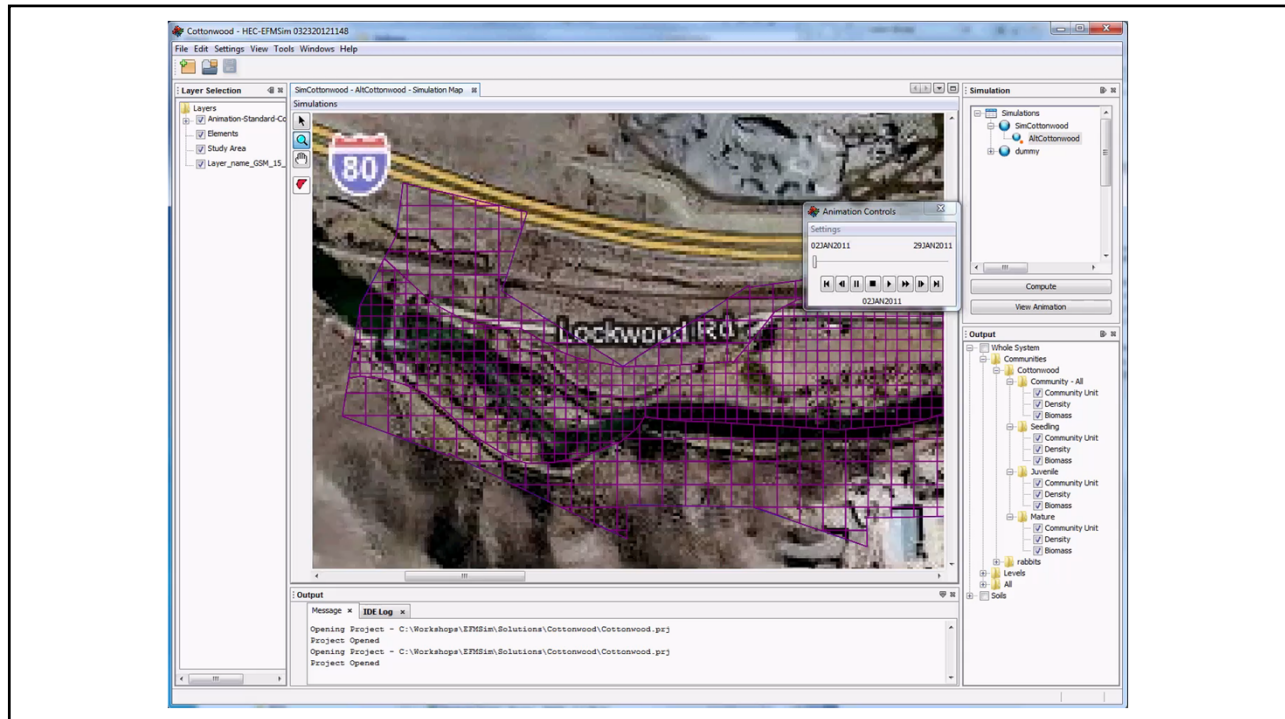
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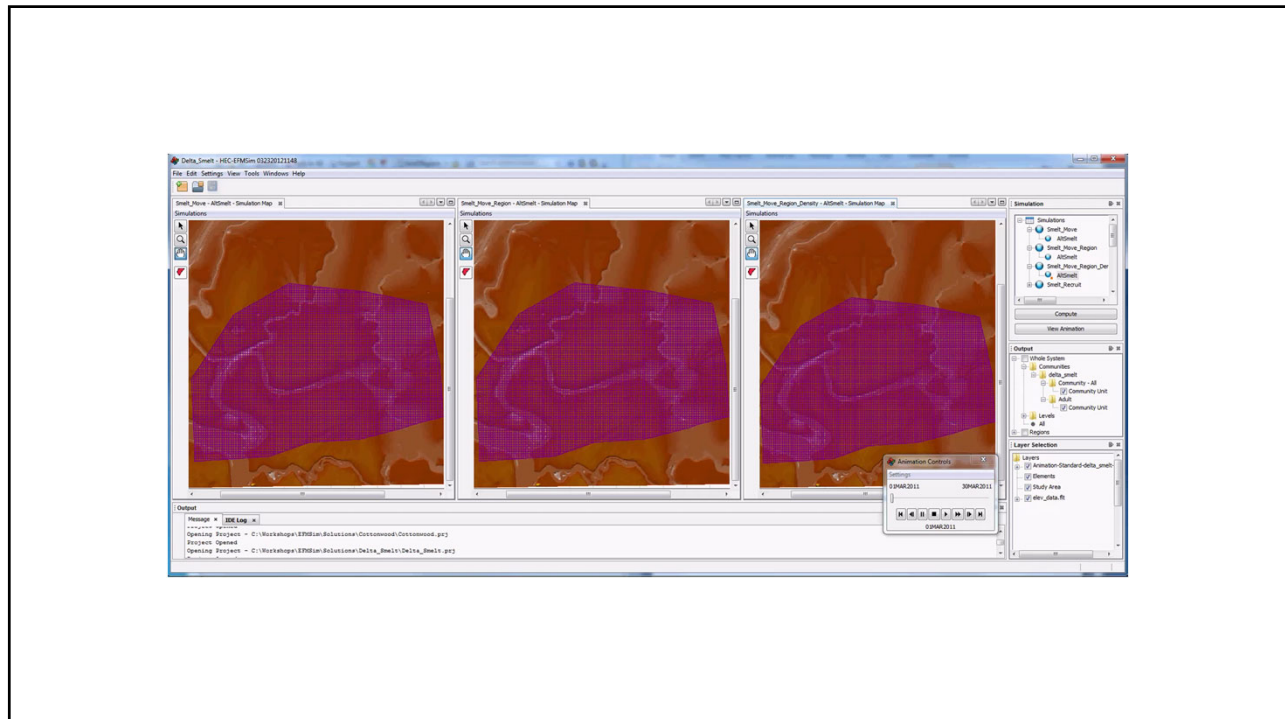
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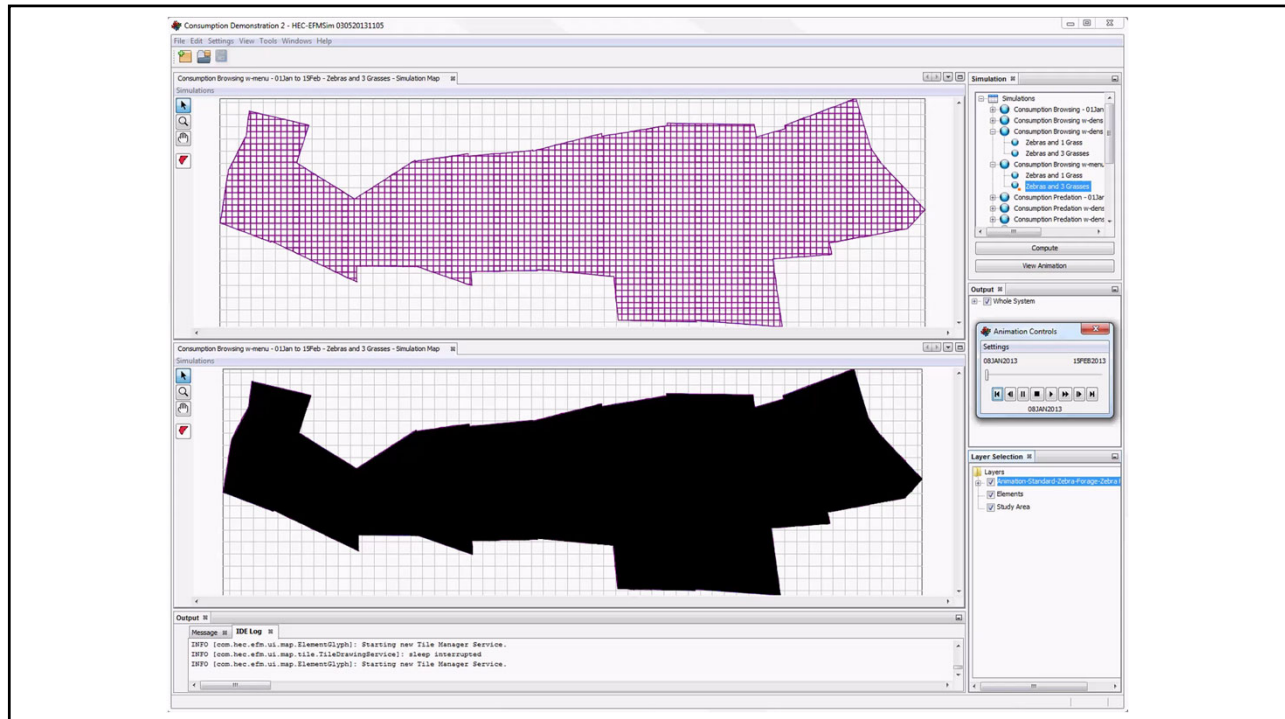
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