Guided Ecological Simulation for Artistic Editing of Plant Distributions in Natural Scenes

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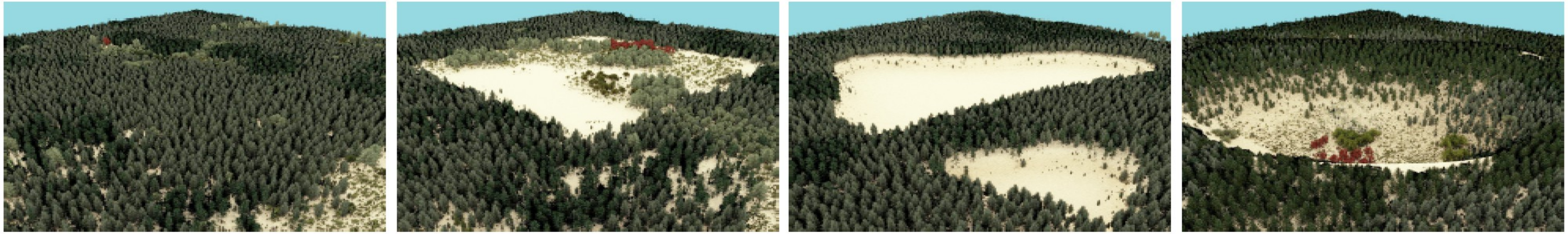
- Commercial tools for virtual landscapes
- Benefits and shortfalls
- Improvements and contributions
- Results

Guided Ecological Simulation for Artistic Editing of Plant Distributions in Natural Scenes

Ecological modelling provides a basis for realistic vegetation cover, drawing on research in biology

Editing these models in a realistic way is a challenge but can be overcome by involving the artist in the simulation



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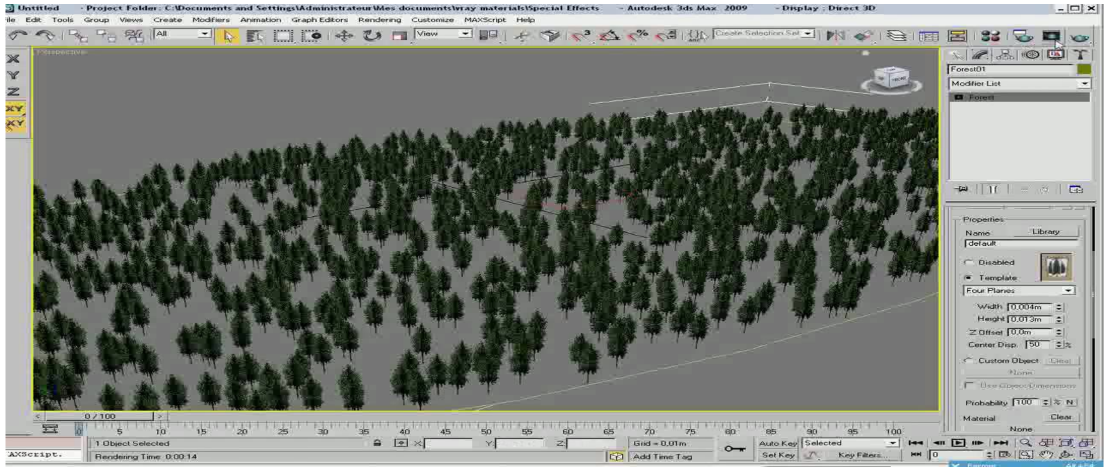
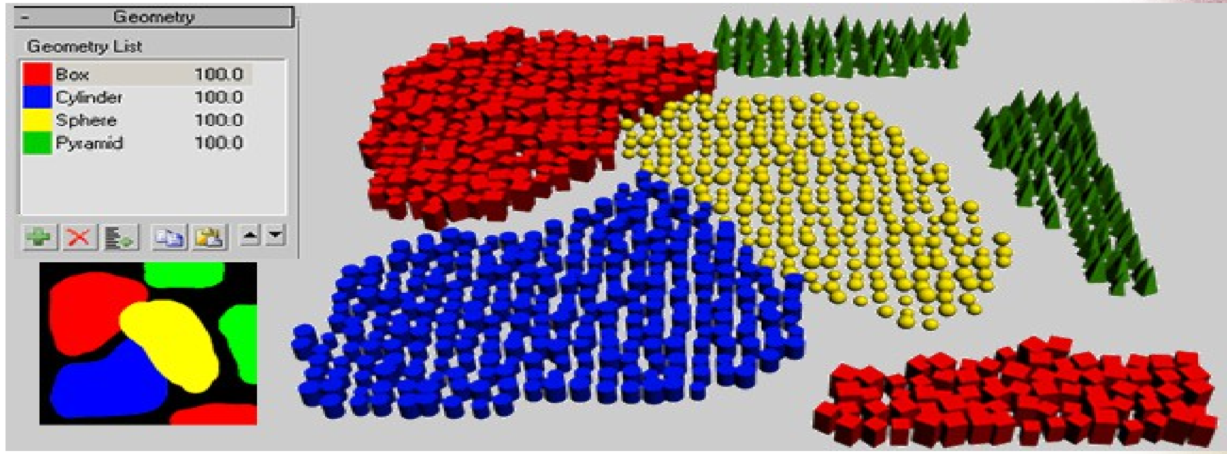
Commercial tools

Commercial content generation tools

- **(Multi-class) random placement**
  - **brush-based or area scatter**





- Procedural placement (simulation) according to certain terrain-based rules

- Good model variety

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Commercial content generation tools

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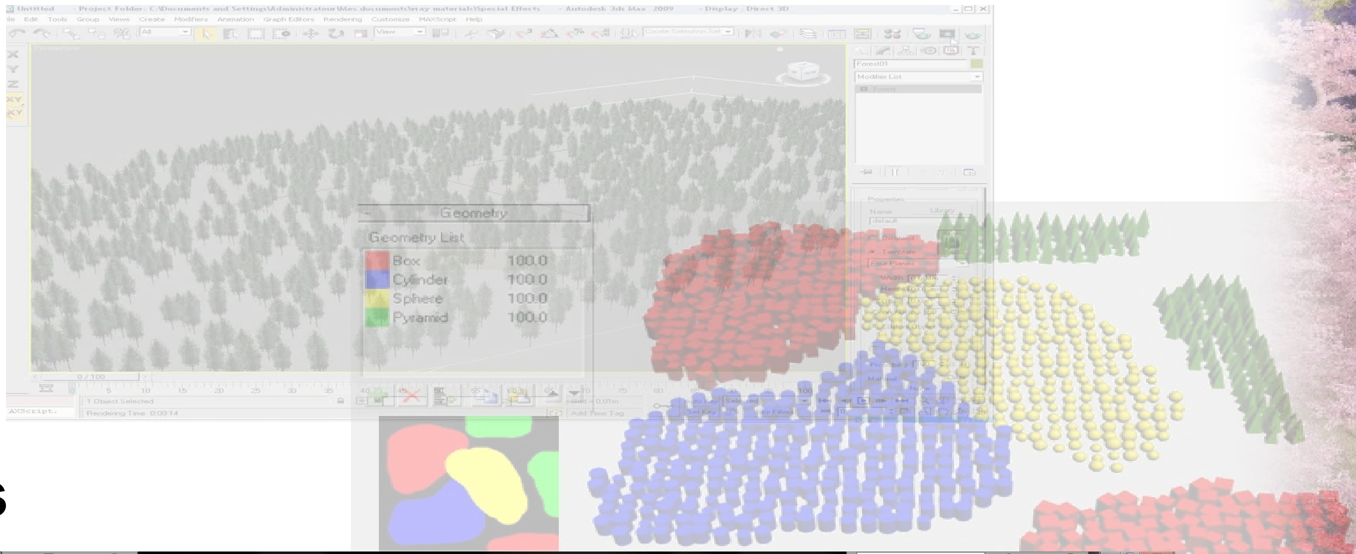

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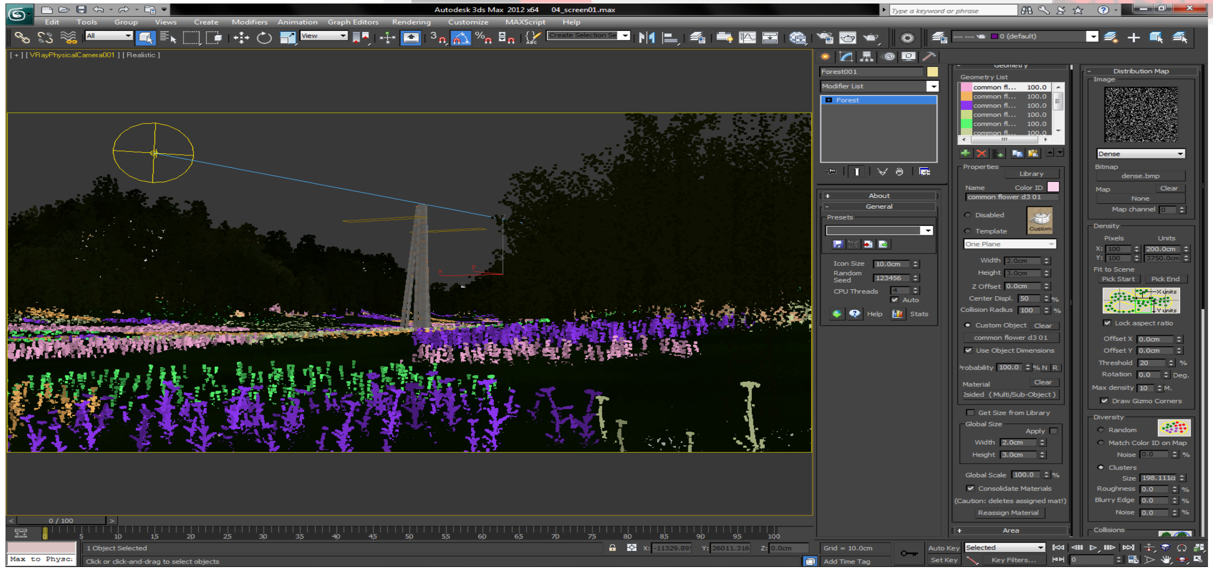

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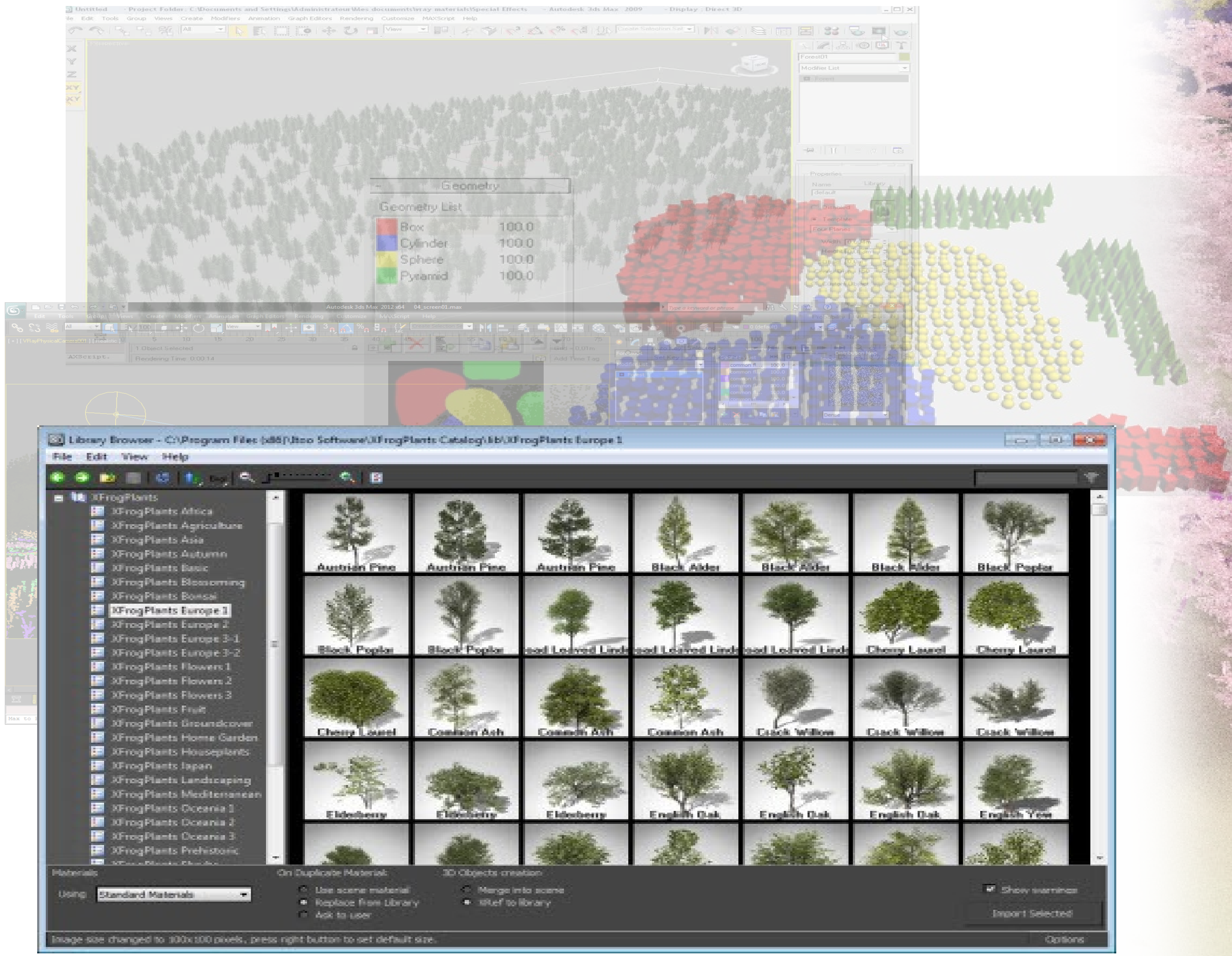

Advantages

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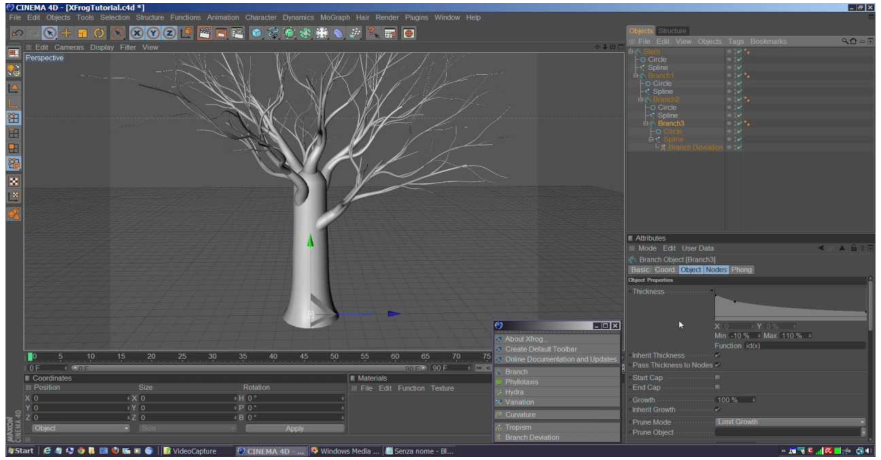

XFrog

iToo

- **Fine-grain control of model appearance and location**
- High level of automation from procedural and random approaches
- Potentially faster workflow

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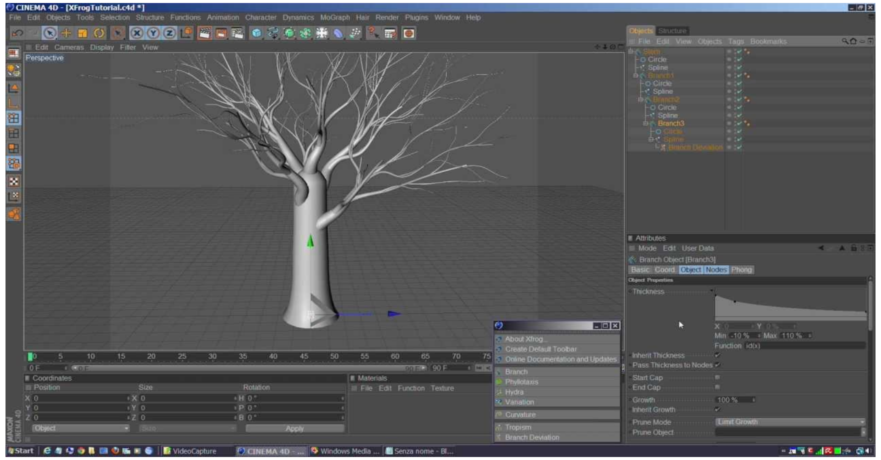

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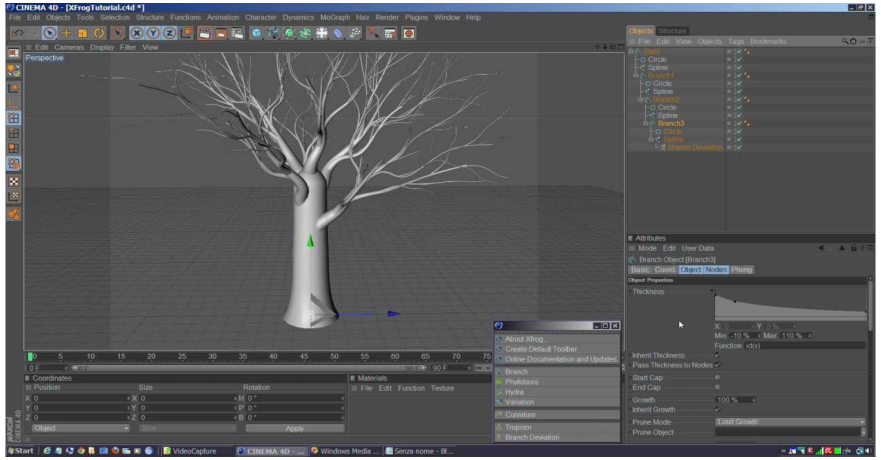

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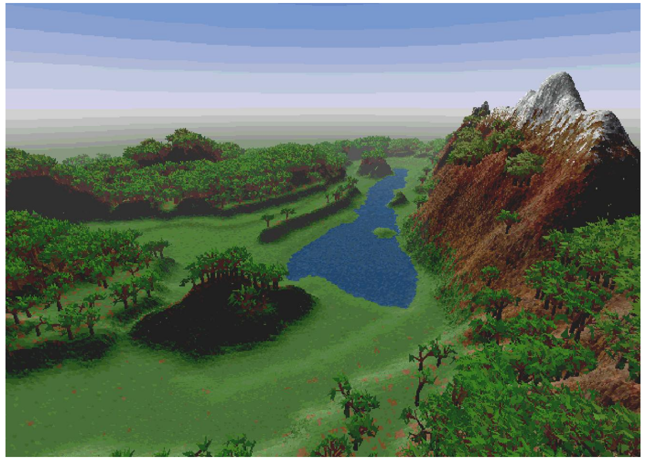
Disadvantages

Shortfalls



- **Don't result in truly natural-feeling scenes (repetitive, lack organic-ness and lack variety)**
- Unintuitive control of edits (link between parameters/result is unclear)
- Lack editing based on natural parameters and phenomena (arguably more intuitive)

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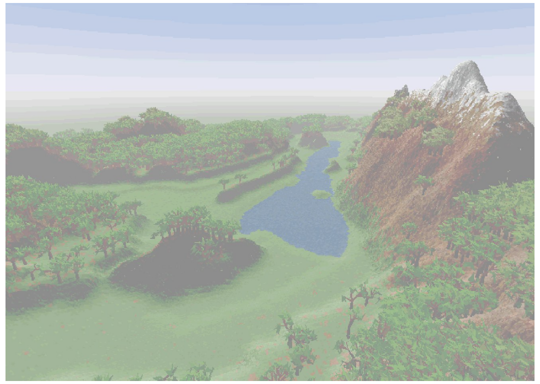

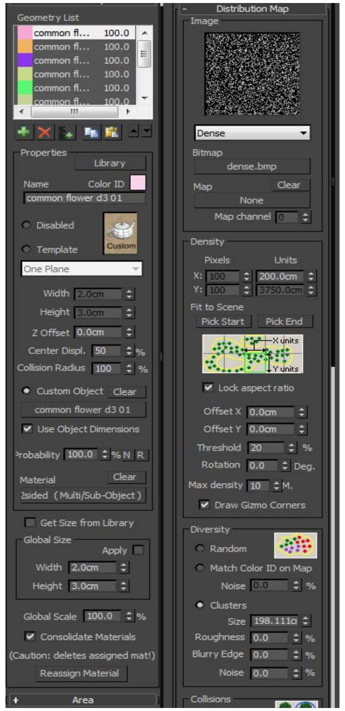

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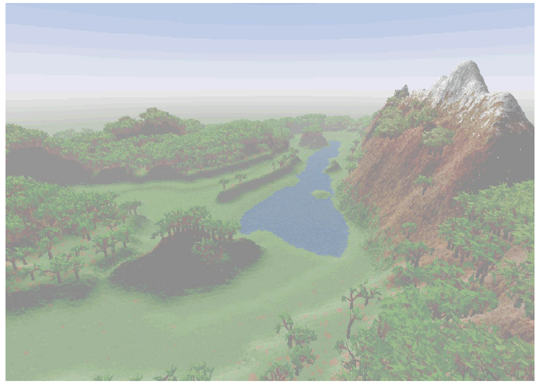

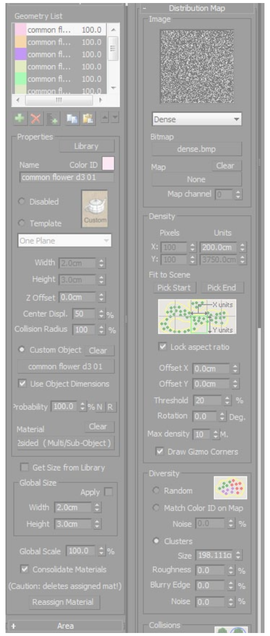

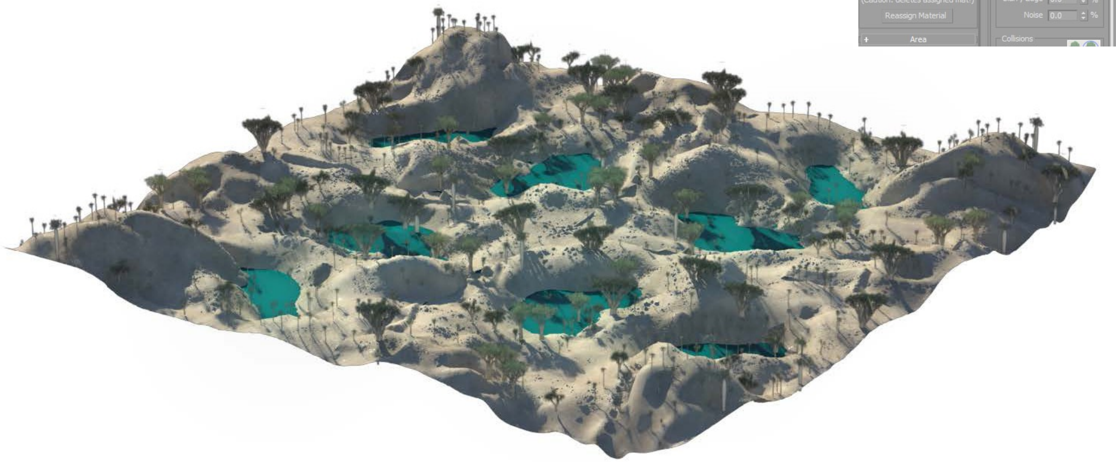

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State of the art: summary

Tools fall into two main categories:

- Scattering brush/area solutions do exist but **lack realism**
- Simulations also exist, but are hard to control and **harder to modify realistically**

Our aims:

- **A better trade-off between usability and realism**
- A locally controllable / editable system that allows selective control of the underlying simulation
- Result: simulation 'fixes' unrealistic changes

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Example – adding a feature

- **Clearing/lake:**

  artist doesn't have to think about brush strokes appearing at transition regions any more

- Mountain ranges:

  species adaptation to the altitude

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Challenges

Designing tools which mimic natural phenomena is non-trivial

Furthermore, they must also maintain the simulation's realism, even after heavy editing

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Contribution

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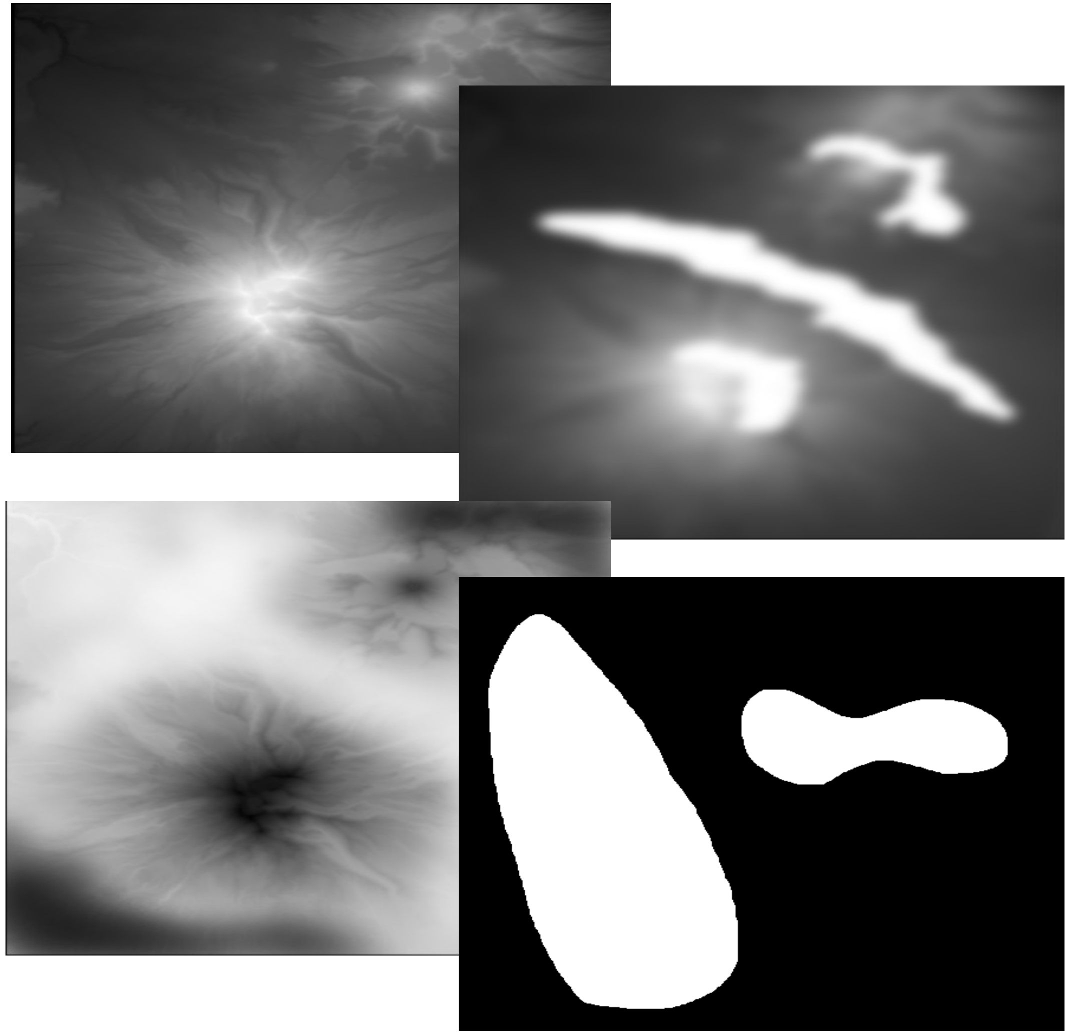
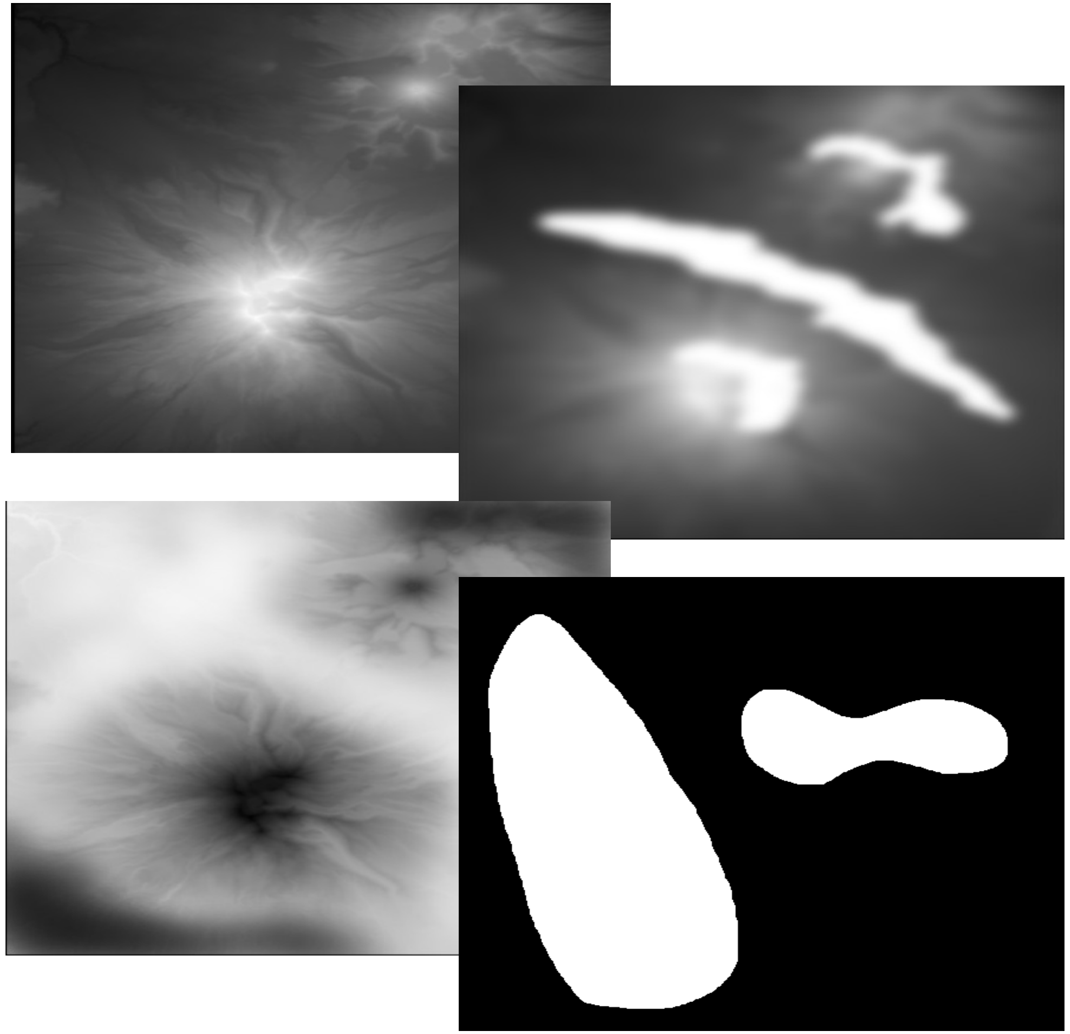


- **Combine ecosystem simulation with editing operations (global and local)**
- Iterative artistic control
- Intuitive parameters for natural scenes: editable maps (elevation, rainfall, soil, masking)
- Editing maintains realism of the initial simulation

Contributions



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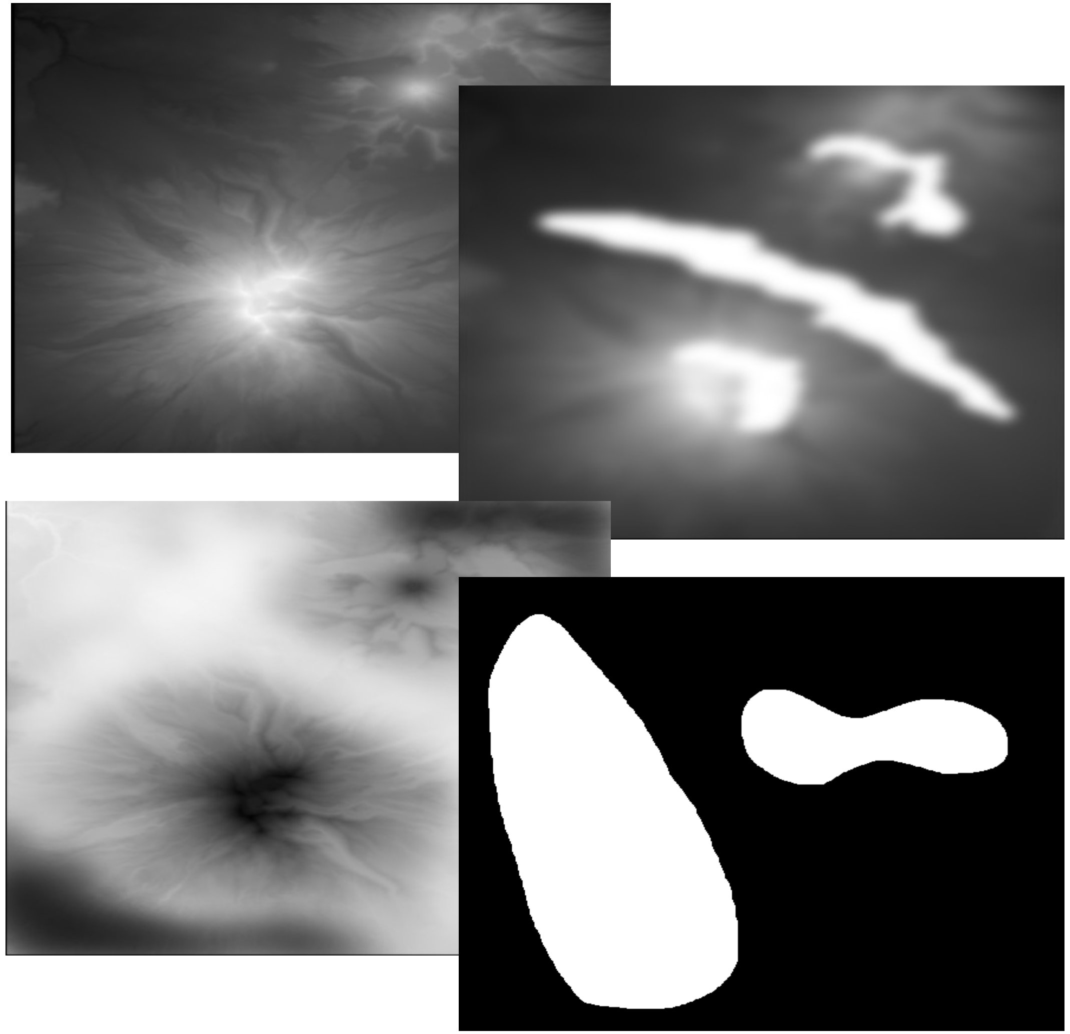

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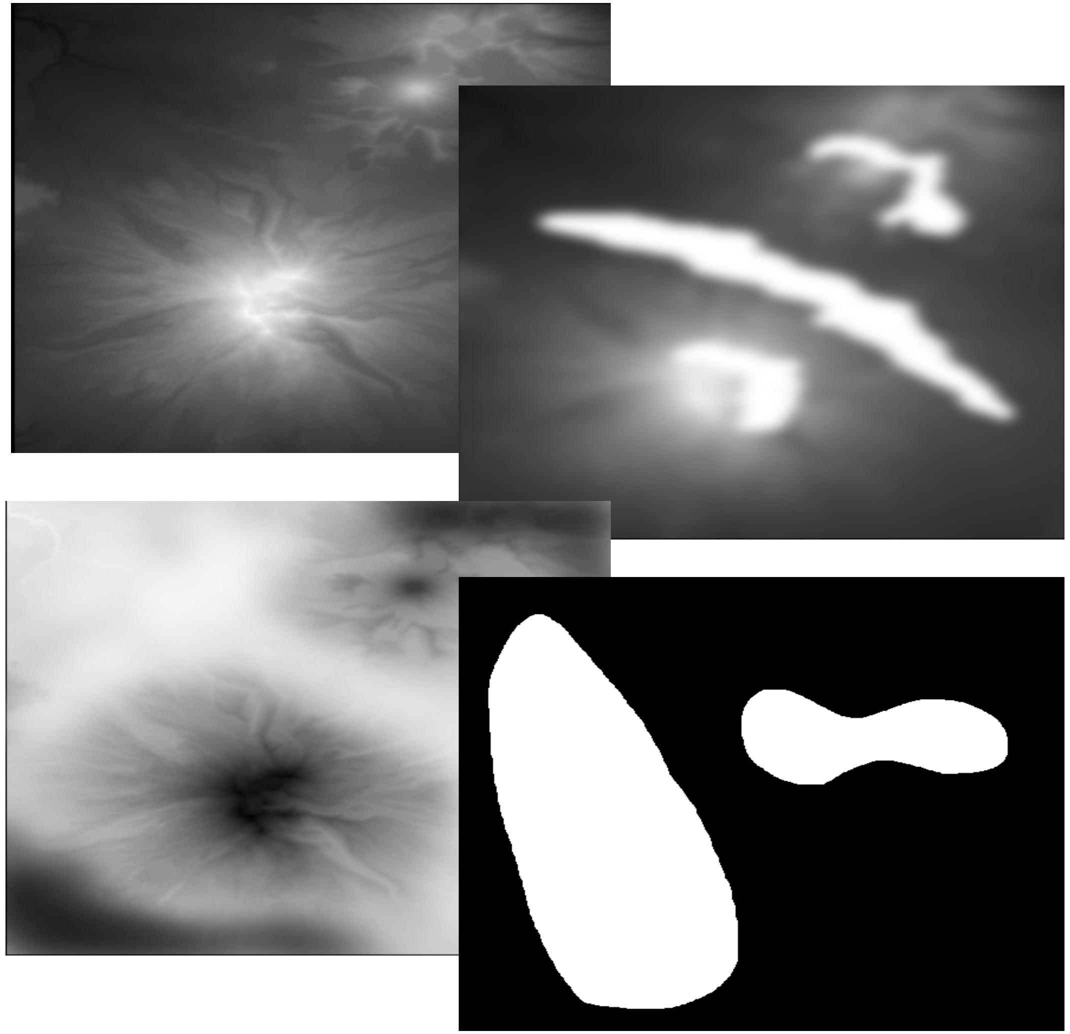

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Method

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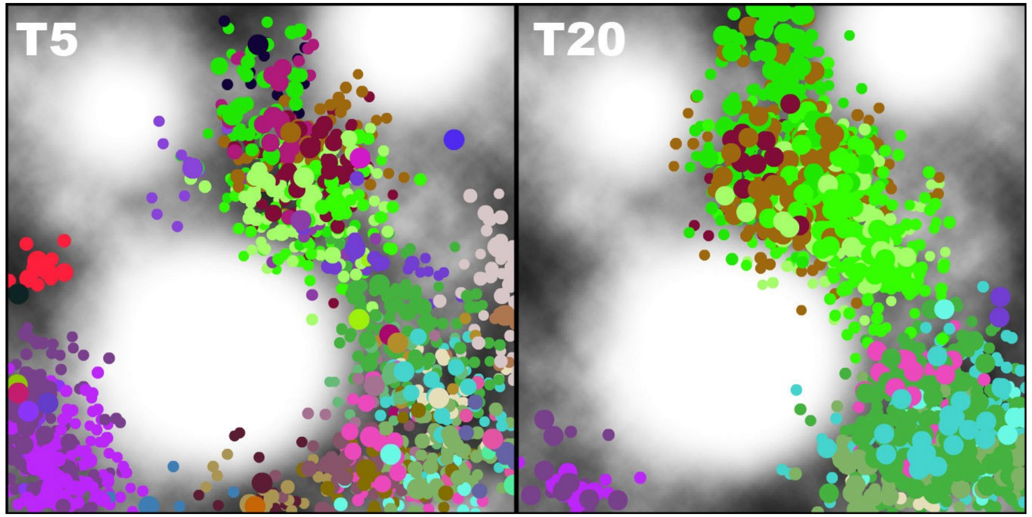
- **Draw on the state of the art in ecosystem simulation**
- Expose the simulation's time axis
- Develop means of artist interaction



Ch'ng 2009

Method

- **Draw on the state of the art in ecosystem simulation**

We use abiotic landscape maps to control a forest simulation using simplified rules found in nature:

- Large species phenotype bank
  (max. height / canopy size / age / seeding, adaptation / tolerance parameters to maps)
- Competition for, and adaptation to, resources (light, soil, water)
- Output: instance genotype (height, canopy size)
- Follows the landscape stability principle (resistance to change)

$$\boxed{Phenotype = F(environment, neighbours, genotype)}$$

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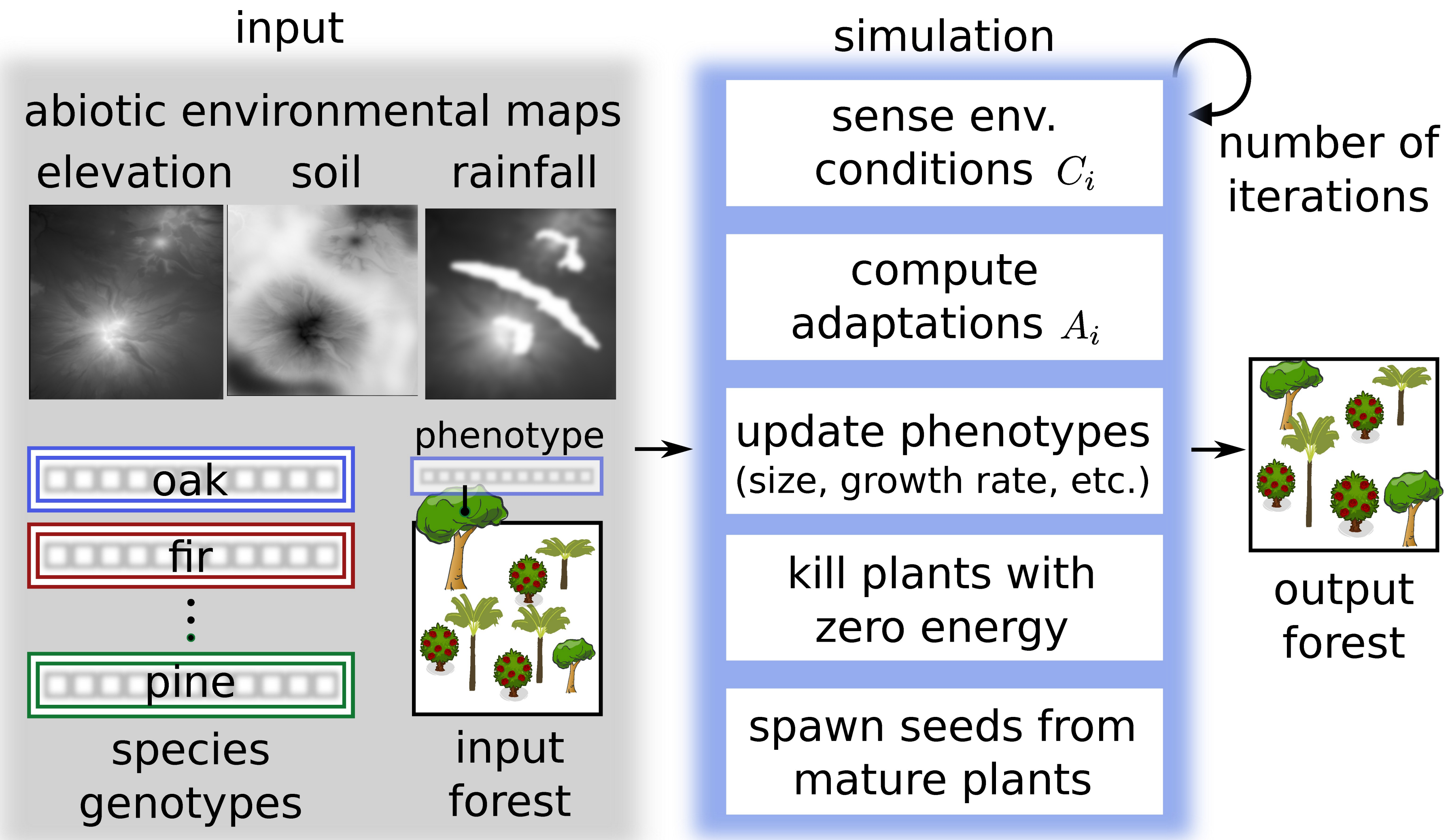
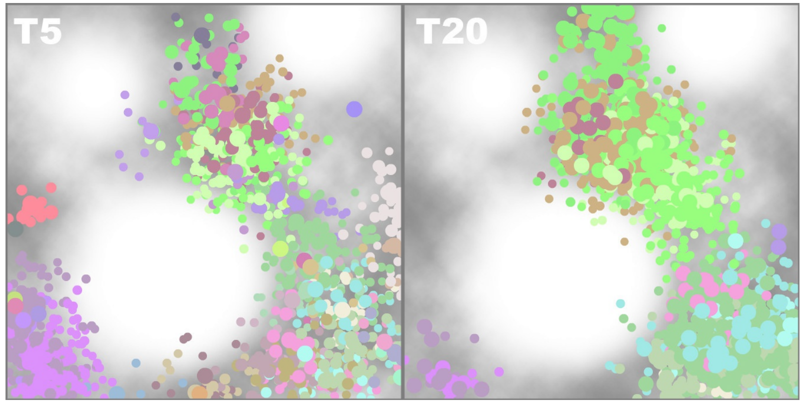
Method



a) Ecologically-based simulator for plant distributions

Method



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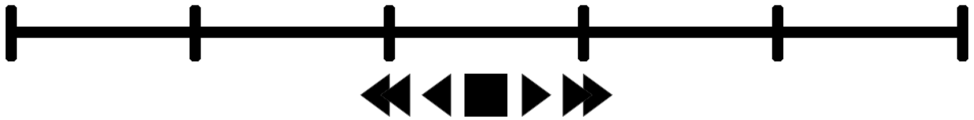

- Develop means of artist interaction

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Method

- **Expose the simulation's time axis**

Allow navigation in temporal dimension:

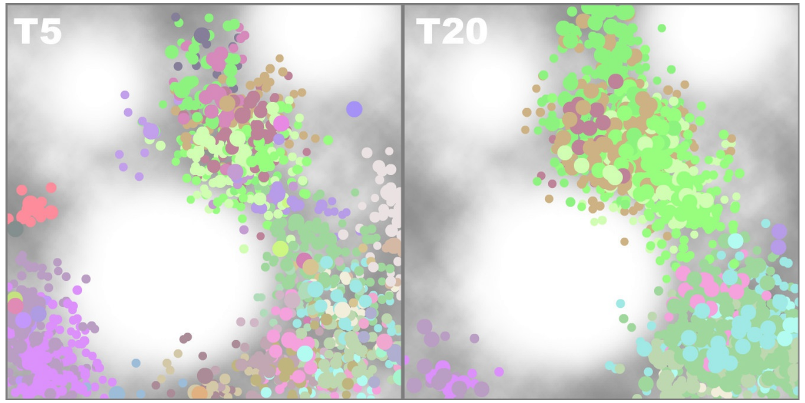
- Rewind, fast-forward, undo, redo

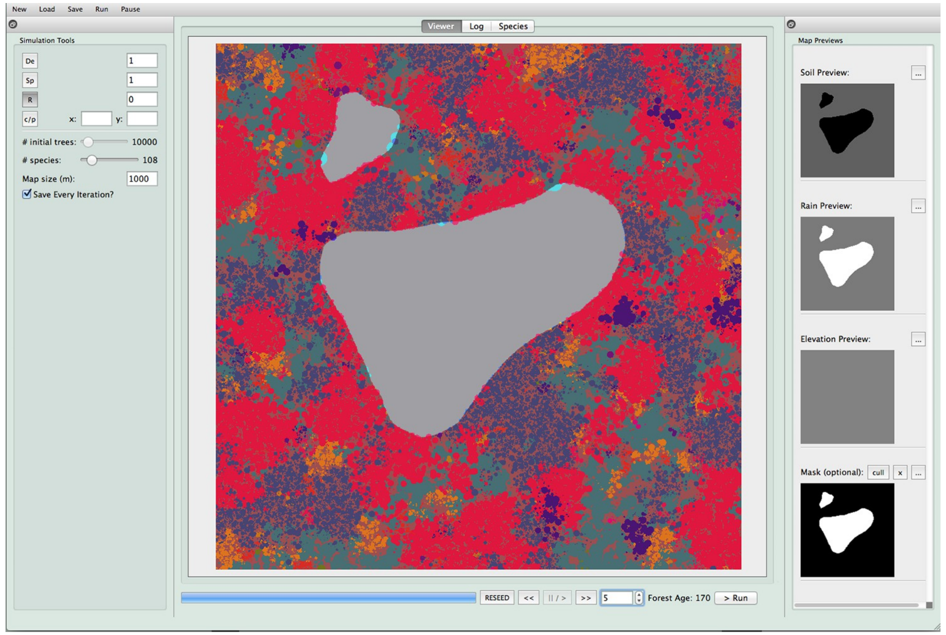
Allow operations to control the rate of simulation in a region

- Adaptive edits

Method

- Draw on the state of the art in ecosystem simulation
- Expose the simulation's time axis
- **Develop means of artist interaction**





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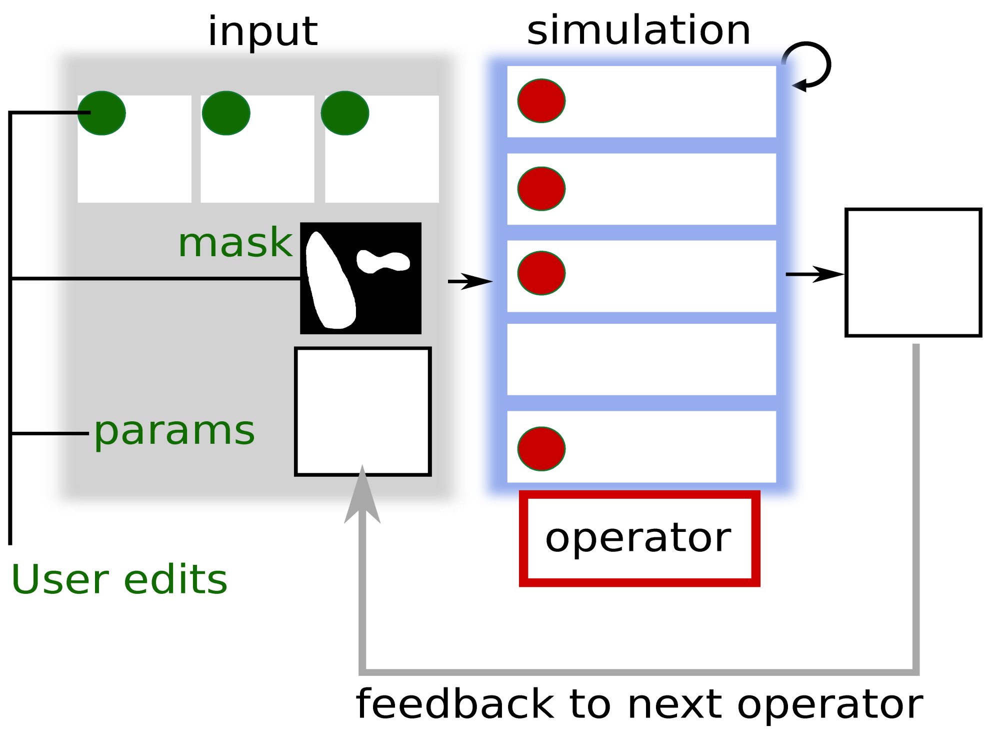

b) We introduce operators for guided editing

- **Develop novel means of artist interaction**

  - Brush-based sparsification/densification operations rerun simulation according to new constraints

  - Temporal feathering of the simulation

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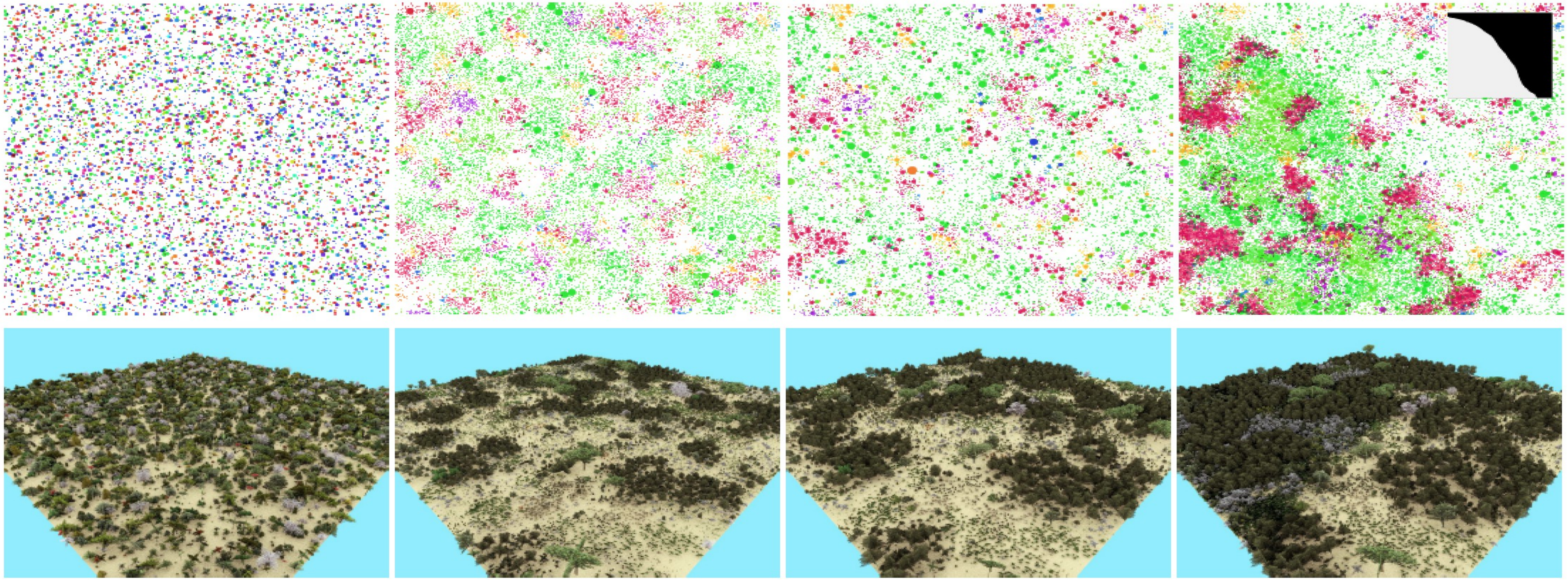
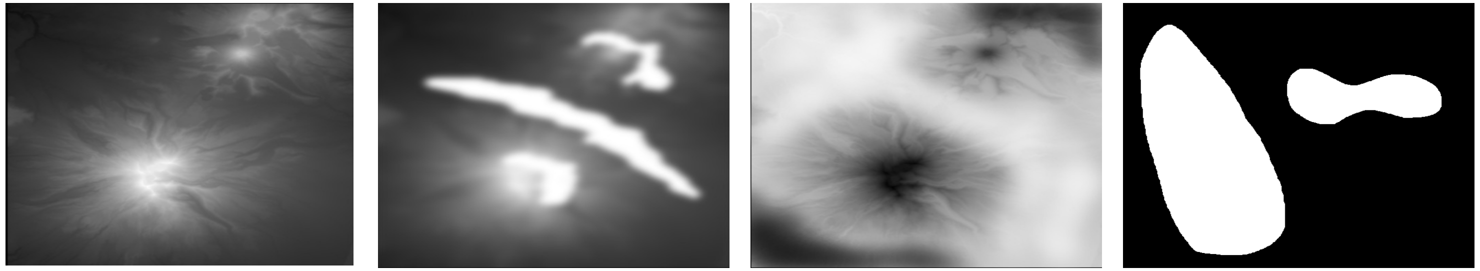
Results

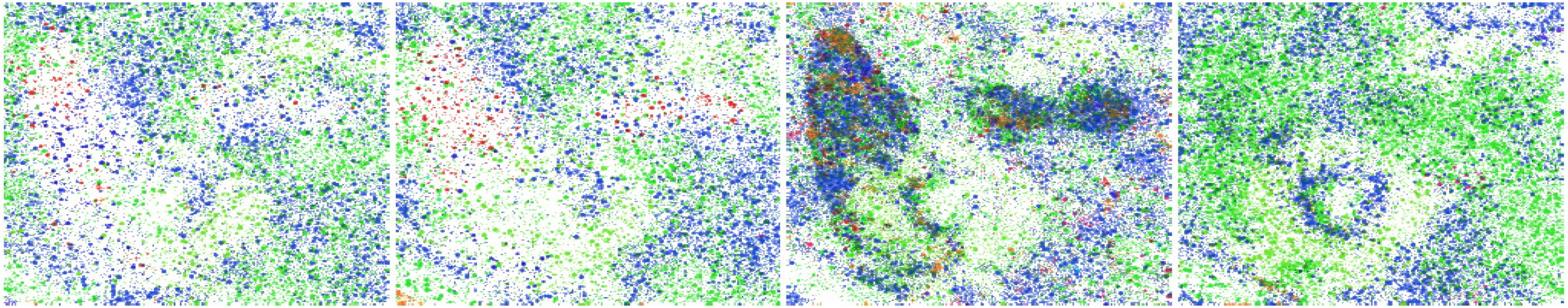
Densify operator



Initial state, burn-in (120 years), adaptation to new abiotic maps (increase precipitation), densify NE side. Rendered from NW.

Sparsify and feathering operators

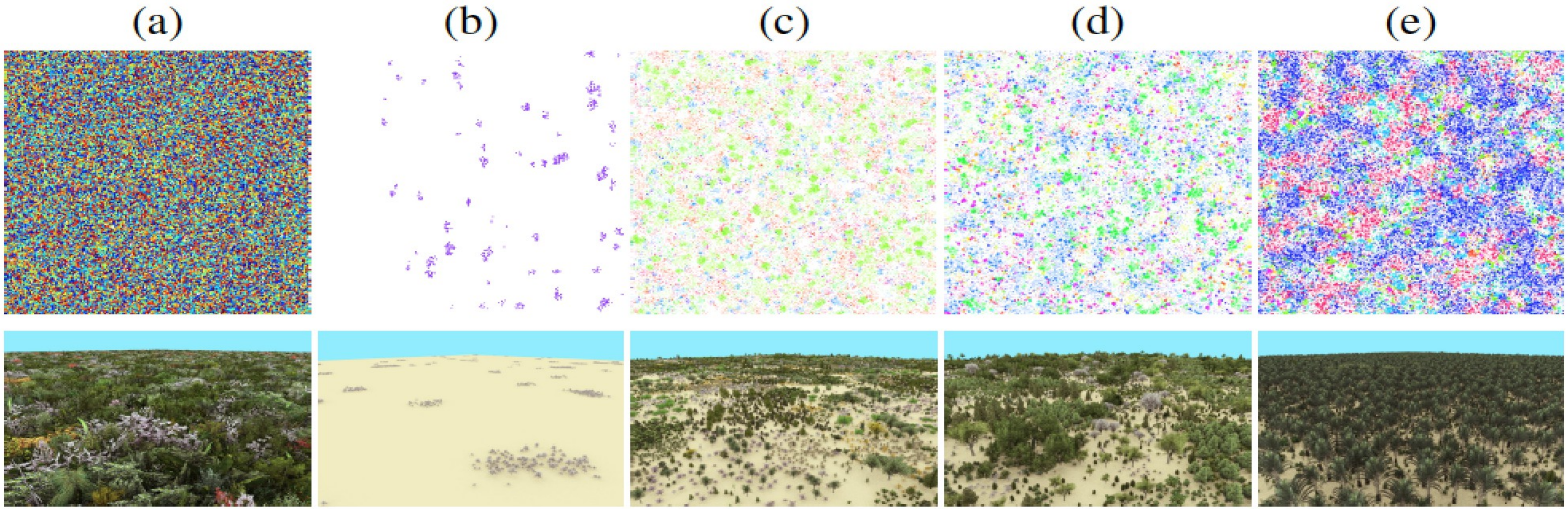




Given a simulation using the earlier abiotics and mask:

(a) sparsification, (b) feathering (c) densification (d) feathering

Creating pre-defined environments



(a) Random initialisation, (b) desert, (c) boreal forest, (d) temperate, (e) tropical.

Simulation and Editing

Limitations and future work

- Large data footprint
- Still a time-consuming task and lacks efficiency
  - but scales linearly doesn't yet exploit GPU
- Interaction rate:
  - 400K trees per second, Intel Core i7 (1.6GHz) with 16GB RAM

- Apply concepts to clutter generation
- Investigate using instances vs clusters

Summary

- We achieve a better trade-off between realism and editability

- Interactive and realistic editing of simulations
  - Artist remains in the loop and edits are ecologically supported
  - Iterative editing towards desired result

- Scales linearly with number of instances – local simulation only

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