

Synthetic Silviculture: MultiScale Modeling of Plant Ecosystem

Makowski et al, 2019

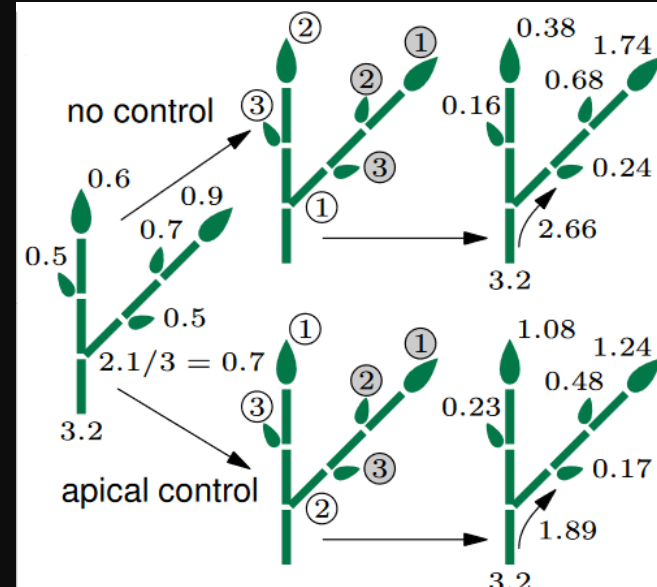
Groupe de Lecture - 28 /
02 / 2024



Previous Methods

Simulating growth

- Pros:
 - Detailed tree model
 - Adapts to the environment
- Cons:
 - Only feasible for small ecosystems
- Output:
 - Tree model



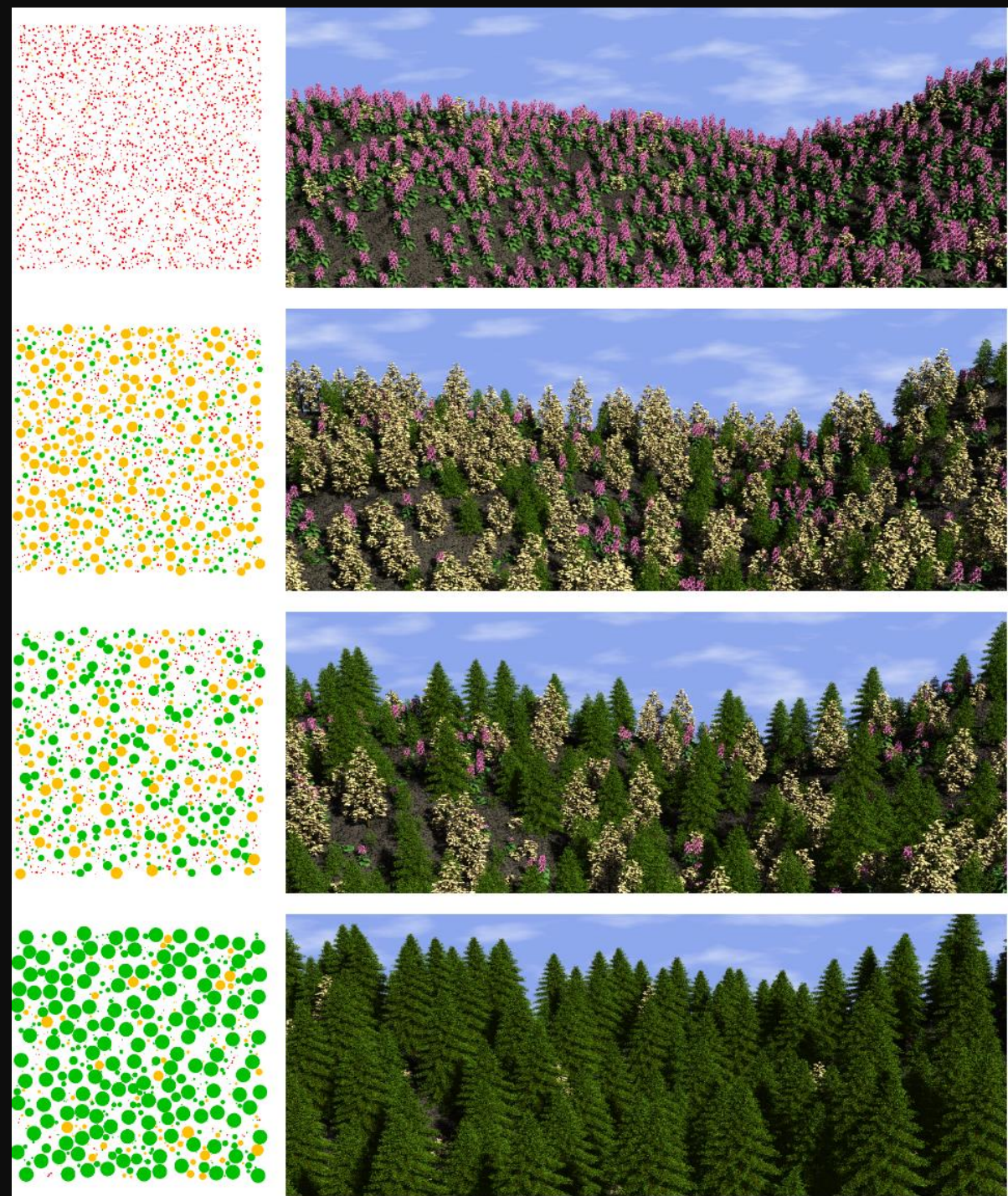
Previous Methods

Approximating the individual plants

- Pros:
 - Simulate complex interactions
 - Capture complex phenomena:
 - Succession
 - Clustering
- Cons:
 - Ecosystem size limited (4x4 km)
- Output:
 - Plant positions and species
 - Height and trunk radius

$$CA = k_{\text{allom1}} D^{k_{\text{rp}}}$$

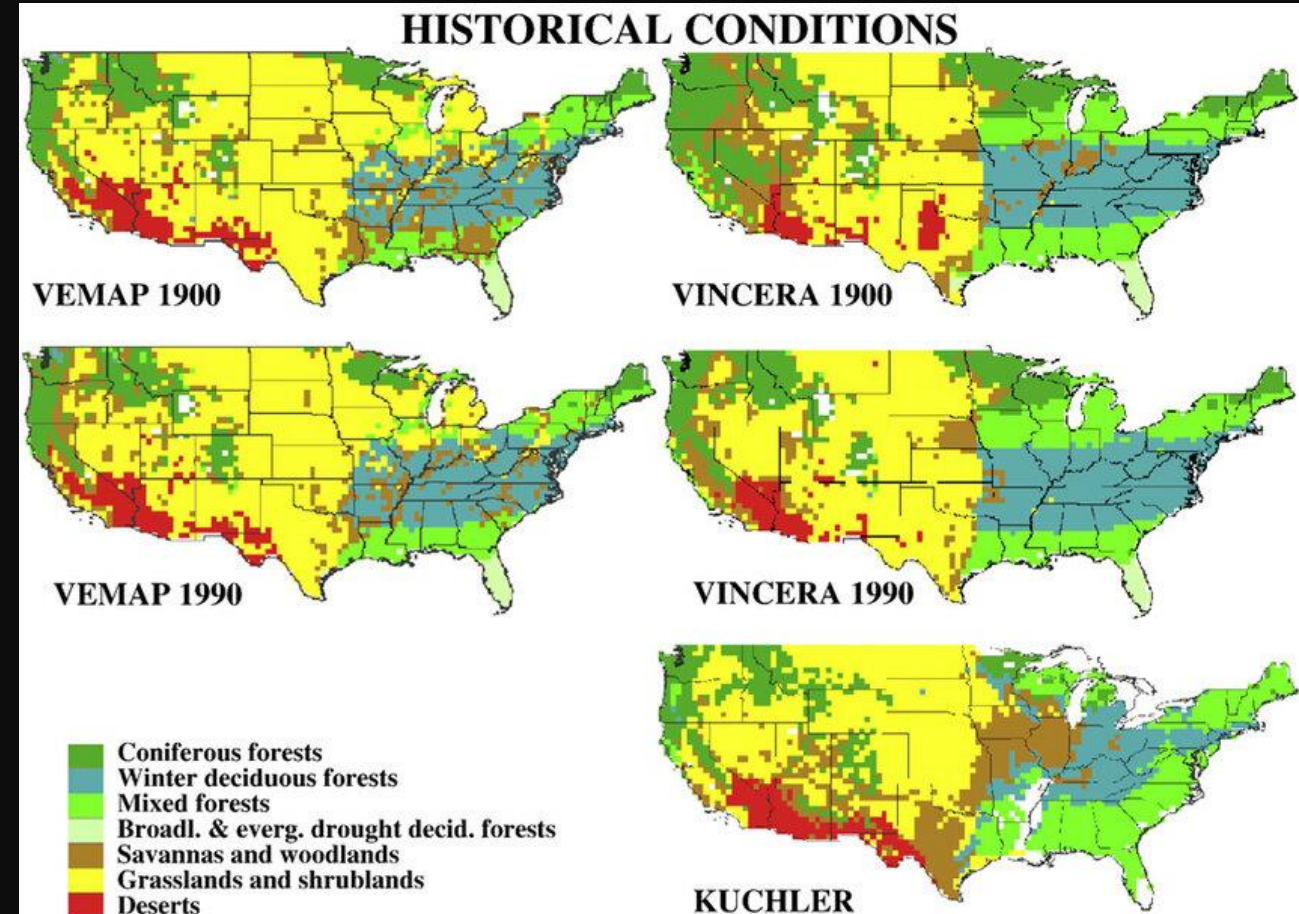
$$H = k_{\text{allom2}} D^{k_{\text{allom3}}}$$



Previous Methods

Simulating at larger scales

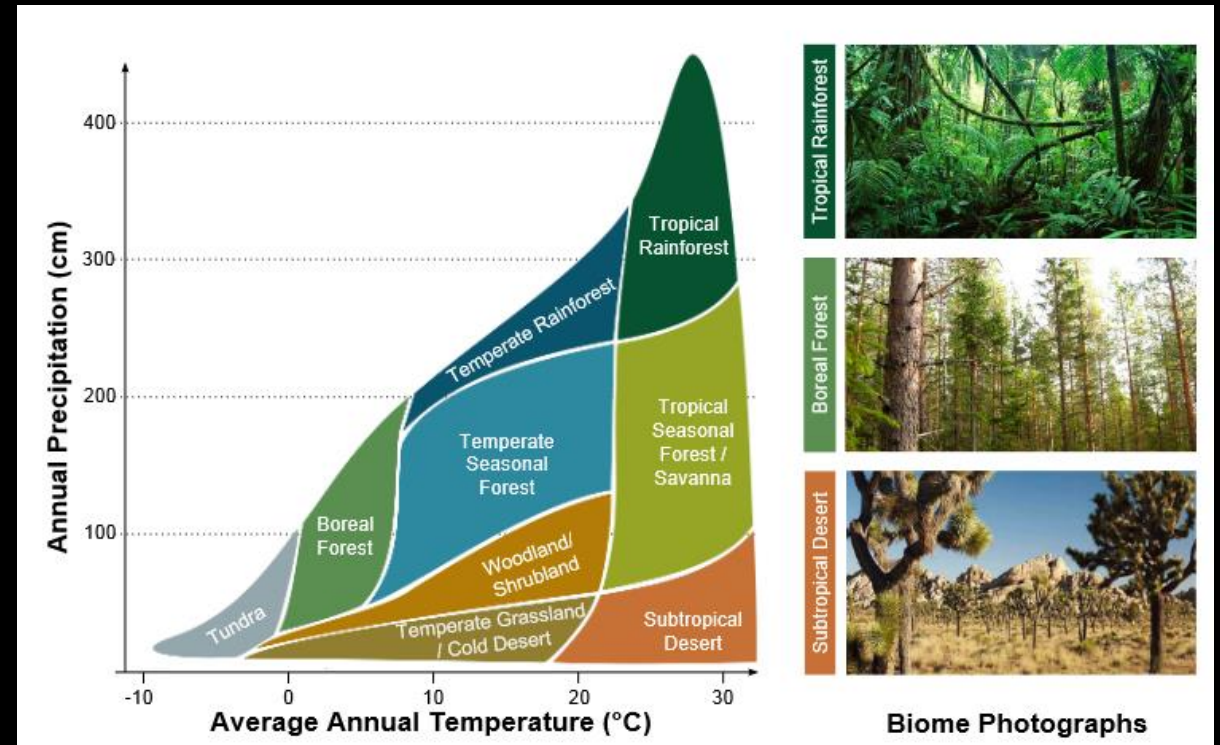
- Pros:
 - Faster
 - Cons:
 - Much less detailed
 - No individual tree positions
 - Output:
 - Quantity of biomass
 - Type of biome
-



Method

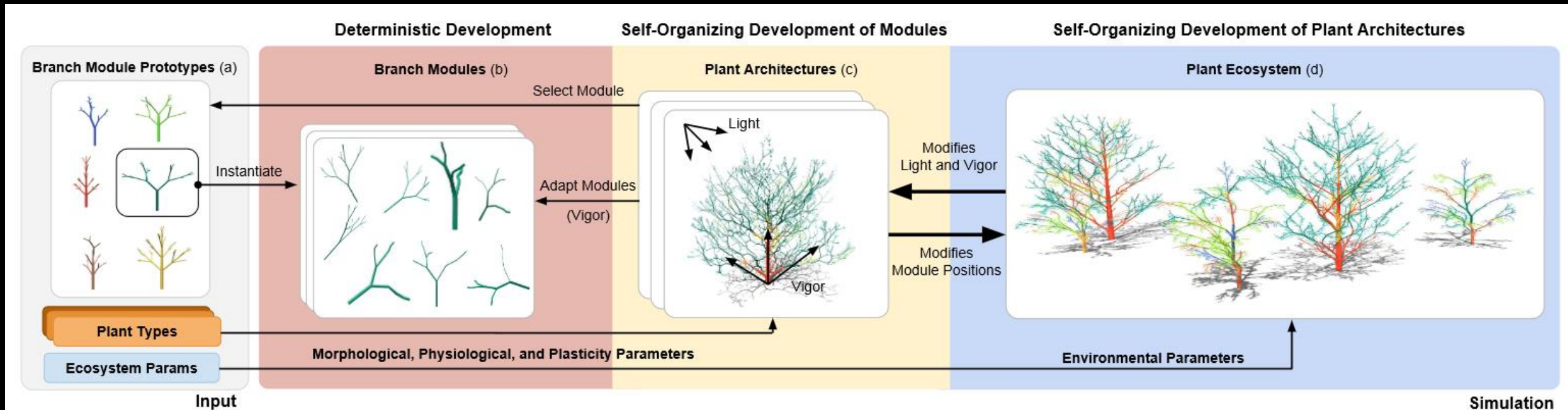
- Biome selection using
 - Temperature
 - Annual precipitation

Determines the species planted



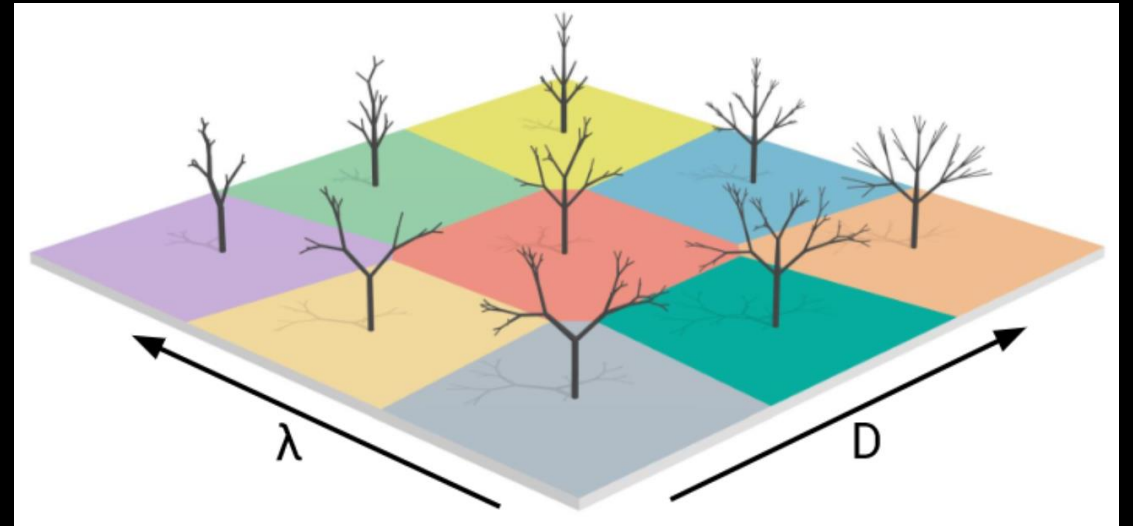
Method

- Approximate the growth of all plants in the ecosystem
- 3 different scales:
 - Branch modules
 - Plants
 - Ecosystem



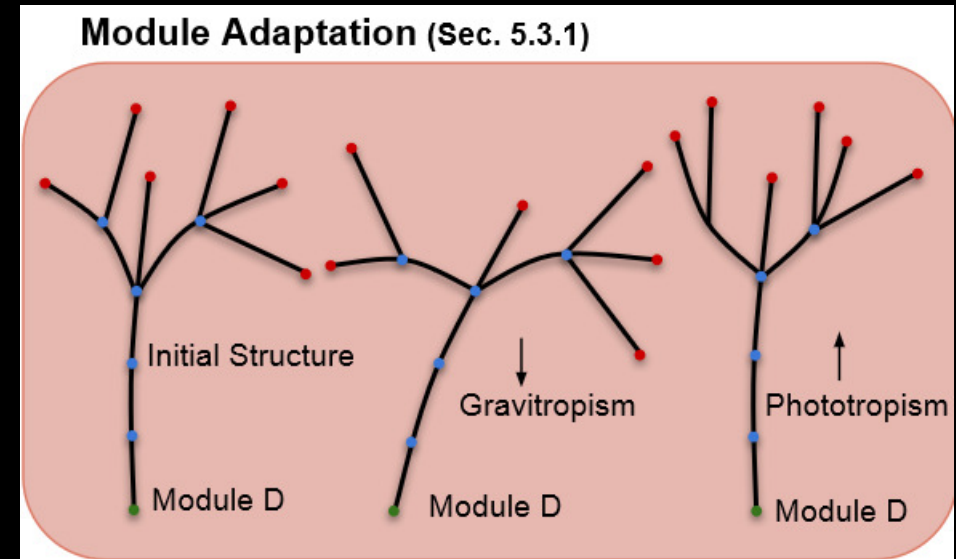
Method

- Hypotheses:
 - Self Similarity
 - Self Organization / Emergence
- Module selection with:
 - Apical Dominance
 - Vigor:
 - Received light is accumulated towards root
 - Redistributed as vigor towards leaves



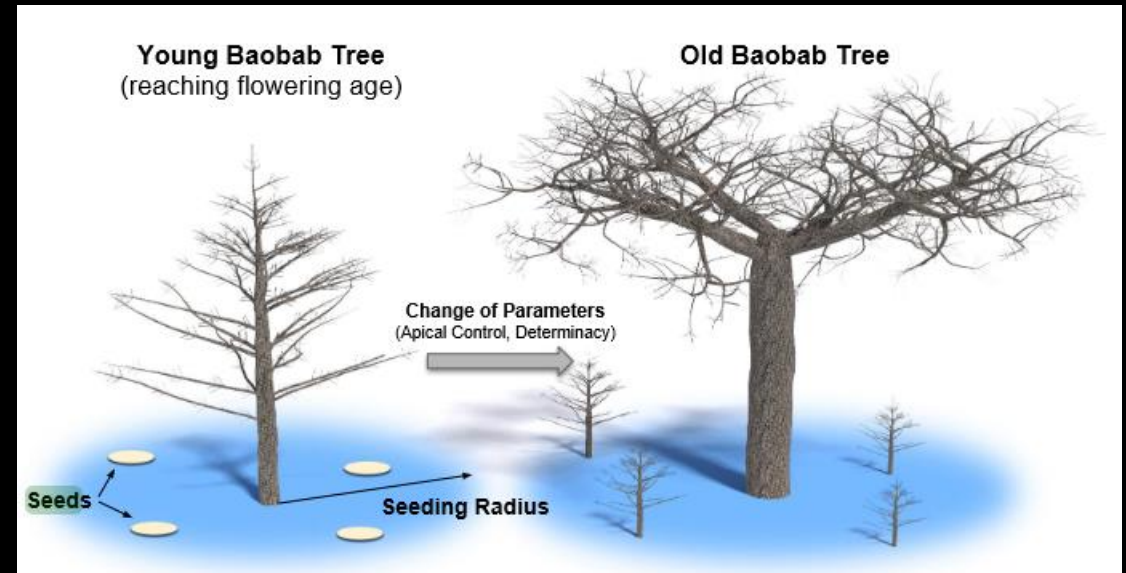
Method

- Module orientation, optimized with a gradient descent:
 - Phototropism
 - Gravitropism
 - Collisions with other branches
- Module growth according to vigor
- Module length depend on its age



Method

- Seeding
 - When the flowering age is reached
 - In a radius around the plant
 - Check climatic conditions:
 - Temperature
 - Precipitation

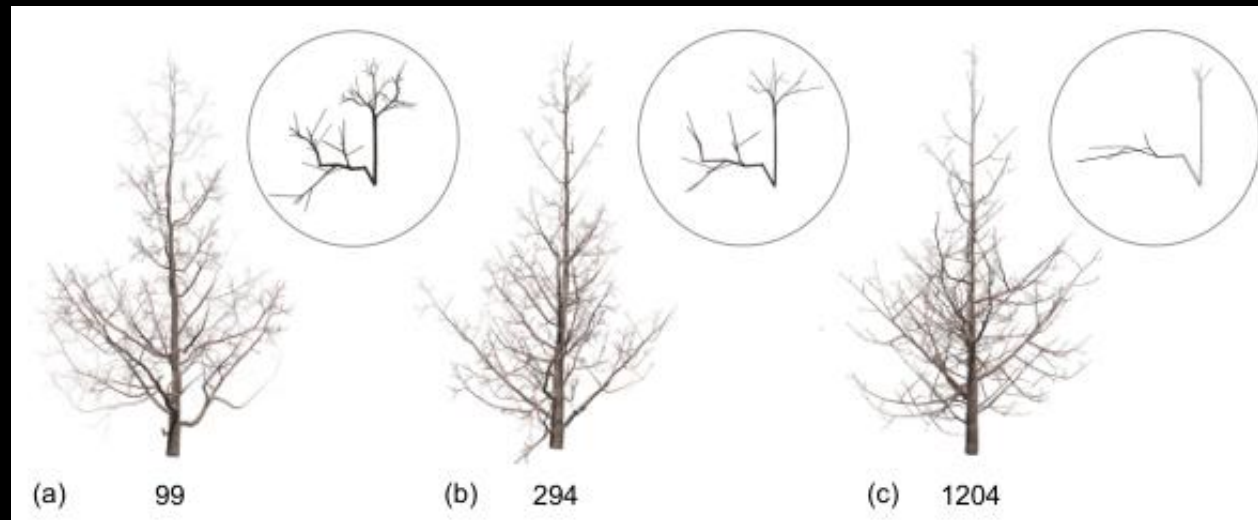


Results

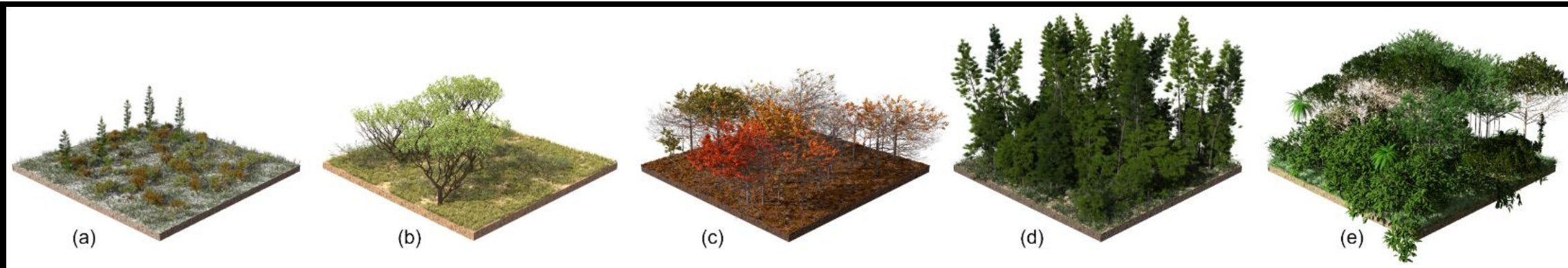
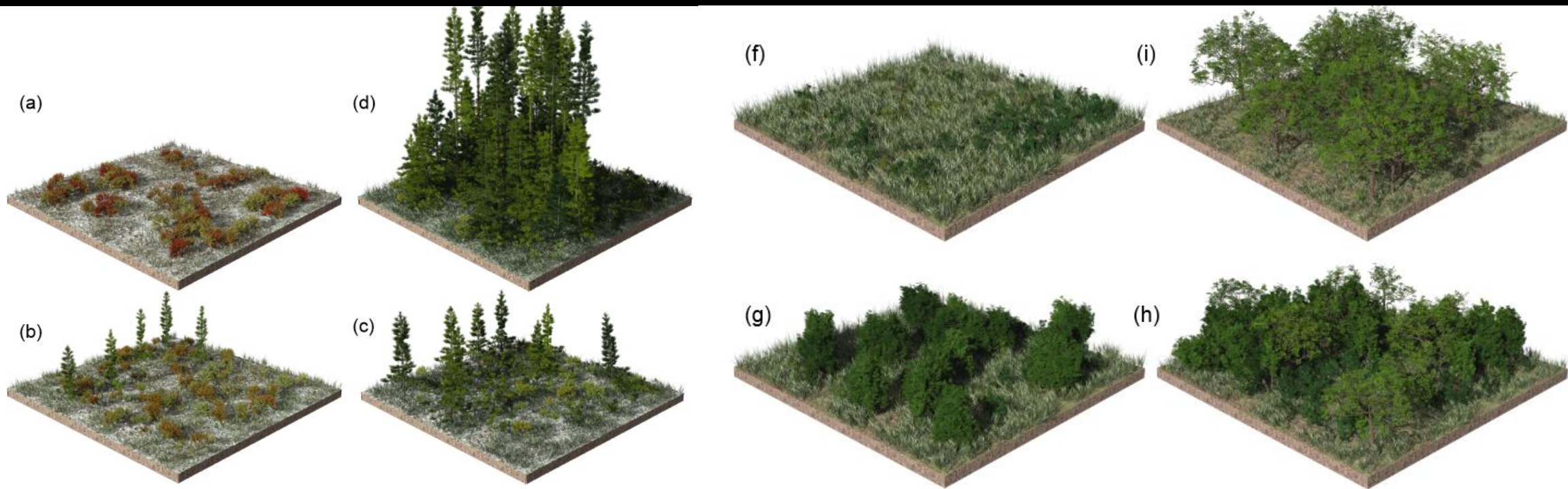
- Few module prototypes needed
- 500k plantes: 70s de simulation

Fig. #	P	PT	M	MP	B	N	TS	TR
1 a	218	3	4.6	8	57.05	61.64	7	4
1 b	87	3	14.0	7	182.80	196.83	11	5
1 c	611	3	34.4	4	392.45	435.50	14	19
1 d	1,248	6	18.9	7	215.97	113.89	45	12
10 a	938	7	8.4	10	123.30	131.48	43	15
10 b	926	7	7.40	10	111.78	118.89	43	15
10 c	984	7	8.0	10	112.29	120.00	42	15
10 d	950	7	7.6	9	97.13	104.60	42	15
10 e	848	7	7.5	9	94.26	101.58	41	15
11 a	147	2	2.9	3	30.39	33.35	4	3
11 b	205	2	3.8	5	49.73	53.58	11	5
11 c	264	3	4.1	4	48.16	52.23	10	4
11 d	428	3	20.40	4	188.72	208.98	35	9
11 e	640	5	37.49	8	412.22	449.52	87	18
11 f	330	3	4.2	7	45.96	50.15	15	6
11 g	423	4	14.38	11	191.15	205.39	30	8
11 h	776	4	19.8	11	273.21	292.67	34	8
11 i	967	4	6.68	8	56.48	62.27	17	4
11 j	1,404	3	9.23	4	103.45	112.47	20	7
12 a	463	10	8.5	9	105.47	113.89	18	5
12 b	168	2	2.6	5	38.83	41.39	6	4
12 c	767	5	13.6	5	148.70	162.13	20	8
19 g	461,711	3	2,215	15	22,891	26,603	7071	4152

Results

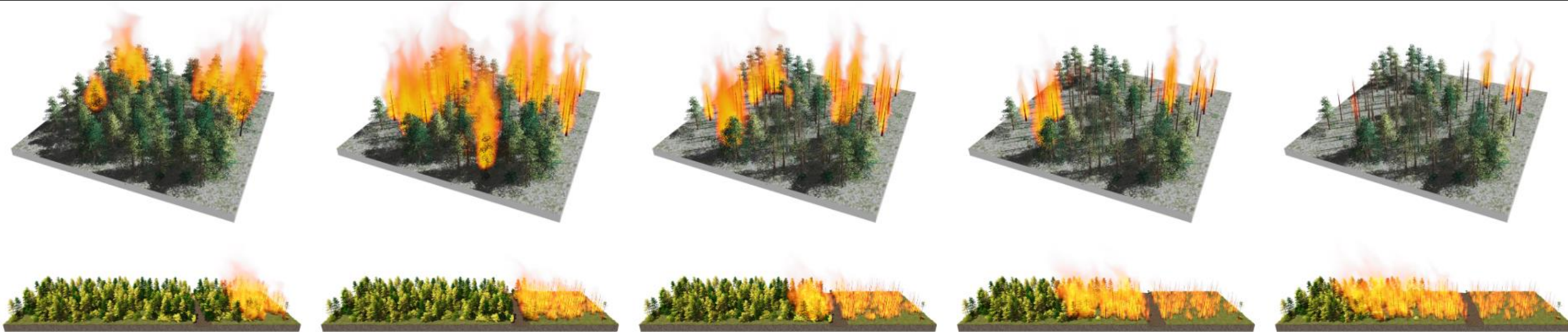
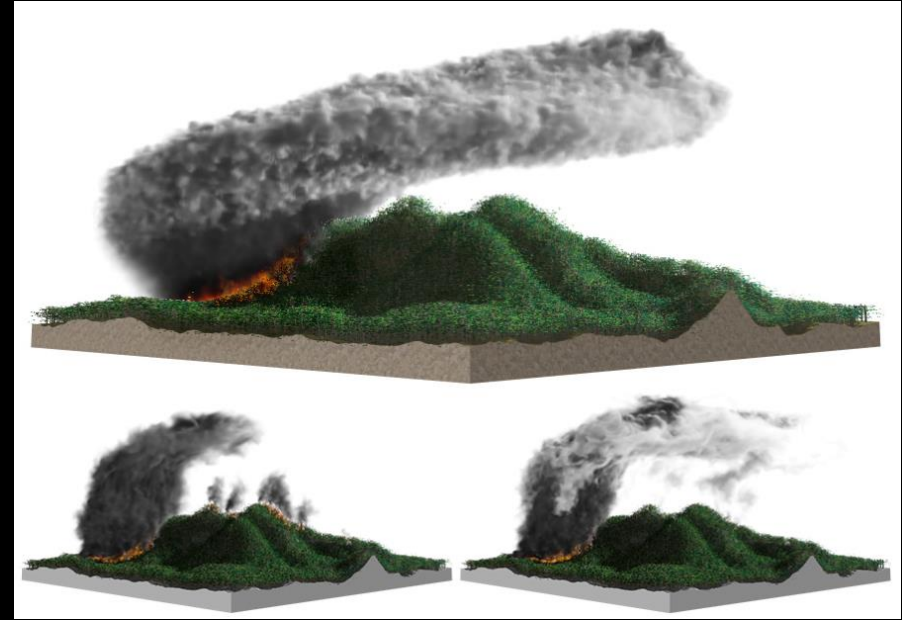
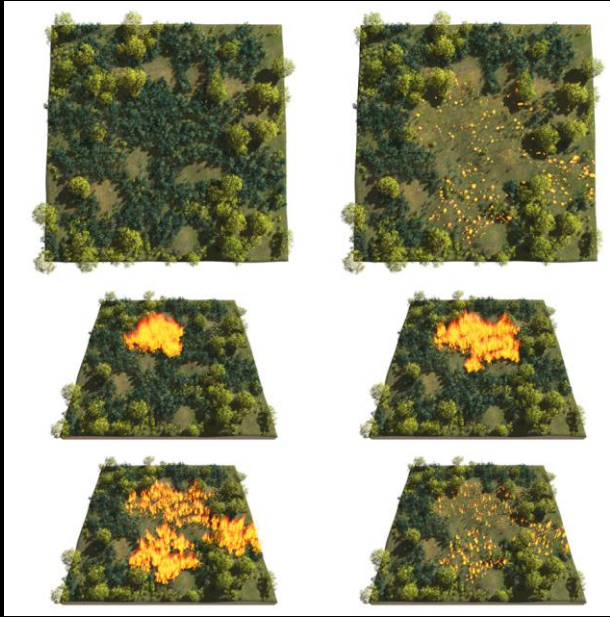


Results



Applications: Paradise

Fire in



Applications:

Ecoclimates

