DisturPloidy

https://github.com/rosemckeon/ploidy

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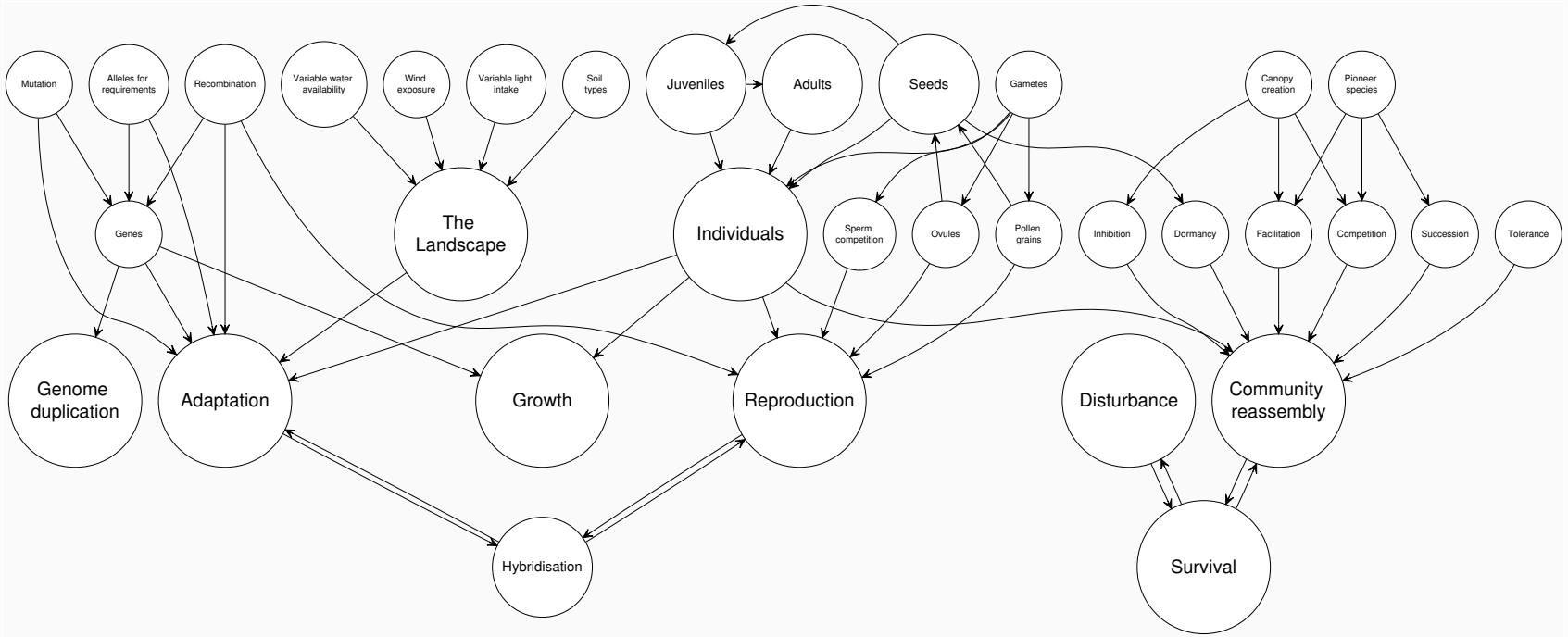
How does disturbance on a landscape affect the establishment of new polyploid plant species?

Individual-based models (IBMs)

IBMs emulate long-term evolutionary studies *in-silico* by simulating biological systems over virtual time.

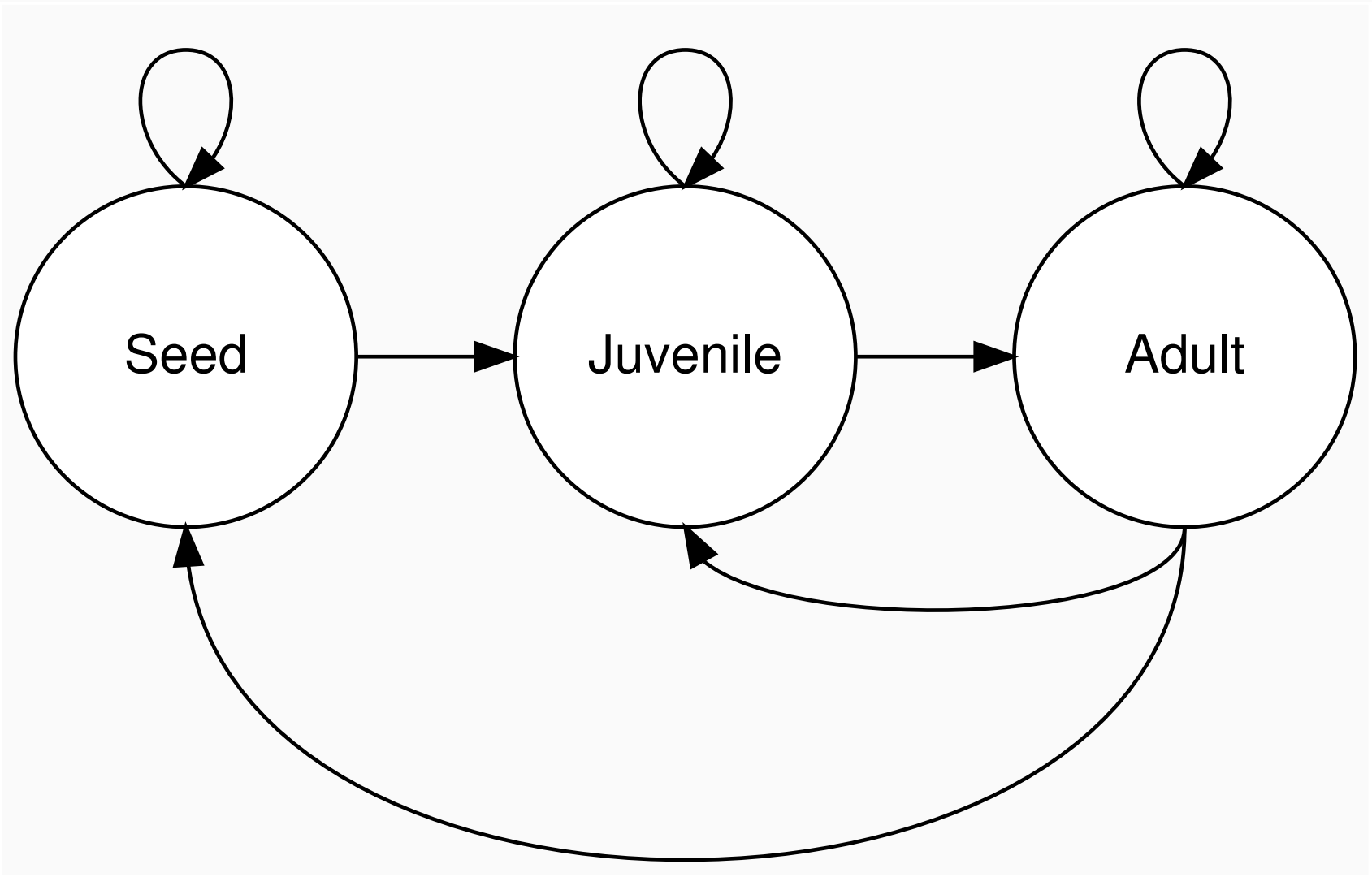
- They allow for individual variation by representing all individuals in a population *explicitly*.
- Variables we're used to seeing in mathmatical models (like N) become *emergent properties* of the simulation.
- IBMs are often targeted to simulate a specific system, but can also be applied more broadly.

What I thought the model had to do



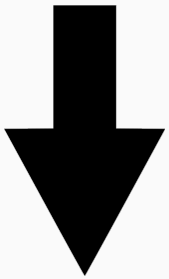
Basically, everything.

The Life Cycle



Costs/Benefits of Being Polyploid

Costs
Triploid sterility
Diploid pollen-swamping



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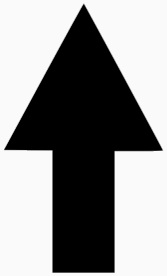
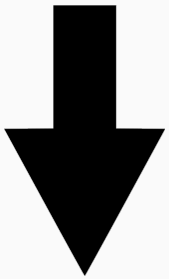


Costs	**Benefits**
Triploid sterility	**Gigas-effects**
Diploid pollen-swamping	**Genetic buffering**
	Reversal of selfing inhibition



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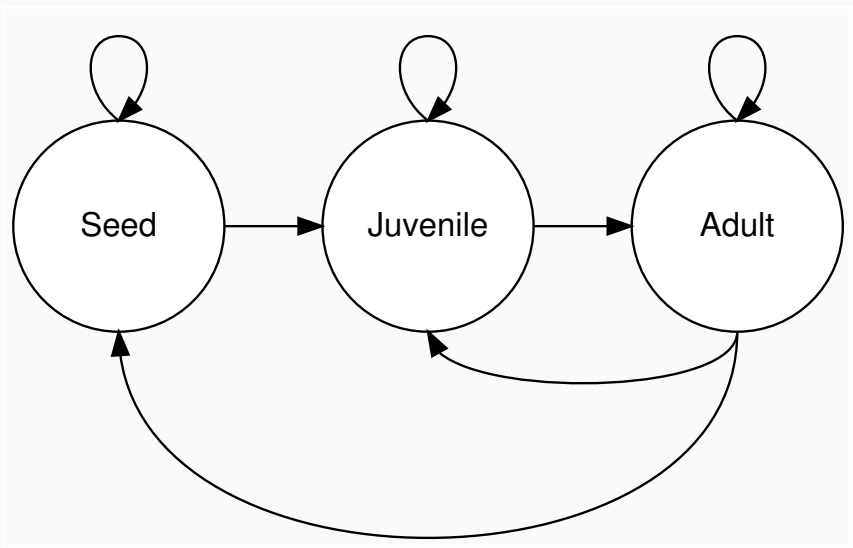
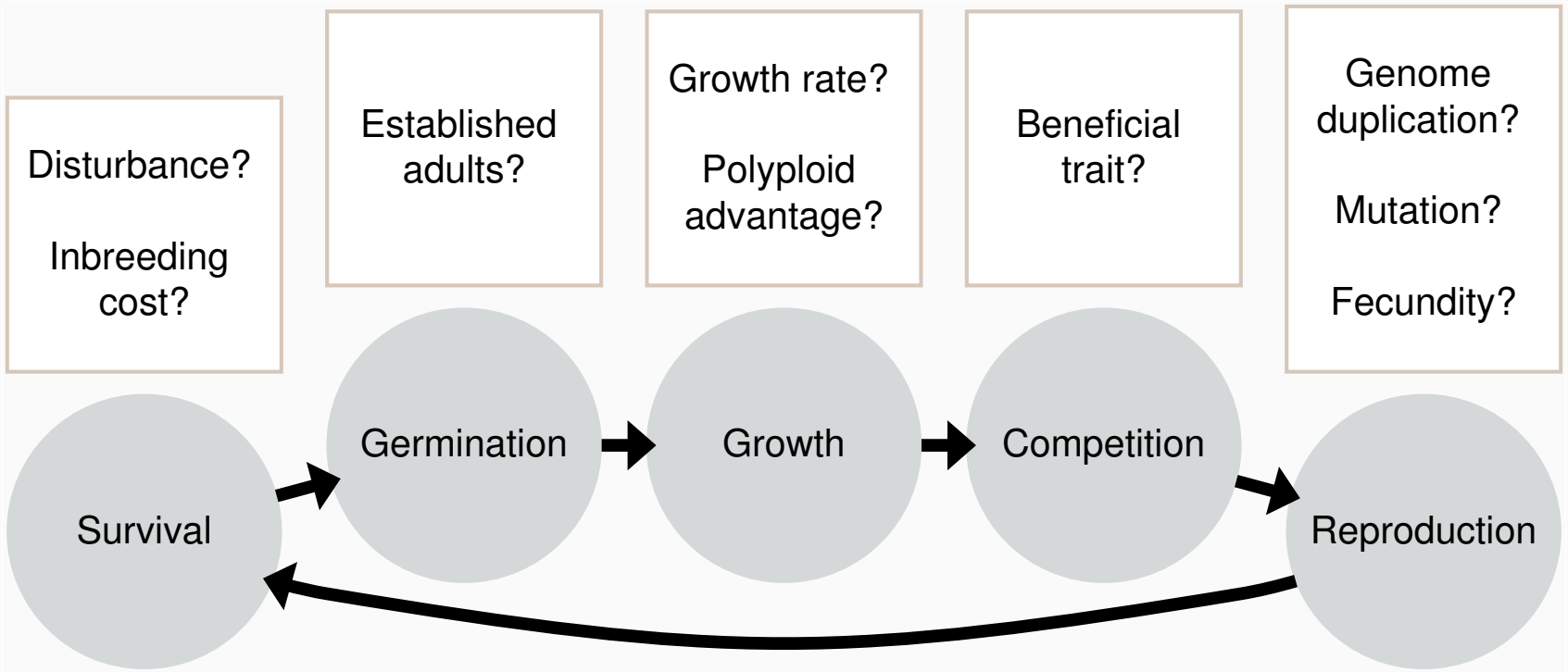
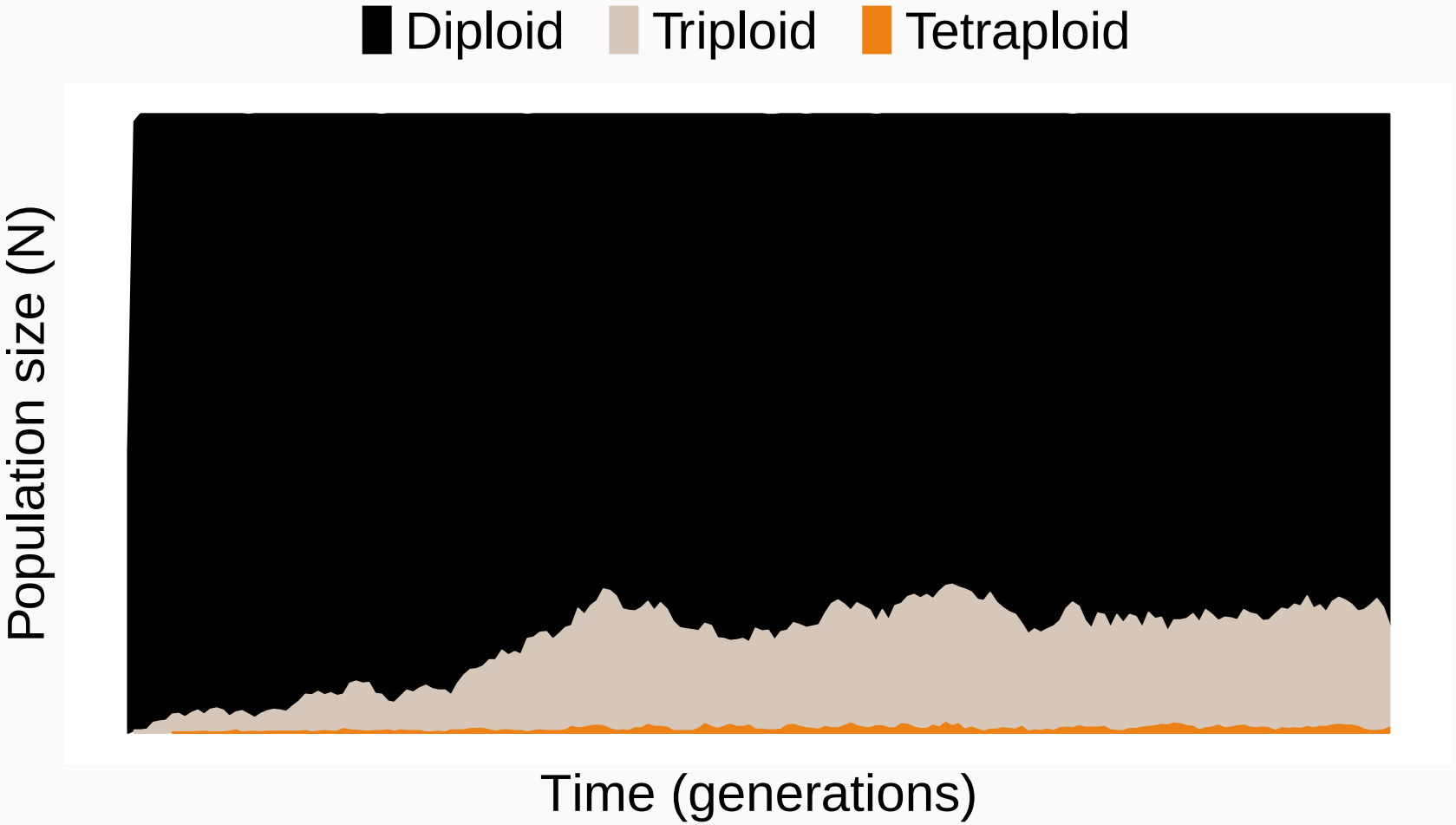


Model Flow

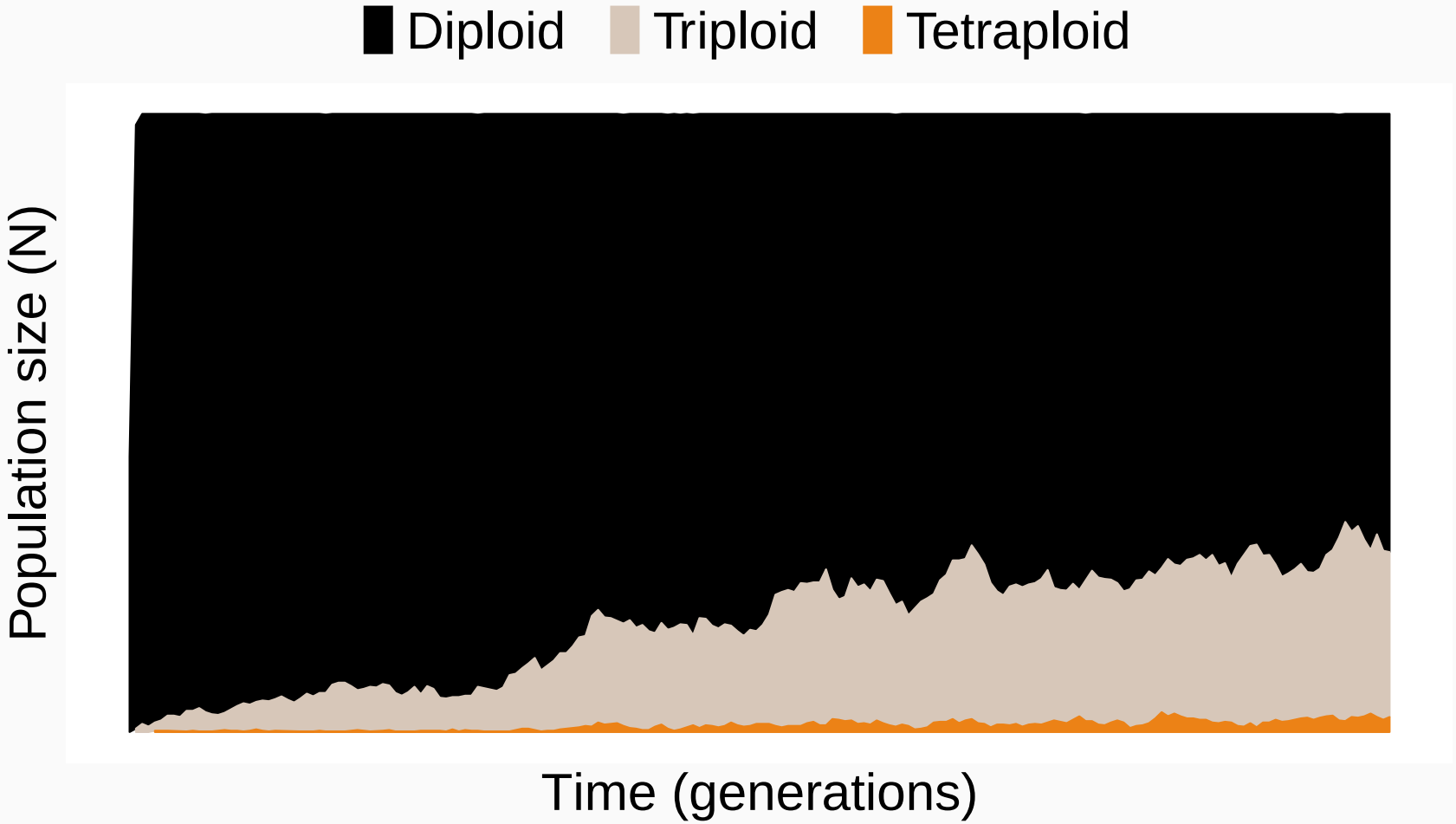

Disturbance?
Inbreeding cost?
Established adults?
Growth rate?
Polyploid advantage?
Beneficial trait?
Genome duplication?
Mutation?
Fecundity?
Survival
Germination
Growth
Competition
Reproduction

Baseline Results



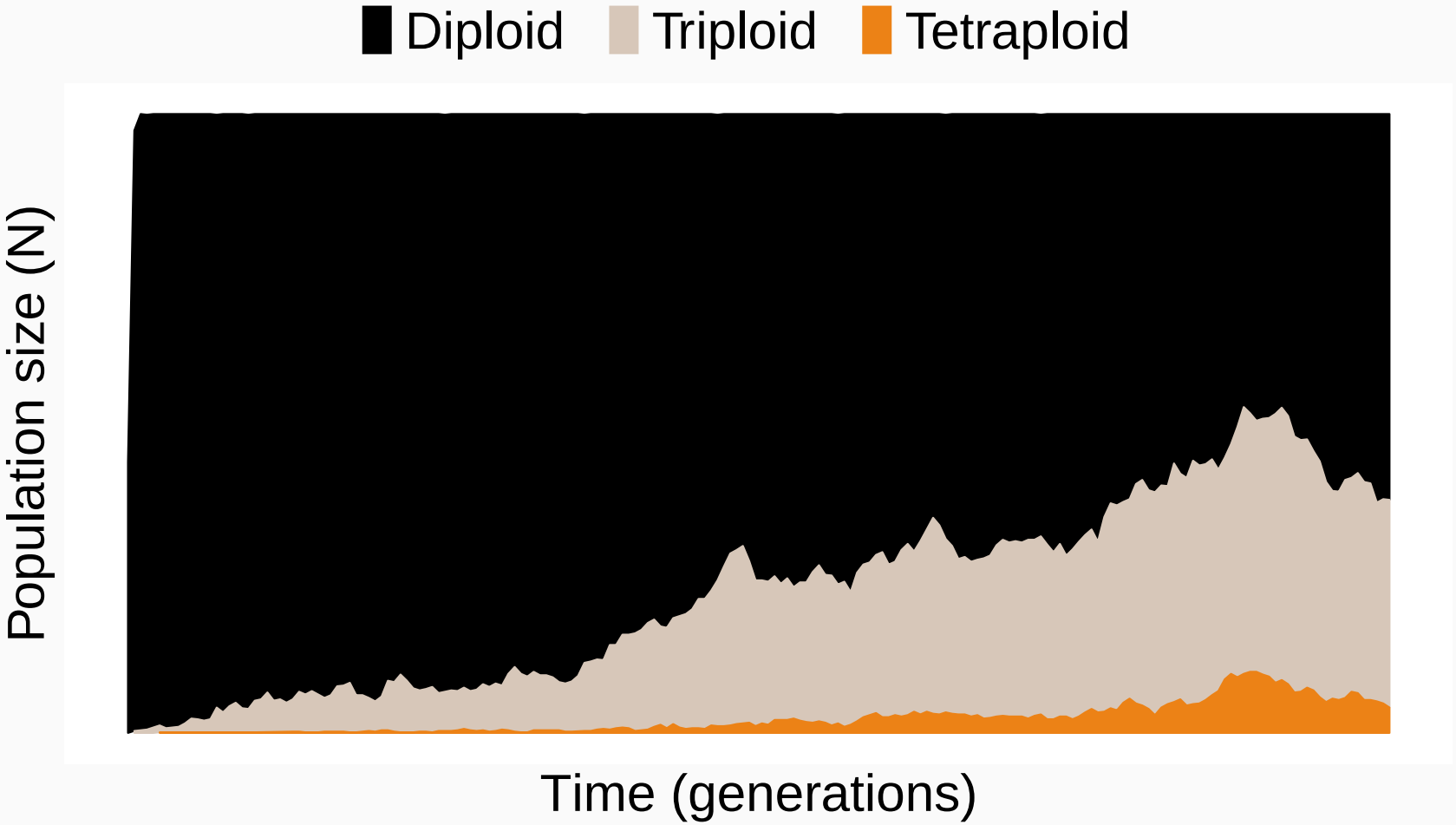
Whole genome duplication occurs at a rate of 0.01
There is no cost/benefit to being polyploid.
There is no disturbance.

Reversal of selfing-inhibition



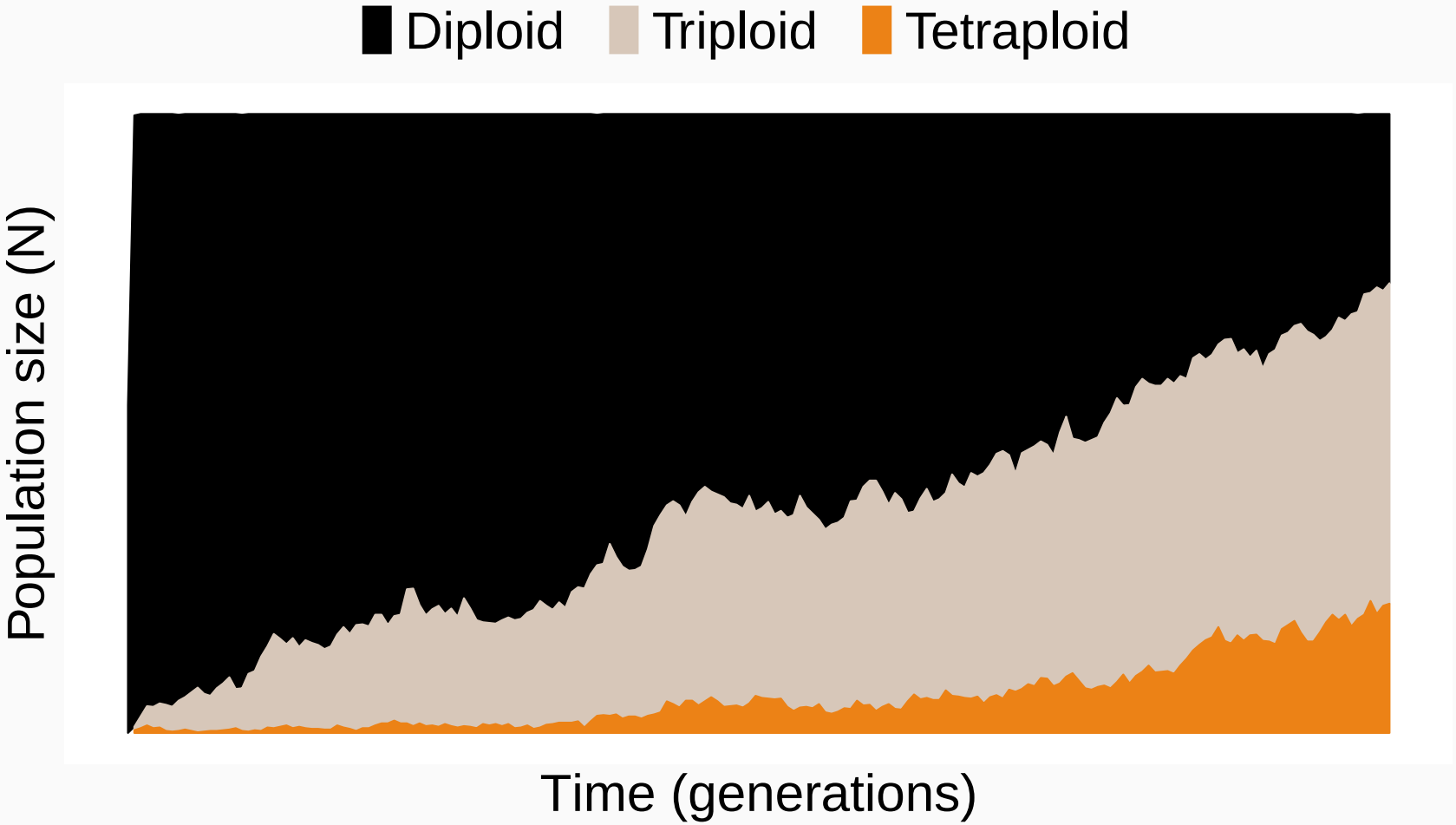
Now polyploids can self where diploids cannot.
There is still no disturbance.

Genetic buffering against the deleterious affects of inbreeding



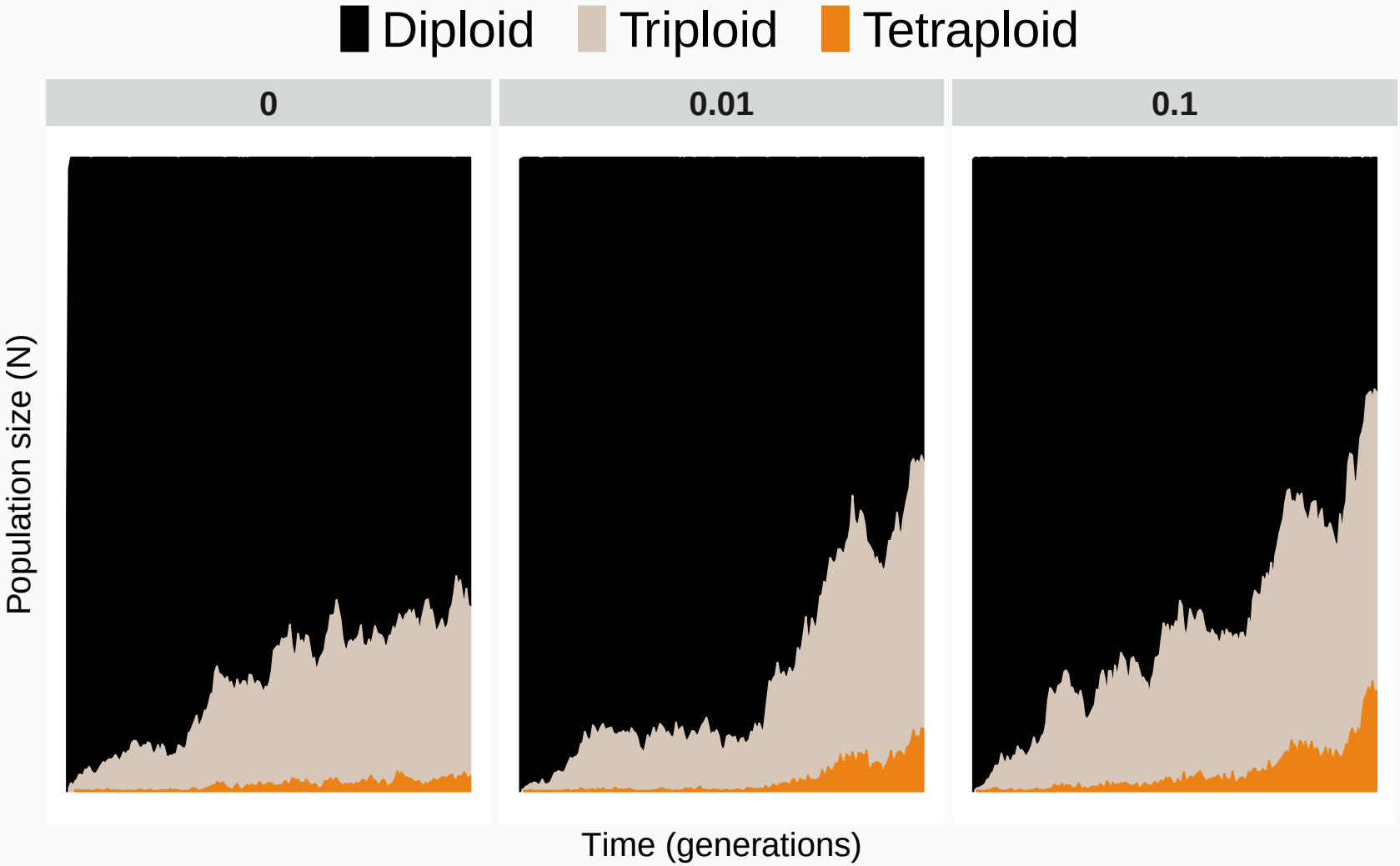
Now polyploids buffer the effects of inbreeding depression.
There is still no disturbance.

Gigas effects which increase growth



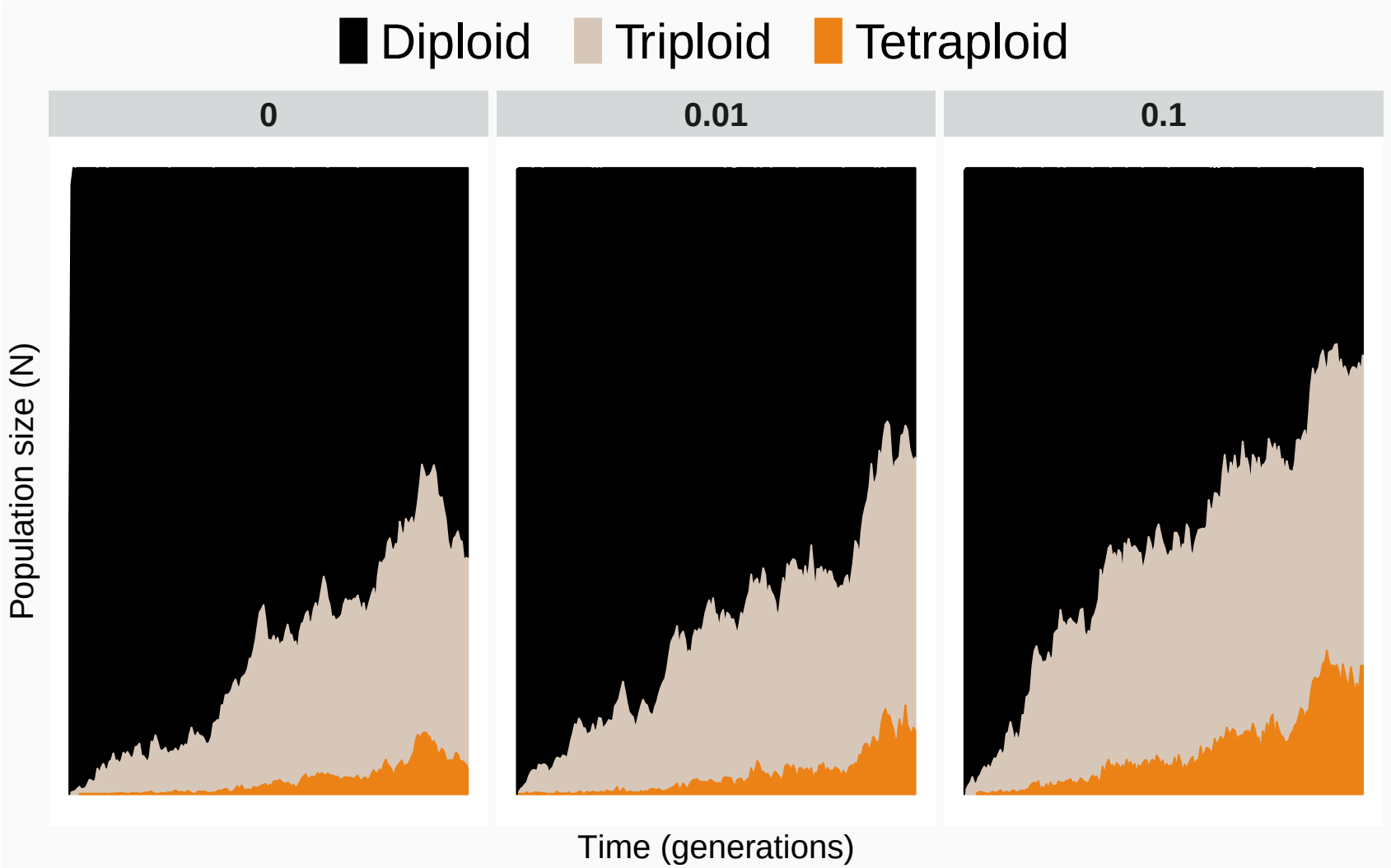
Now polyploids have increased growth rate.
There is still no disturbance.

Disturbance when polyploids have reversal of selfing-inhibition



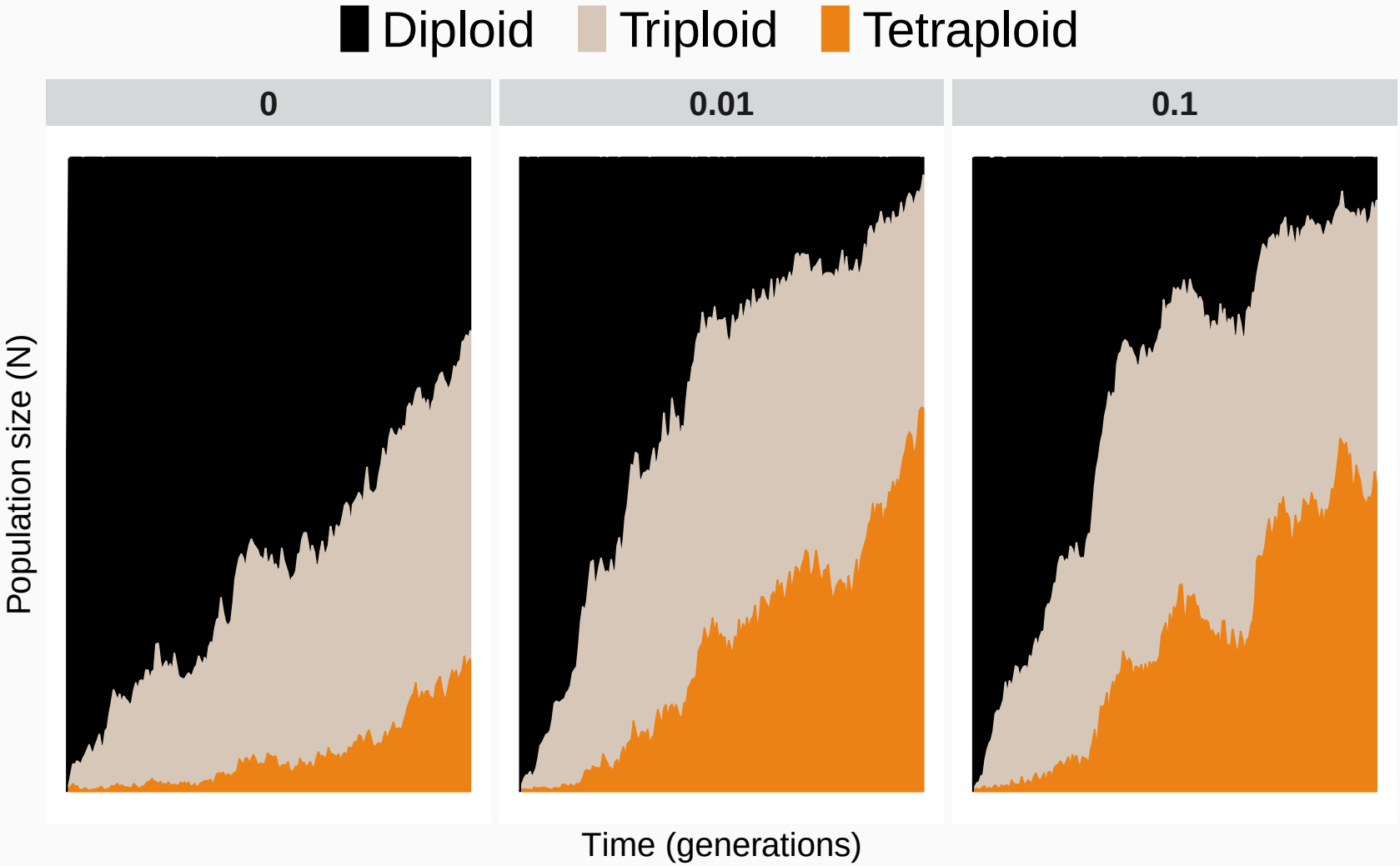
Probability of disturbance increases from left to right.

Disturbance when polyploids buffer the deleterious affects of inbreeding



Probability of disturbance increases from left to right.

Disturbance when polyploids have increased growth rate



Probability of disturbance increases from left to right.

Summary / Questions

Disturbance really does play a key role in the establishment of polyploids within plant populations.

Try it for yourself:

```
library(devtools)
install_github("rosemckeon/ploidy")
library(disturploidy)
?disturploidy
```

https://github.com/rosemckeon/ploidy

The Individuals

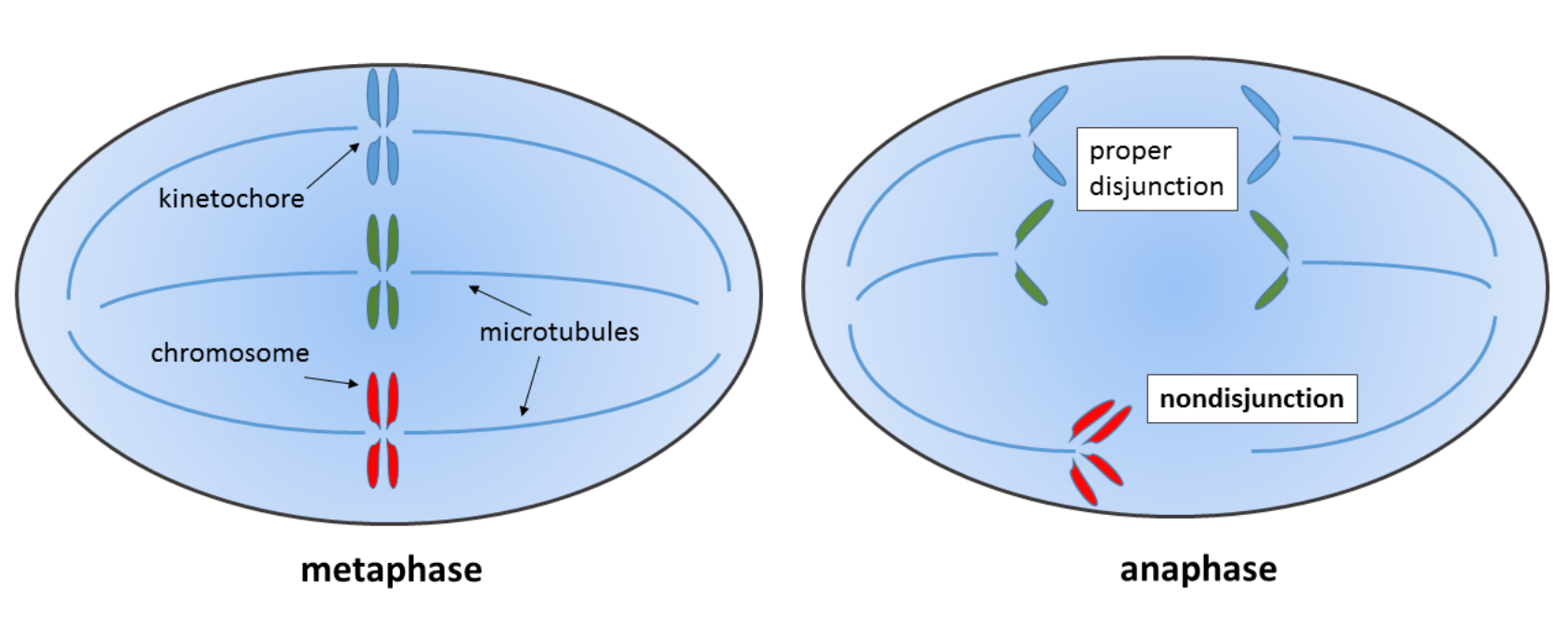
X	Y	ID	life_stage	size	ploidy	gen	genome	growth_rate	inbreeding
9	4	4_659	2	1.919	2	5	—	1.919	FALSE
9	5	4_792	2	1.843	2	5	—	1.843	FALSE
9	6	4_606	2	2.109	3	5	—	2.109	FALSE
9	7	4_1057	2	1.590	2	5	—	1.590	FALSE
9	8	4_719	2	2.070	2	5	—	2.070	FALSE
9	9	4_1097	2	1.479	2	5	—	1.479	FALSE

The Genome

locus	value	allele
1	56.77818	1
1	68.56308	2
2	12.61929	1
2	44.58789	2

The Landscape

Whole-Genome Duplication (WGD)



[1]Wpeissner (2014). *Non-disjunction* [image]. Available at: https://commons.wikimedia.org/w/index.php?curid=32332257

Benefit: Gigas-effects

`ploidy_growth_benefit`

- Can take a value between `0` and `1`.
- Any value above `0` allows the contribution of additional alleles for growth rate and so simulates *gigas-effects*.
- Smaller adults have lower fitness.
- Polyploids will have an advantage if `ploidy_growth_benefit > 0`.

Benefit: Genetic Buffering

`inbreeding_cost`

- Can take a value between `0` and `1`.
- Any value above `0` will increase winter mortality if an individual is homozygous at a specified locus.
- Polyploids will have better survival probabilities than their diploid counterparts, because the chance of being homozygous at any given locus is far smaller.

Benefit: Reversal of selfing inhibition

`selfing_polyploid_prob`

- Takes a value beteen `0` and `1`.
- Any value above `0` will give polyploids the ability to self-fertilise.
- This will increase fecundity, especially in the face of limited mate-choice (when `pollen_range` is low).
- Will convey a benefit to being polyploid when set to a value greater than that of diploids (default = `0`).

Cost: Triploid sterility

`triploid_mum_prob`

- Takes a value between `0` and `1`.
- Any value below `fertilisation_prob` will reduce the fecundity of triploids.
- Triploids in the model make 50/50 haploid/diploid gametes, so including triploid sterility also substantially reduces the chance of new polyploid lines arising.

Cost: Diploid pollen-swamping

`uneven_matching_prob`

- Take a value between `0` and `1`.
- Acts to affect fertilisation success when gametes possessing different ploidy levels meet (ie: a haploid gamete and a diploid gamete).
- Any value below `fertilisation_prob` will reduce the fecundity of polyploids, especially when diploid density (an emergent property) is high, and when mate-choice is not limiting (when `pollen_range` is high).
- This will reduce the appearance of triploids.

Disturbance

`disturbance_freq`

- Takes a whole number between `0` and max generation.
- Any value above `0` enables a chance of disturbance during the winter survival period.
- The value represents a `1/disturbance_freq` chance of disturbance which is applied every winter.

`disturbance_mortality_prob`

- Takes a value between `0` and `1`.
- Any value above `0` increases the chance of mortality during the survival period by that proportion.

Further work

Version 2

No due date **0%** complete

7 Open 0 Closed

- **Consider including allopolyploids** enhancement
  #104 opened 2 minutes ago by rosemckeon
- **Incorporate delayed maturity of polyploids** enhancement
  #100 opened 4 days ago by rosemckeon
- **Allow polyploids to have increased ovule number** enhancement
  #101 opened 4 days ago by rosemckeon
- **Improve disturbance** enhancement
  #89 opened 14 days ago by rosemckeon
- **Improve cloning** enhancement
  #88 opened 14 days ago by rosemckeon
- **Enable dormancy** bug enhancement
  #98 opened 5 days ago by rosemckeon
- **Free up memory** enhancement
  #103 opened 19 hours ago by rosemckeon — 3