Diagnostic Tests

This document contains diagnostic checks of the `generate_system` function based on 5000 draws. We first run this for 5000 draws with the habitable option turned on, which means that we force one planet in the system to be habitable. In general, our system generations follows the rule in *Campaign Operations* exactly. However when the habitability option is turned on, we do use several tweaks to ensure that we get a habitable planet. Currently, these tweaks are the following:

- We roll on the life friendly column for star type.
- When rolling star subtypes, we disallow M6 and M9 subtypes because these stars have no orbital slots within the life zone, according to the tables provided in *Campaign Operations* (see the file `habit_zones.pdf` for details).
- We randomly pick one slot within the life zone and continue to run the `generate_planet` function until we produce a habitable planet.
- Within the `generate_planet` function called by `generate_system`, we also add the following tweaks for the planet that must be habitable:
  - We do not add the system level habitability modifier.
  - We add three to the atmospheric conditions roll to eliminate toxic atmospheres and reduce the frequency of tainted atmospheres (which are otherwise more than 40% of the cases).
  - We add two to the water coverage roll on the assumption that colonizers would prefer planets with generous water.
  - We use different functions to determine diameter and density of terrestrials that will have averages closer to Earth and less variance in order to get gravities that are closer to Earth and less variable. These functions are:
    - diameter $= 9000 + 500 * 2d6$
    - density $= 3 + 1d6^{0.75}$

We also make one other tweak. Since we are using a computer, there is no need for the discrete changes in temperature and water coverage by units of 10. So we allow these values to vary by single digits by subtracting five and then drawing a number randomly between 0 and 9 (i.e. a d10 roll). This slightly changes the mean values because the mean of that random draw is 4.5 and not 5, but we preferred the aesthetics of whole numbers.

The figures and tables below show the distribution of key characteristics across all of the habitable planets found in the 5000 draws to `generate_system`. For quantitative variables, we show both histograms and kernel density smoothers and the blue dotted line gives the mean.

% Table created by stargazer v.5.2.2 by Marek Hlavac, Harvard University. E-mail: hlavac at fas.harvard.edu
% Date and time: Sun, Sep 30, 2018 - 12:53:08

```
## `geom_smooth()` using method = 'gam'
```

Lets compare these results to a sample of all the inhabited planets we get when we don't enforce habitation. This will give us a sense of how selective colonists were in choosing planets based on certain characteristics. We will need many more draws here because of the lower likelihood of getting inhabitable planets. Preliminary tests suggested about a 2% chance, so if we want at least 1000 inhabited systems, we will need 50,000 draws.

% Table created by stargazer v.5.2.2 by Marek Hlavac, Harvard University. E-mail: hlavac at fas.harvard.edu
% Date and time: Sun, Sep 30, 2018 - 12:57:36

Table 1: Summary measures for all quantitative variables for habitable worlds when forced inhabitation used

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
orbital_dist	5,113	0.939	0.781	0.040	0.240	1.400	2.560
inhabitable	5,113	1.000	0.000	1	1	1	1
life_zone	5,113	1.000	0.000	1	1	1	1
gravity	5,113	0.949	0.202	0.220	0.800	1.090	2.110
temperature	5,113	30.853	6.623	9	26	36	48
water	5,113	43.947	15.897	1	35	51	100
continents	5,113	3.355	2.018	0	2	5	14
diameter	5,113	12,156.050	1,169.307	4,500	11,400	12,900	18,500
density	5,113	5.479	1.001	3.000	4.682	6.344	8.000
escape_velocity	5,113	10,595.430	1,452.946	3,147	9,644	11,581	19,560
orbital_velocity	5,113	7,492.109	1,027.384	2,225	6,820	8,189	13,831
day_length	5,113	22.387	3.221	6	20	25	30
year_length	5,113	1.587	1.155	0.300	0.800	2.000	4.300

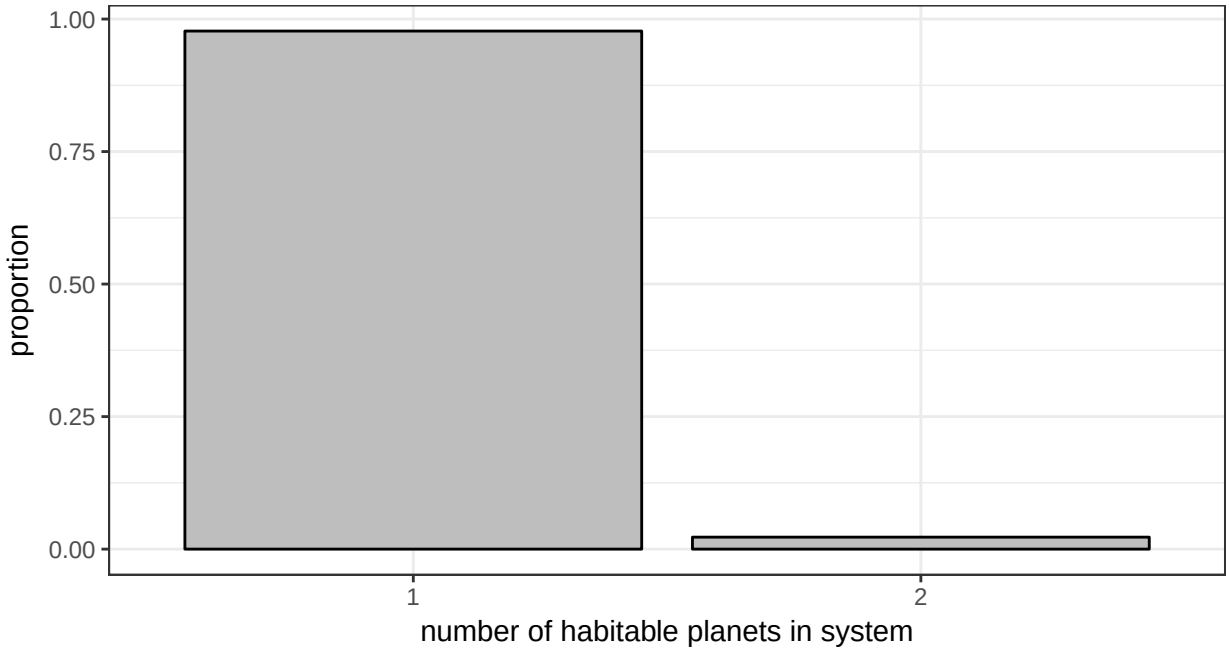

Figure 1: Distribution of the number of habitable planets generated within each system, based on 5000 draws of system generation with forced inhabitation

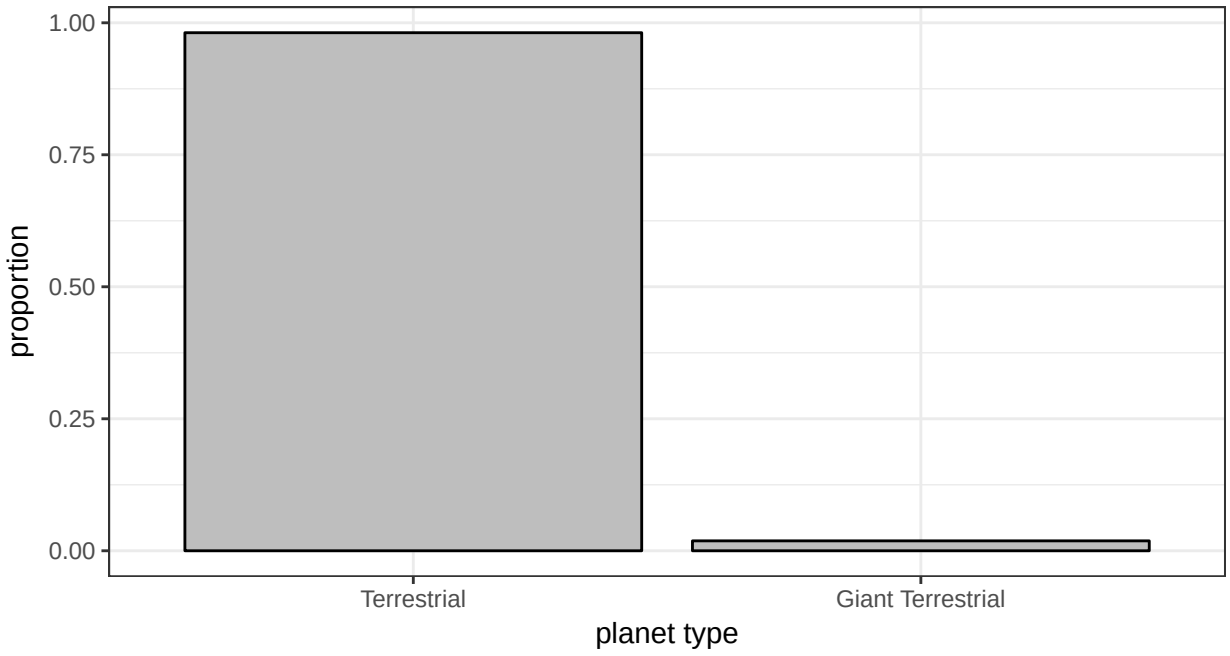

Figure 2: Distribution of planet type on habitable planets from 5000 draws of system generation with forced inhabitation

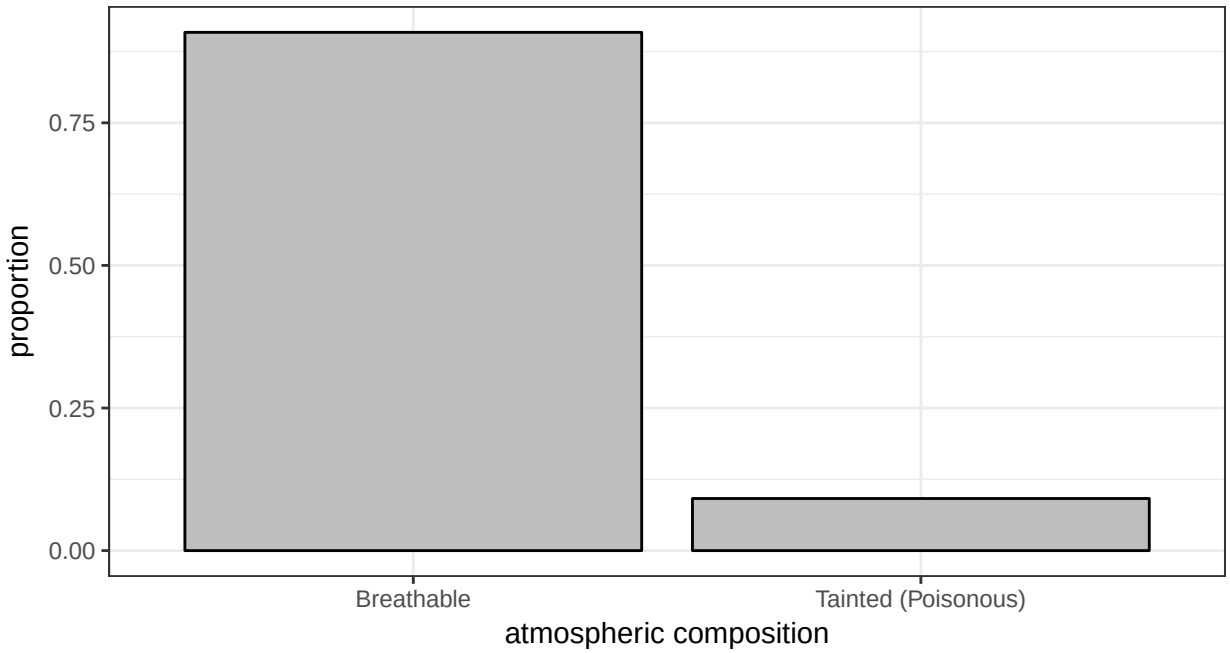

Figure 3: Distribution of atmospheric composition on habitable planets from 5000 draws of system generation with forced inhabitation

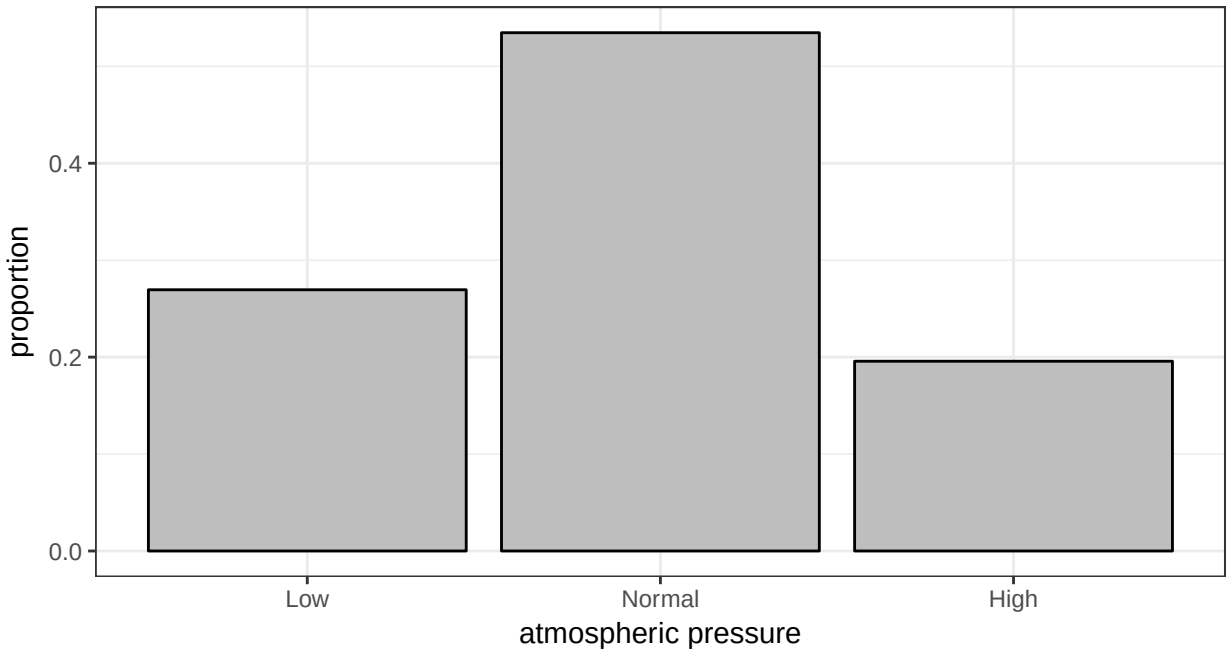

Figure 4: Distribution of atmospheric pressure on habitable planets from 5000 draws of system generation with forced inhabitation

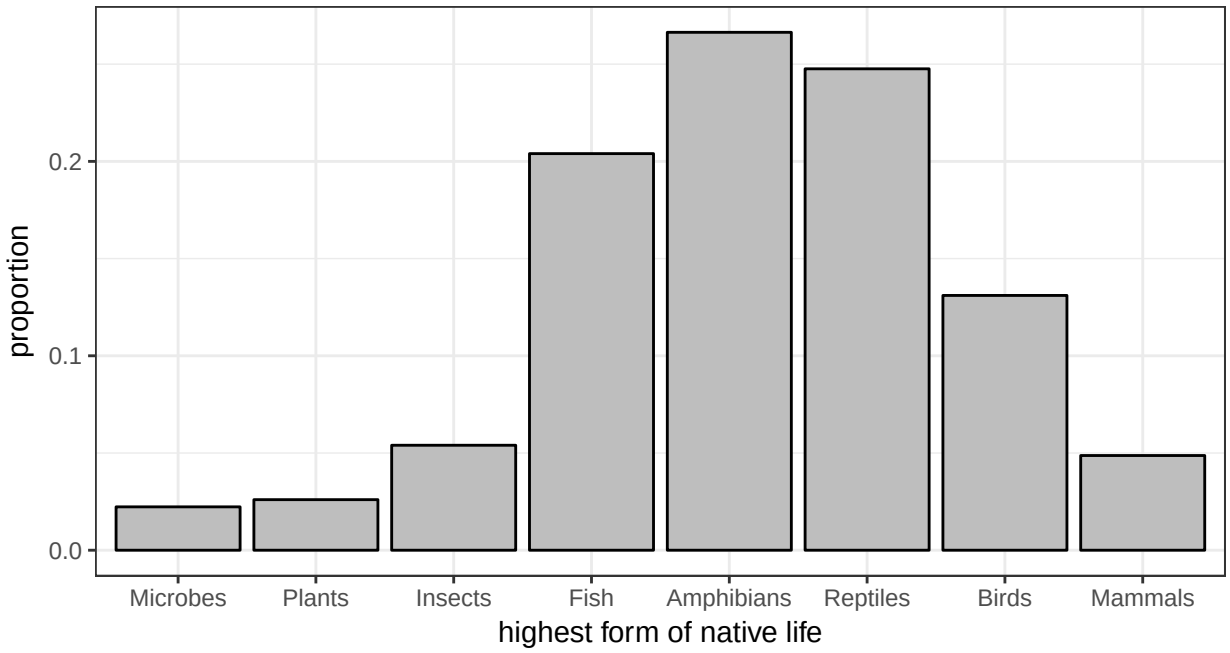

Figure 5: Distribution of highest native life form on habitable planets from 5000 draws of system generation with forced inhabitation

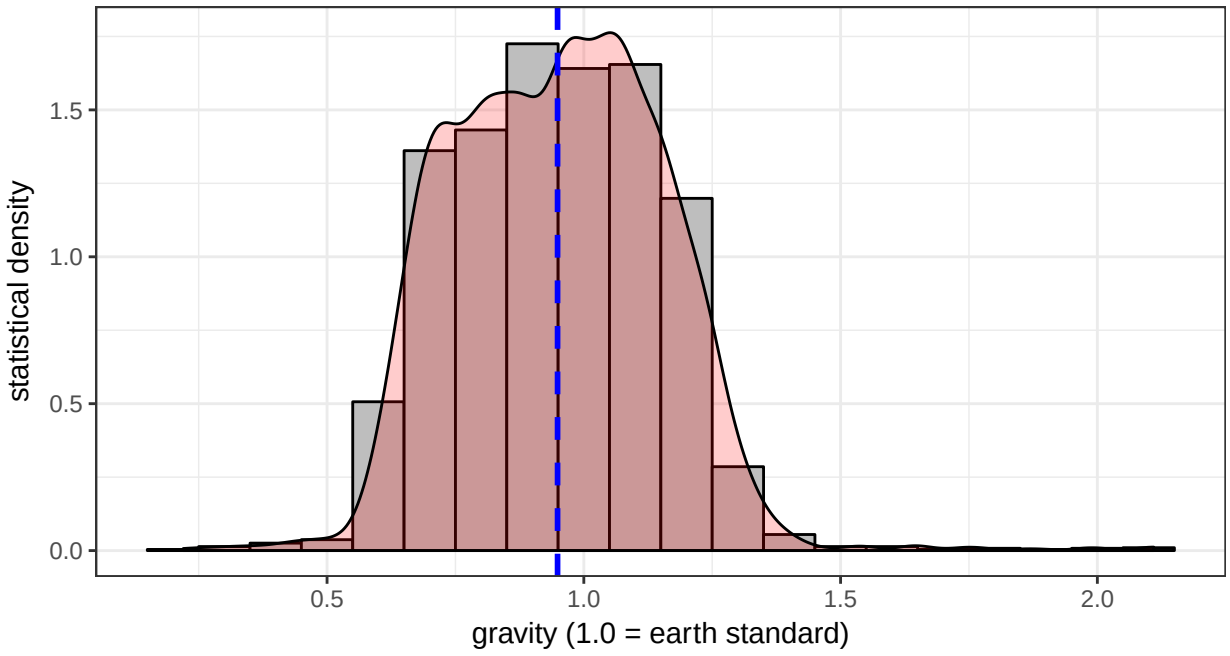

Figure 6: Distribution of gravity on habitable planets from 5000 draws of system generation with forced inhabitation

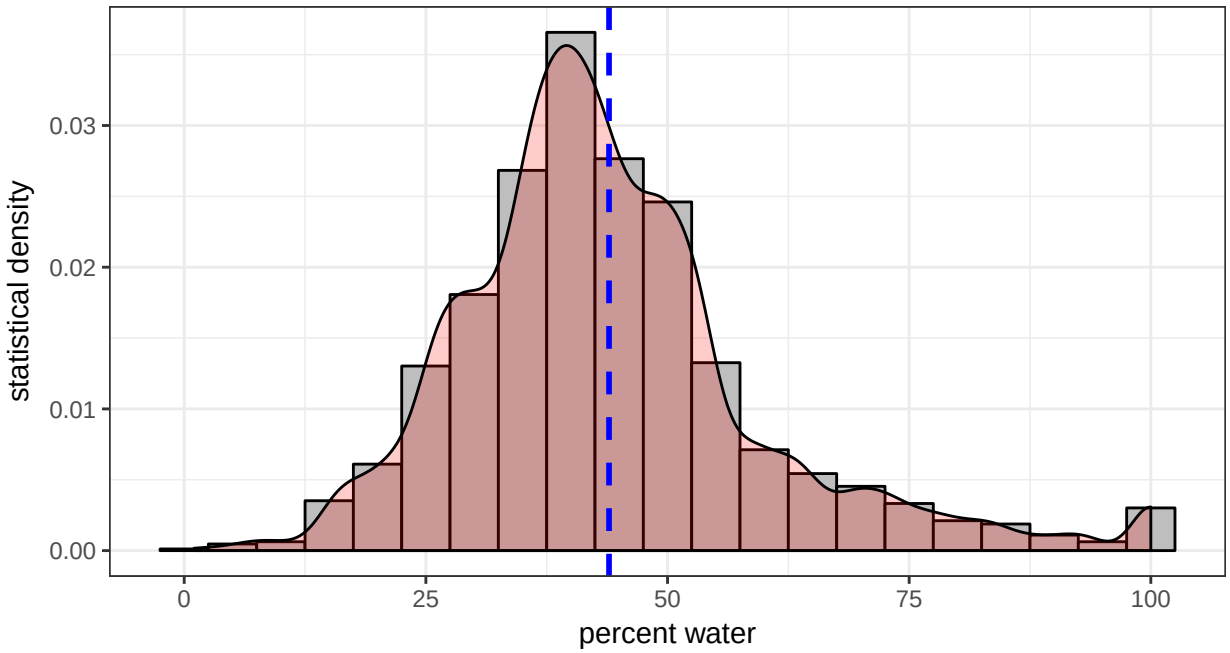

Figure 7: Distribution of surface water coverage on habitable planets from 5000 draws of system generation with forced inhabitation

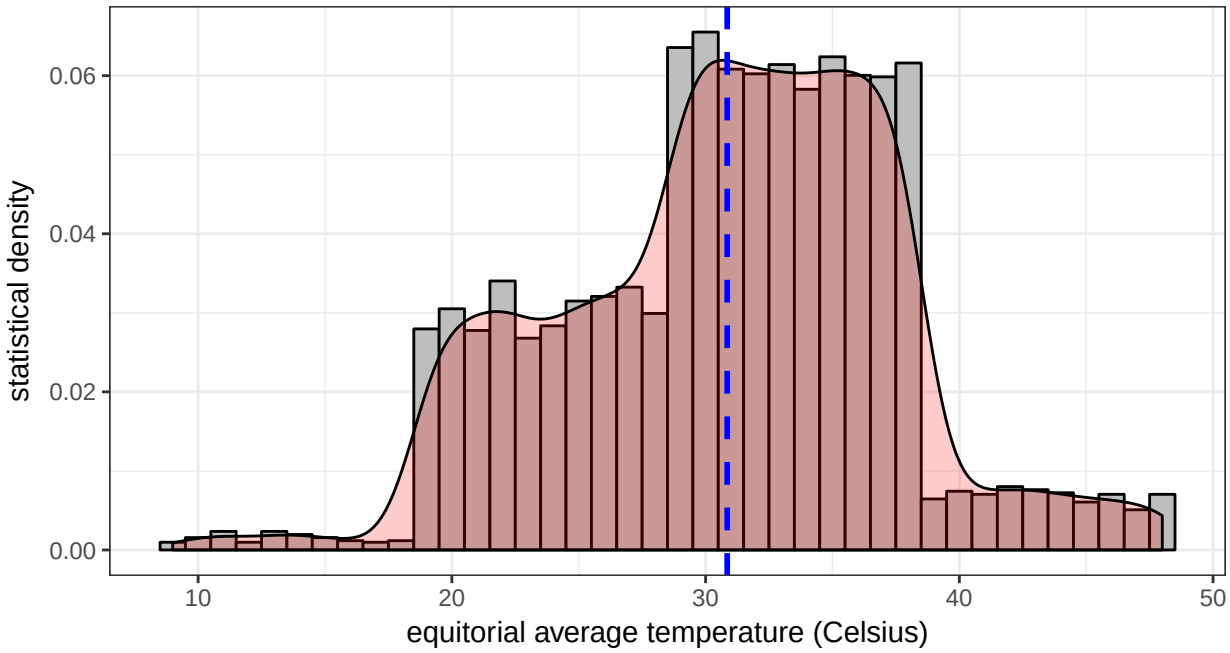

Figure 8: Distribution of equitorial temperature (Celsius) on habitable planets from 5000 draws of system generation with forced inhabitation

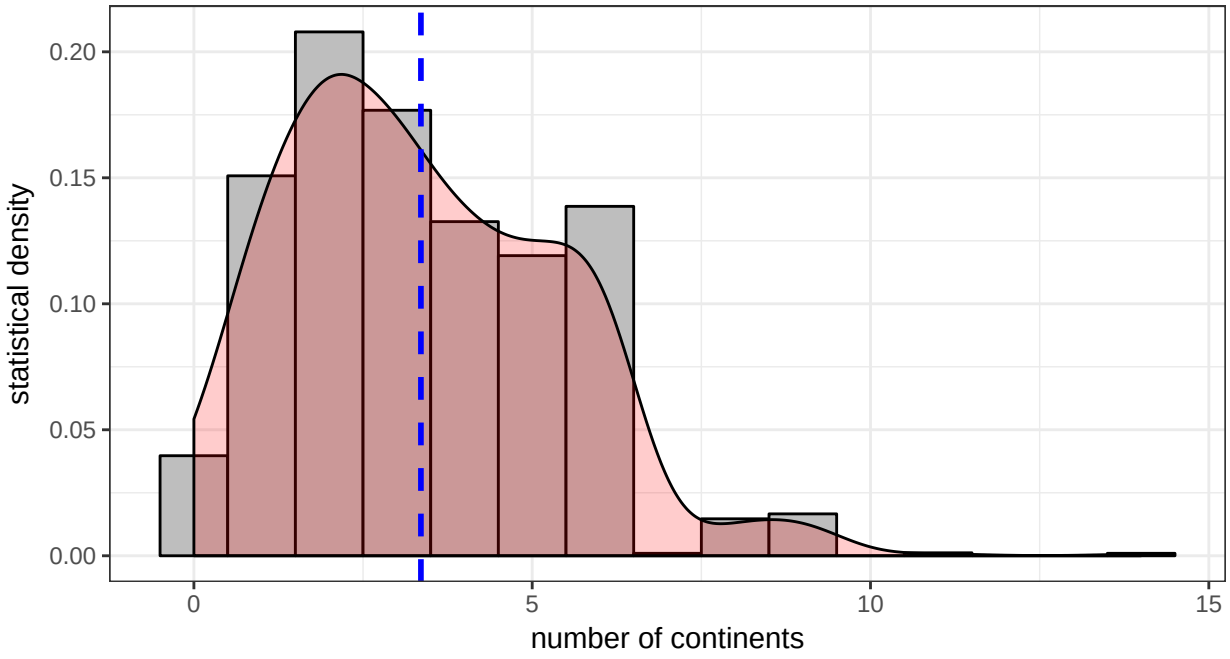

Figure 9: Distribution of continents on habitable planets from 5000 draws of system generation with forced inhabitation

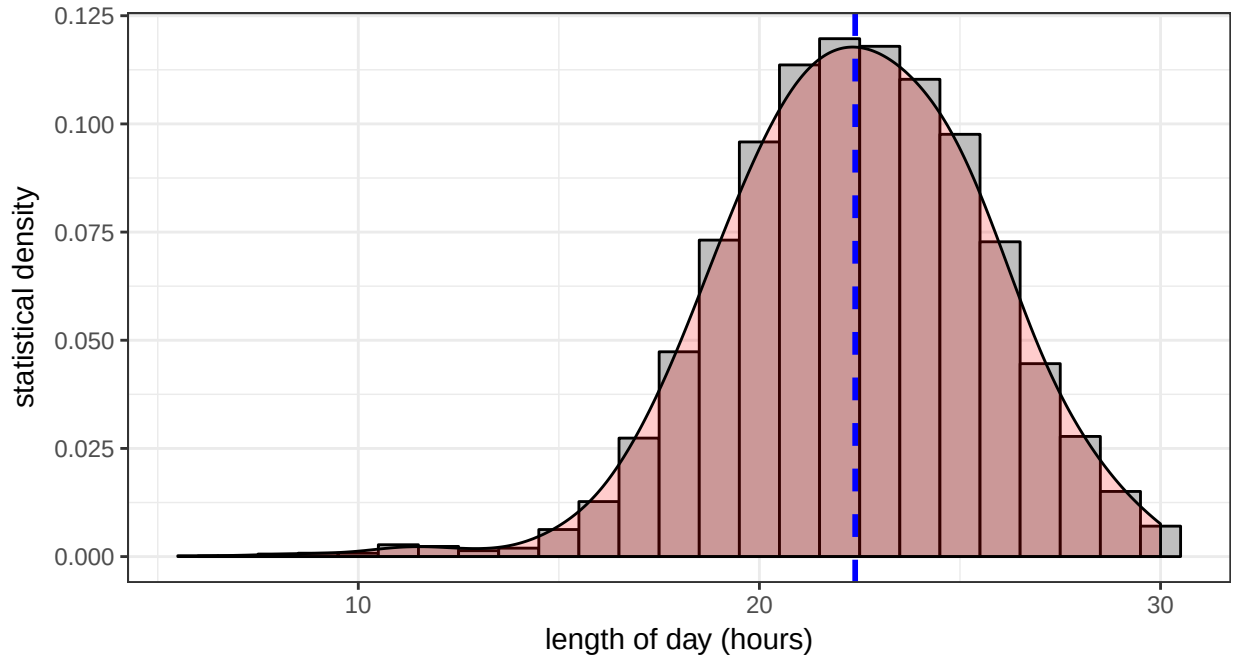

Figure 10: Distribution of day length on habitable planets from 5000 draws of system generation with forced inhabitation

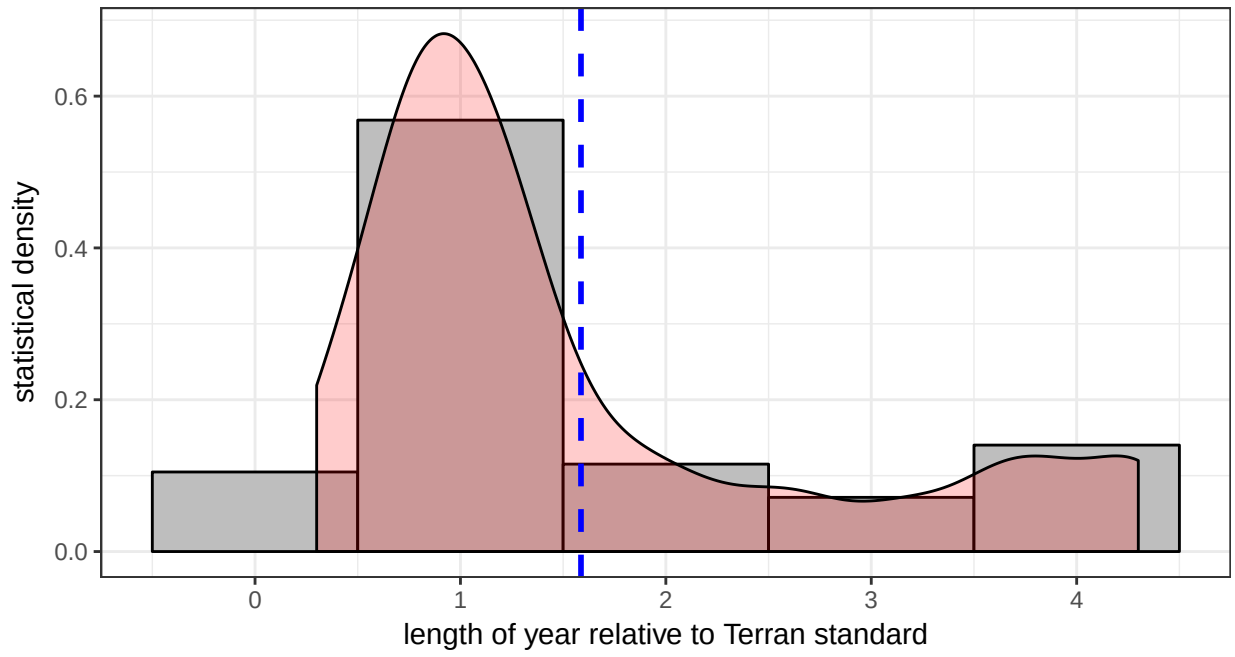

Figure 11: Distribution of year length on habitable planets from 5000 draws of system generation with forced inhabitation

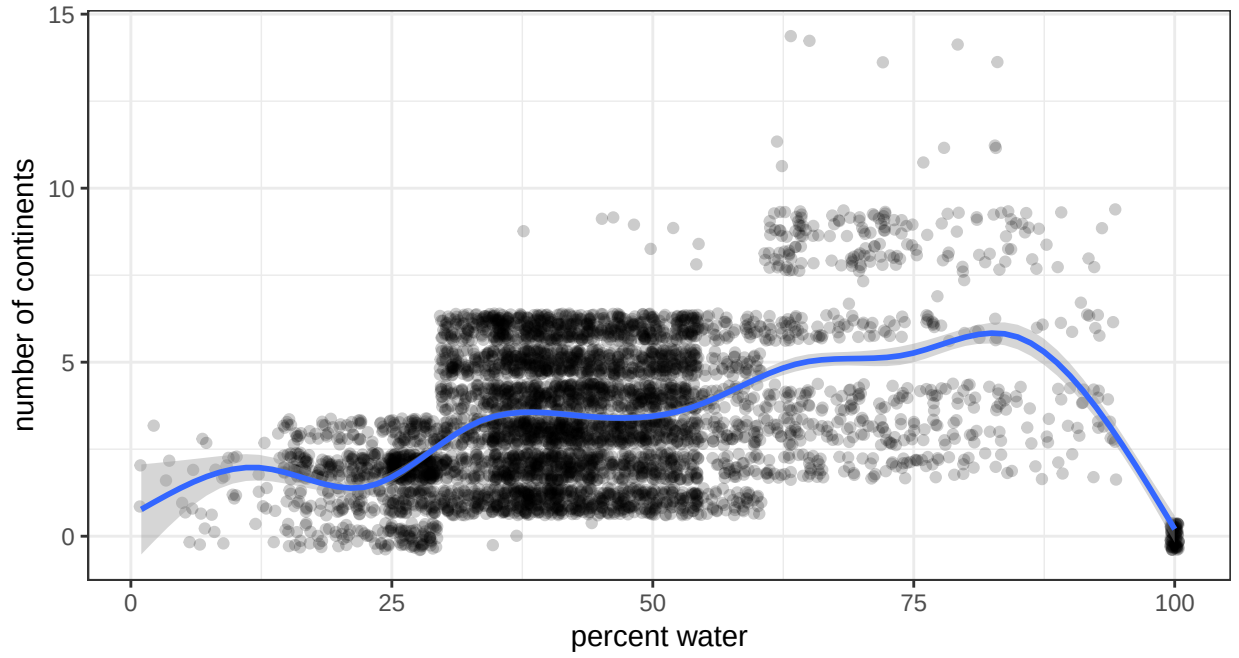

Figure 12: Relationship between water coverage and number of continents on habitable planets from 5000 draws of system generation with forced inhabitation

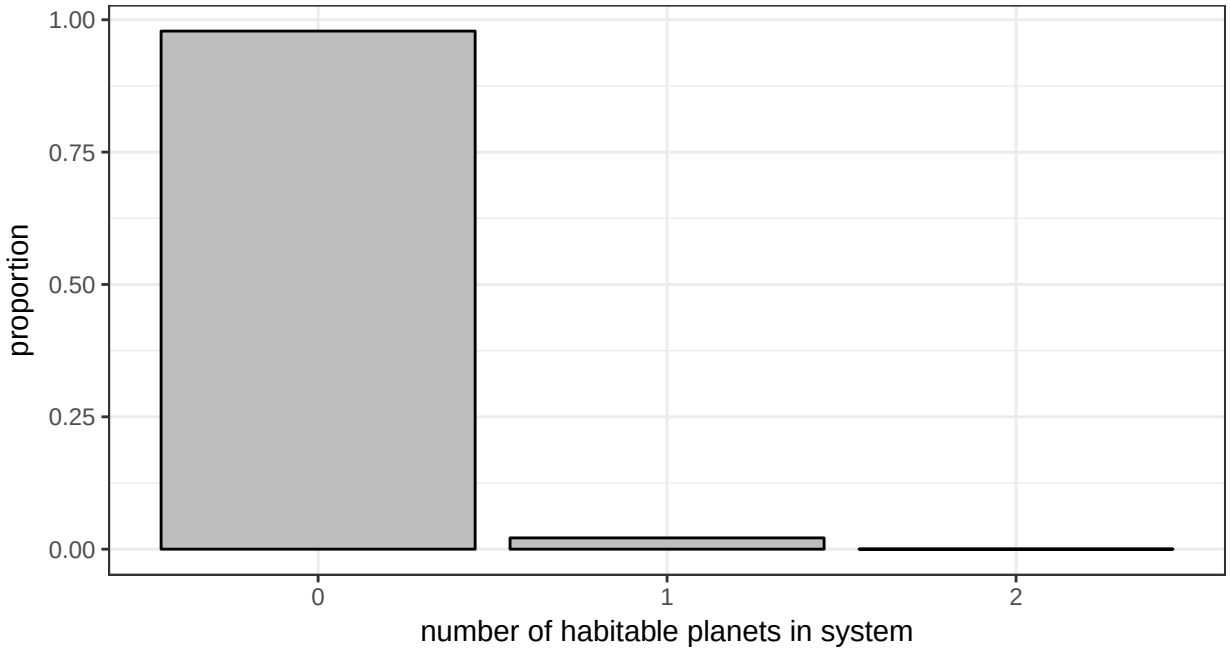

Figure 13: Distribution of the number of habitable planets generated within each system, based on 5000 draws of system generation without forced inhabitation

Table 2: Summary measures for all quantitative variables for habitable worlds when forced inhabitation used

Statistic	N	Mean	St. Dev.	Min	Pctl(25)	Pctl(75)	Max
orbital_dist	1,076	0.555	0.475	0.040	0.200	0.800	2.400
inhabitable	1,076	1.000	0.000	1	1	1	1
life_zone	1,076	1.000	0.000	1	1	1	1
gravity	1,076	0.681	0.231	0.220	0.510	0.850	1.880
temperature	1,076	29.387	7.112	9	24	35	48
water	1,076	26.107	15.375	0	13	37	100
continents	1,076	2.054	1.786	0	1	3	14
diameter	1,076	9,573.420	2,593.229	4,500	7,500	11,500	18,500
density	1,076	4.999	0.977	3.000	4.182	5.844	8.000
escape_velocity	1,076	7,960.561	2,301.180	3,147	6,129	9,488	18,297
orbital_velocity	1,076	5,628.904	1,627.208	2,225	4,334	6,709	12,938
day_length	1,076	22.411	3.043	10	20	25	30
year_length	1,076	1.023	0.577	0.300	0.700	1.200	3.900

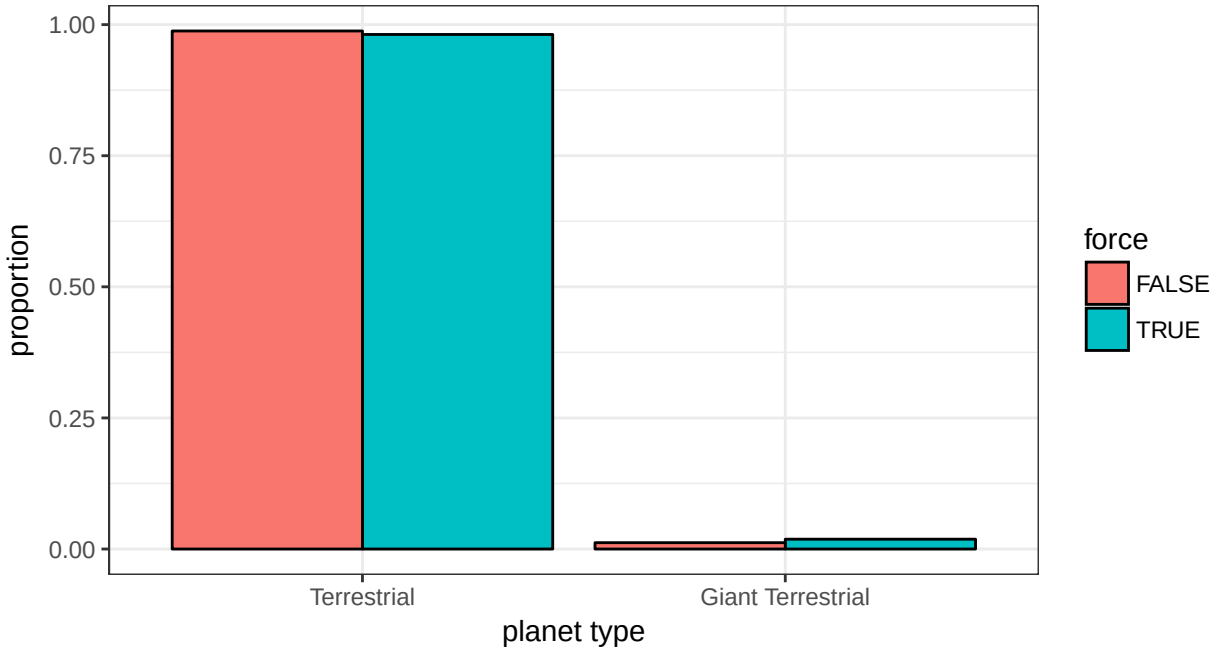

Figure 14: Distribution of planet type on habitable planets by type of generation

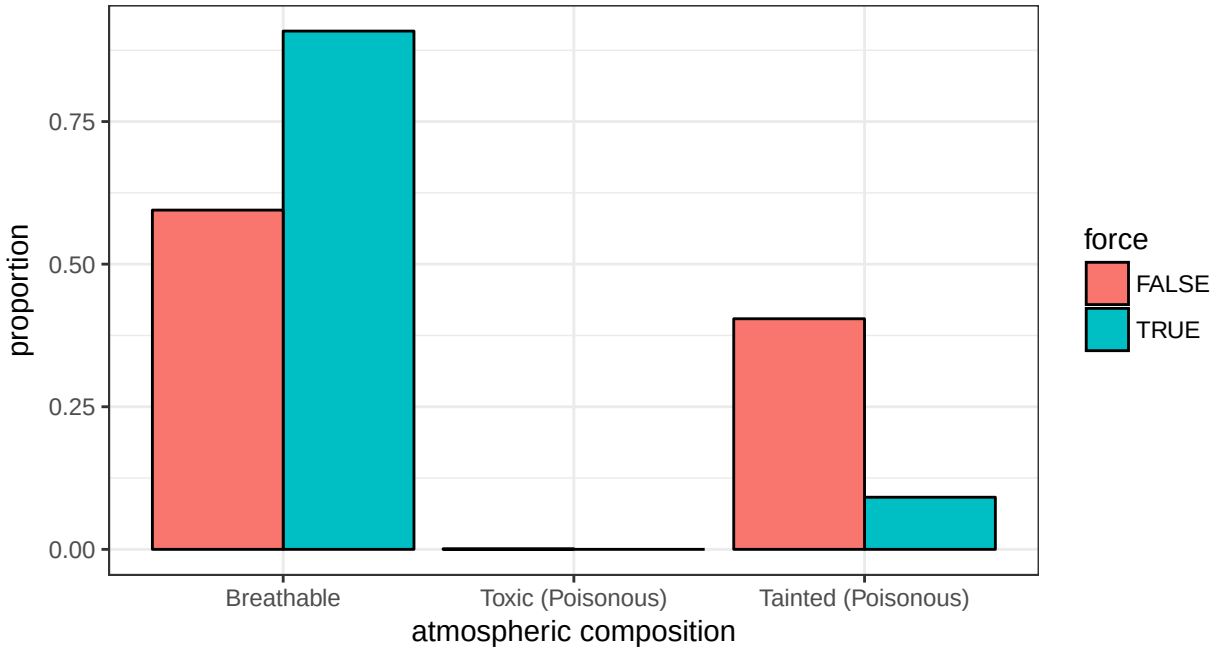

Figure 15: Distribution of atmospheric composition on habitable planets by type of generation

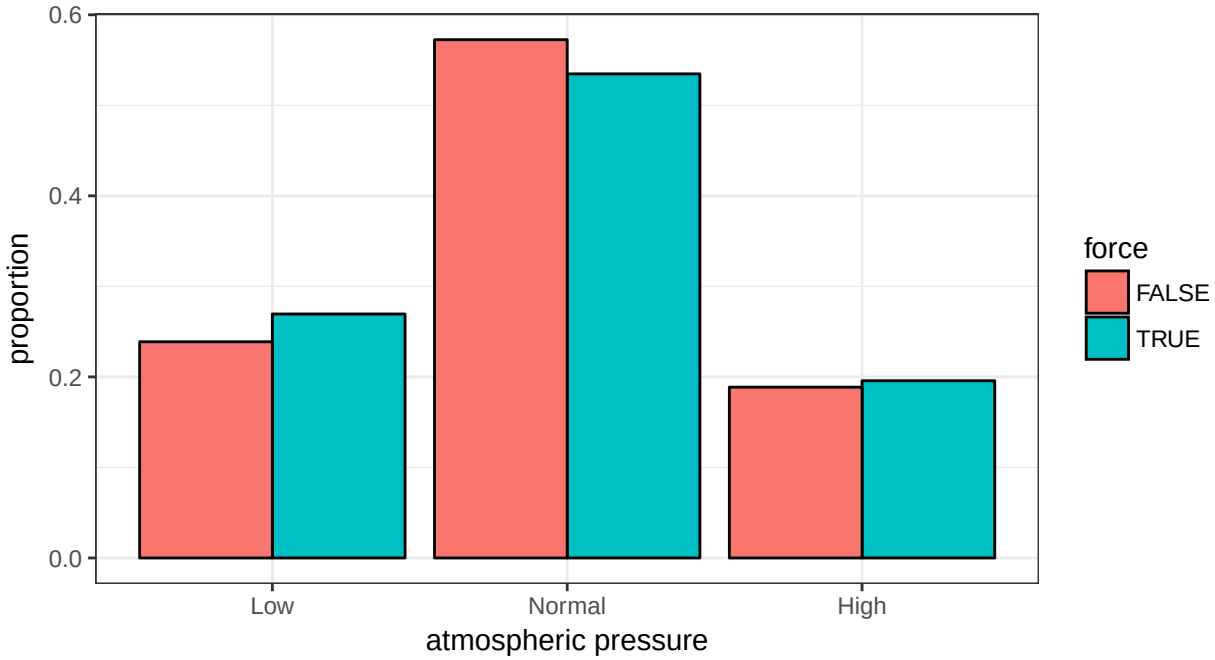

Figure 16: Distribution of atmospheric pressure on habitable planets by type of generation

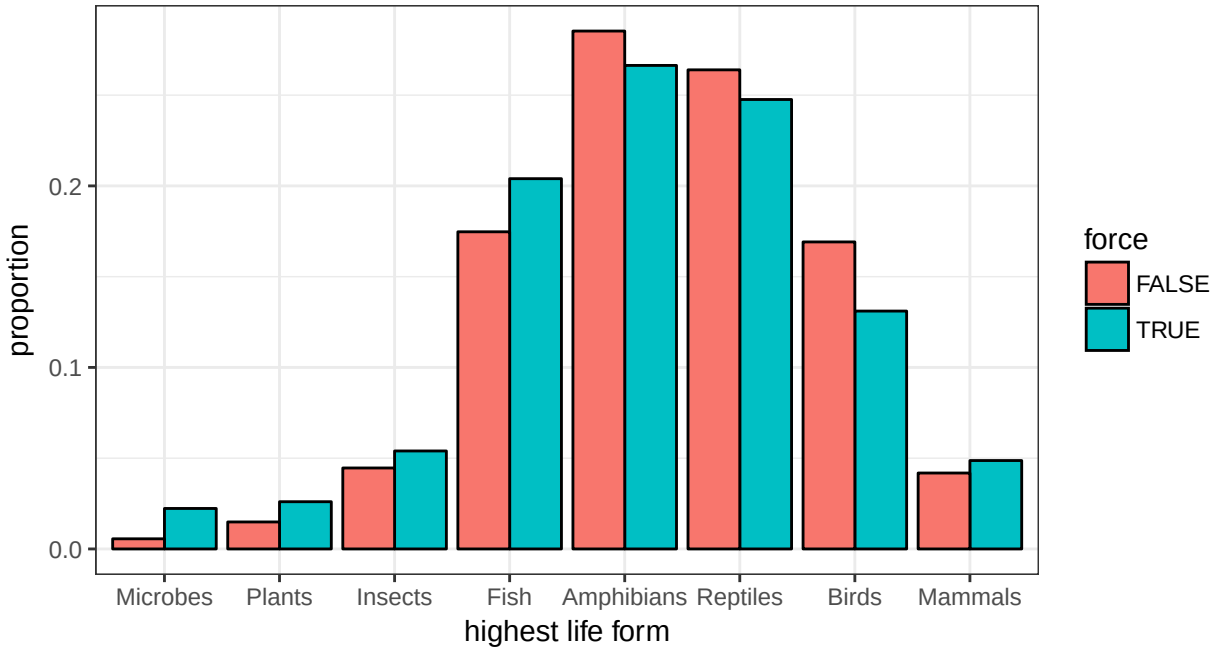

Figure 17: Distribution of highest life form on habitable planets by type of generation

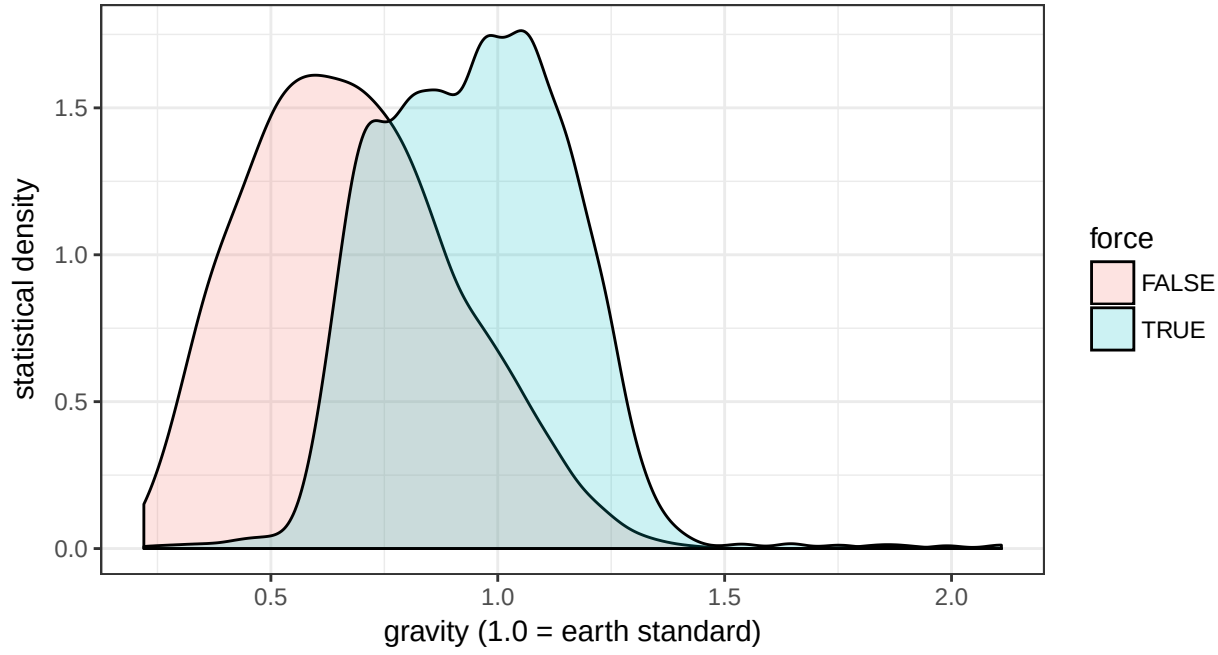

Figure 18: Distribution of gravity on habitable planets by type of generation

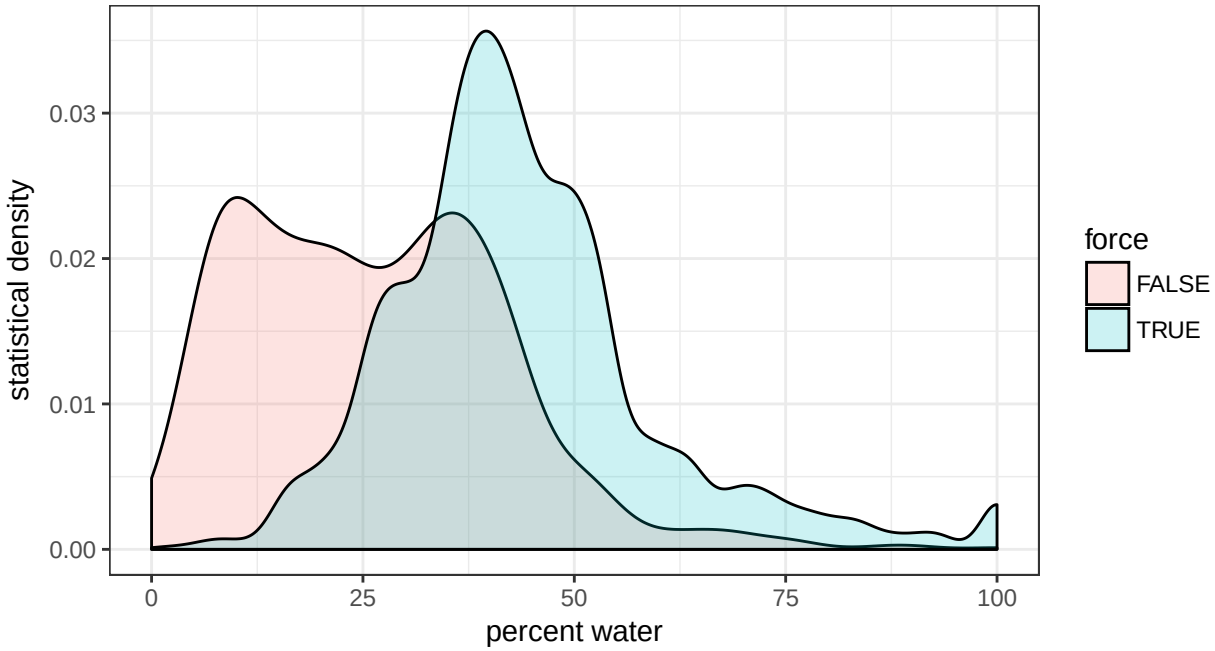

Figure 19: Distribution of surface water coverage on habitable planets by type of generation

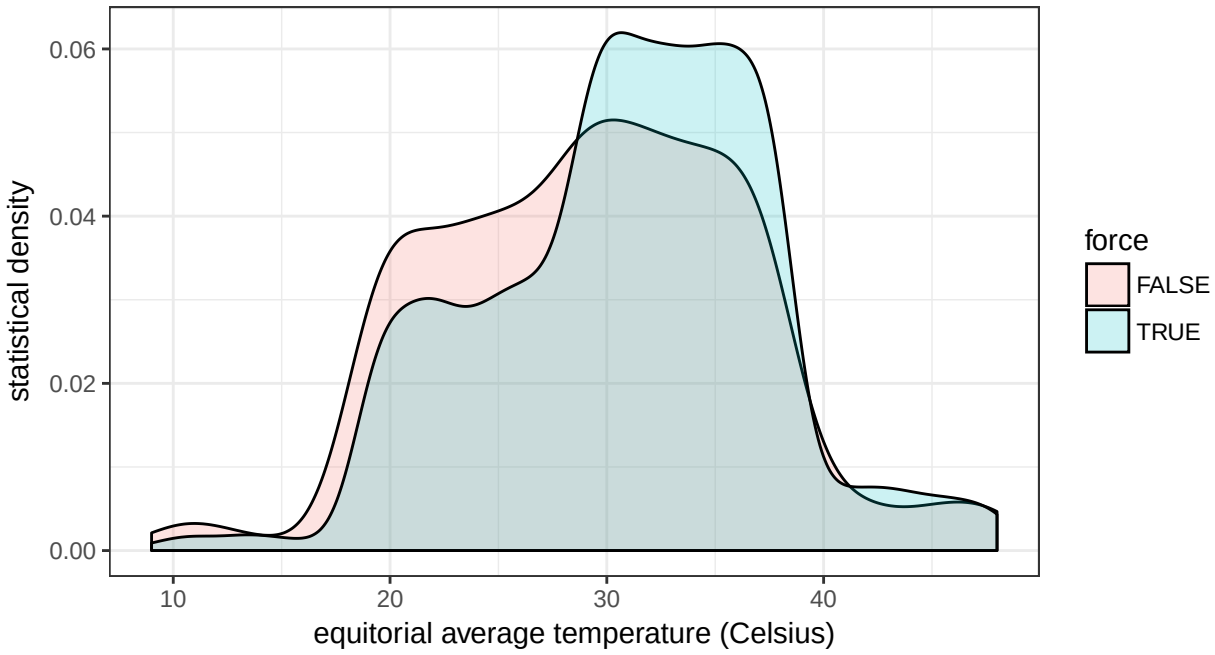

Figure 20: Distribution of temperature on habitable planets by type of generation

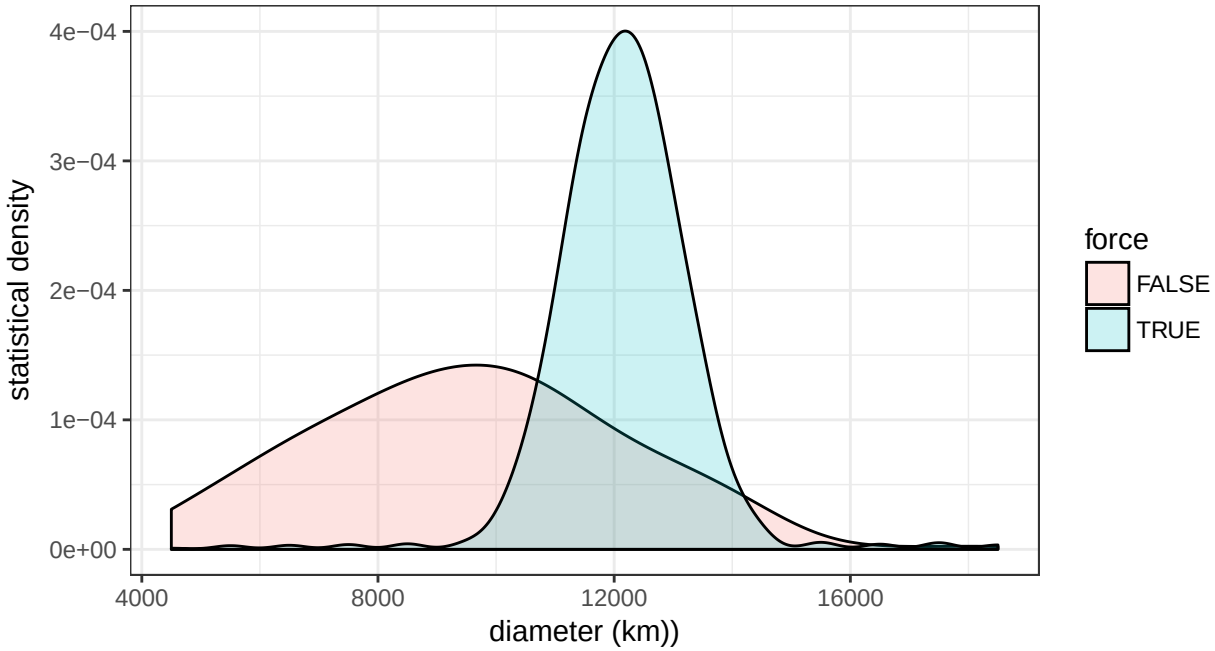

Figure 21: Distribution of diameter on habitable planets by type of generation

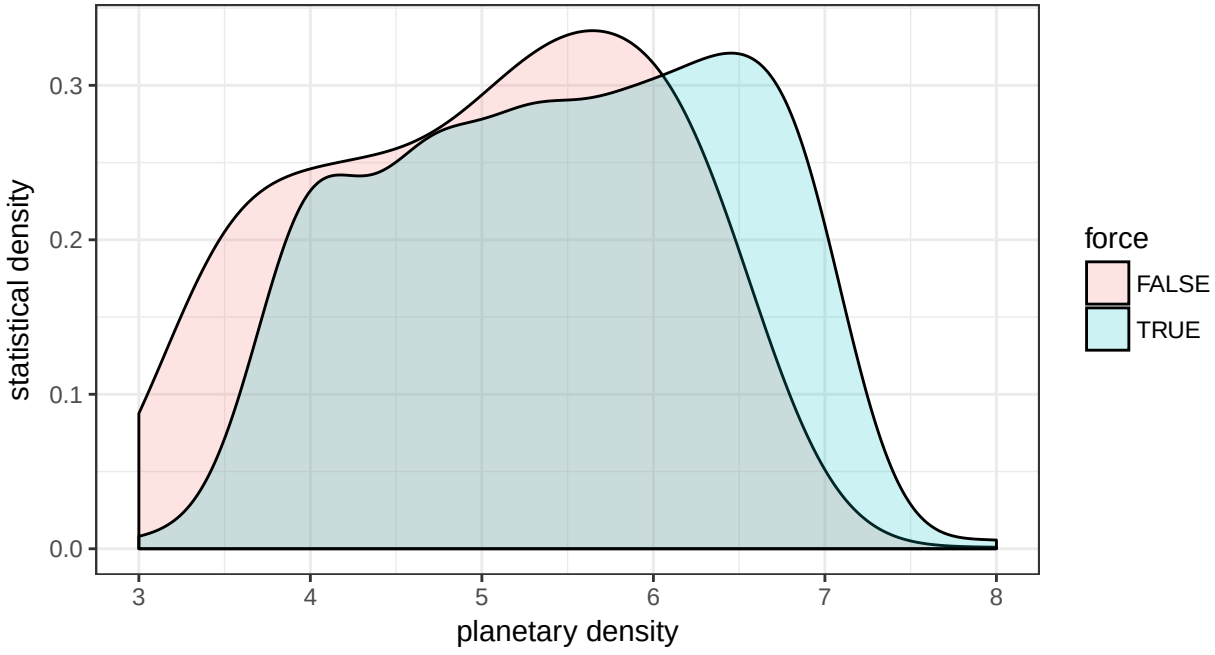

Figure 22: Distribution of density on habitable planets by type of generation

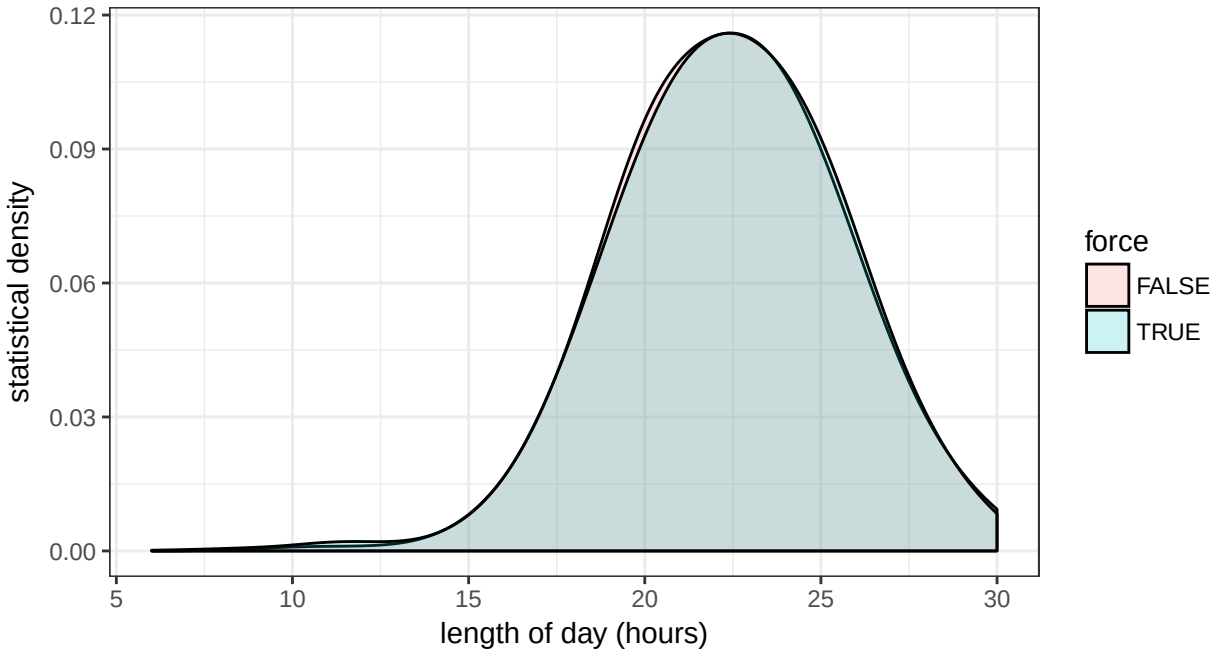

Figure 23: Distribution of day length on habitable planets by type of generation

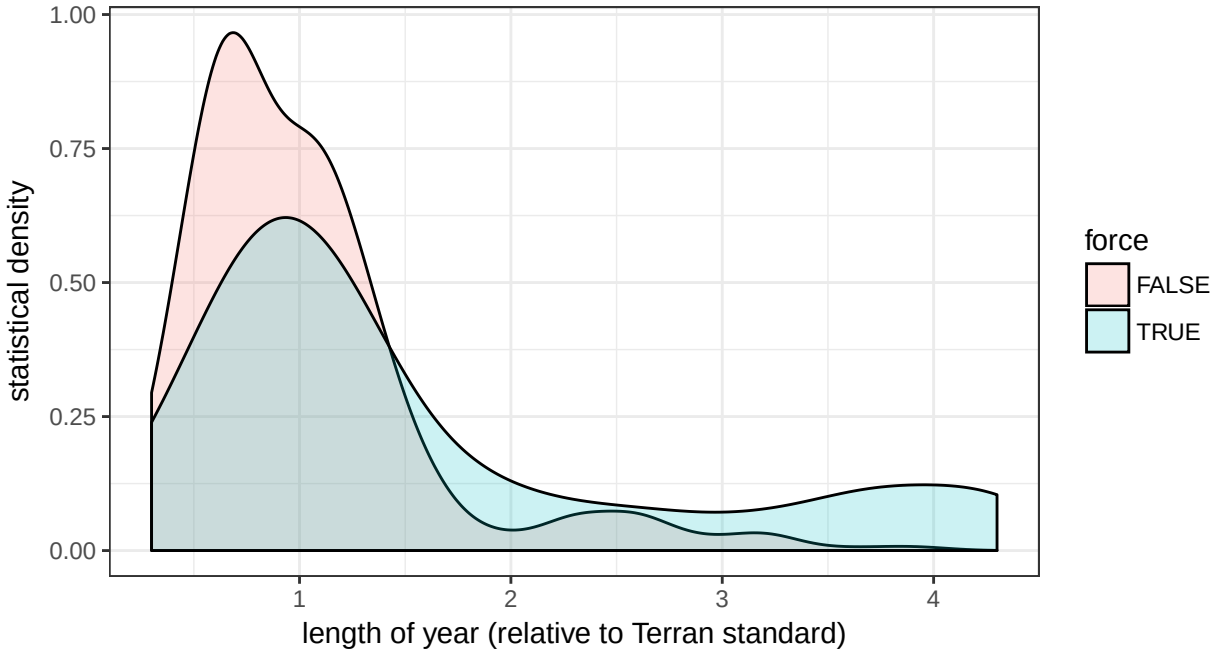

Figure 24: Distribution of year length on habitable planets by type of generation