Figure S1

Parameter Overview

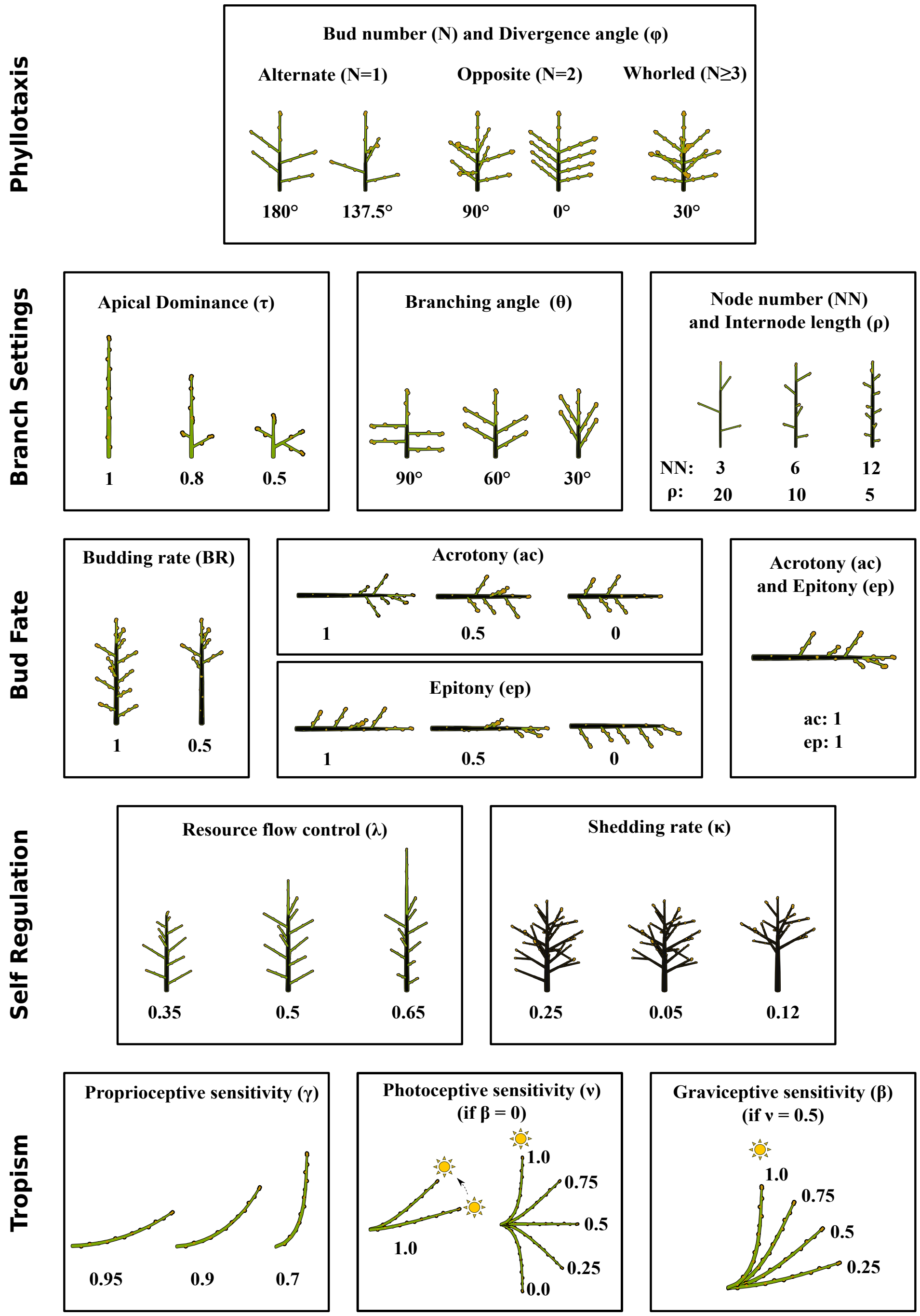

Figure 1: Overview of parameters approximated from biological processes

Figure S2

Example images of real tree species

Figure 2: Example images of the for eight real tree species from the Global Biodiversity Information Facility (GBIF, 2022) image database.

Figure S3

Shapes of the ground truth data

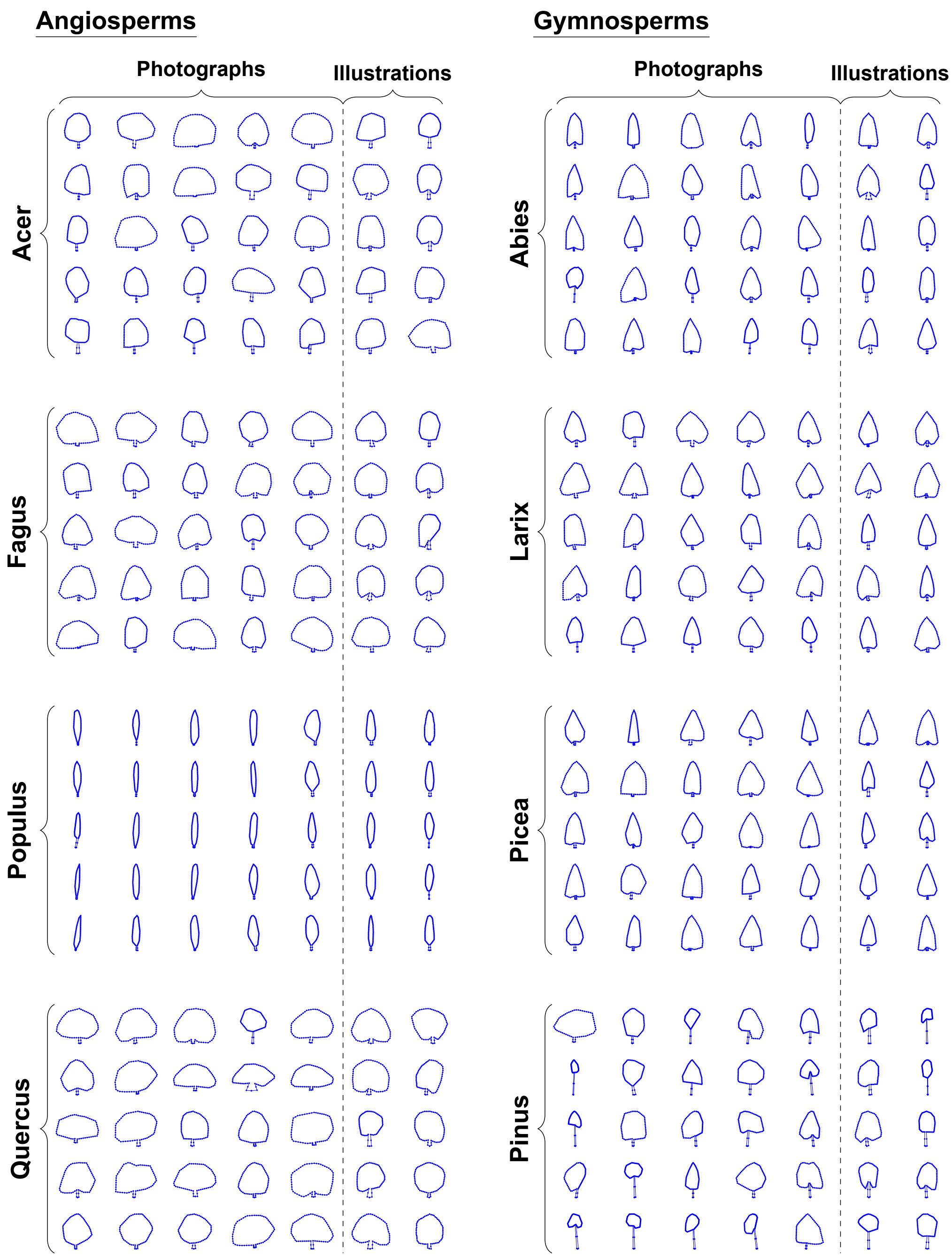

Figure 3: All tree shapes of the real tree photographs and real tree illustrations after landmark data standardization via Procrustes superimposition.

Figure S4

Tree shape affecting by parameter adjustment

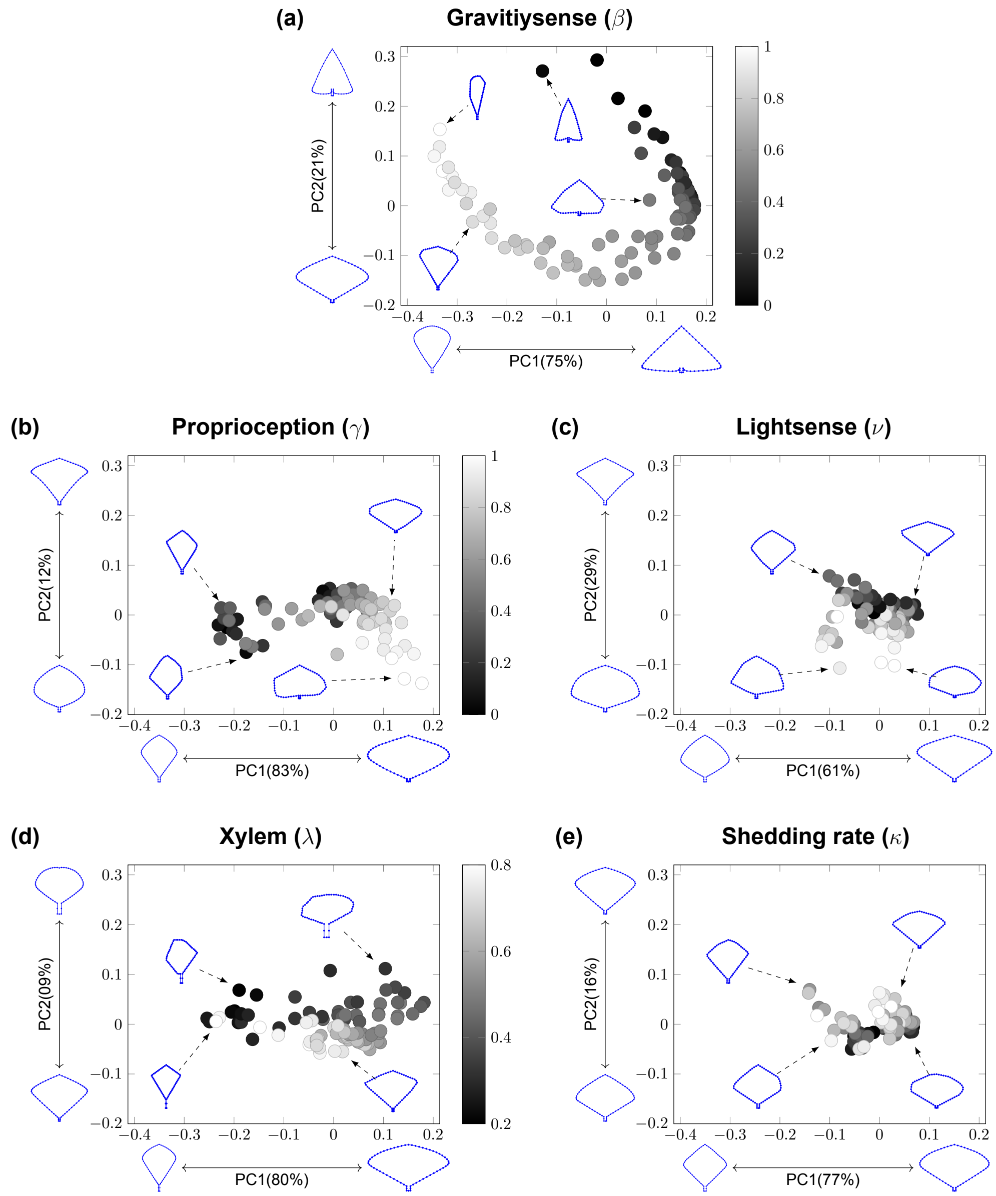

Figure 4: Principal component analysis (PCA) of specific tree shape factors, as shown for gravitysense (a), proprioception (b), lightsense (c), xylem flow (d) and shedding rate (e). The blue wireframe plots represent the shape changes associated with parameter adjustment. A high λ combined with a high κ will affect the lower part of the tree. This results in a long stem and a lower crown height. β in combination with ν and γ determine the preferred direction of growth. They define the $\vec{PGSV}$ and have the most influence on the shape of the tree.

Notes S1

Phyllotaxis parameter derivation

The regular arrangement of leaves on a plant stem and can be categorised by the number of leaves on a *nodium* and their position around the stem. Simplifying by assuming that all leaf primordia are the same size and circular, the vegetation cone can be represented as a cylinder cut lengthwise (Kadereit et al., 2014). The resulting patterns describe the information needed to parameterise the basic forms of phyllotaxis: the number of circles at the same height corresponds to the number of leaves per node N, and the rotation of the pattern provides the divergence angle φ. As soon as there is only one leaf per node, the pattern is alternating. If the golden section of 137.5° is observed, the structure is spiral. If the leaves are always opposite each other, the structure is distichous. With two leaves, the position is either opposite, with $\varphi = 0°$, or opposite-decussate with $\varphi = 90°$. If there are three or more leaves, it is a whorled arrangement (Fig. S1).

Notes S2

Basic definition of the terms used in bud fate.

If the apical bud remains as the leading bud and enters a new phase of dormancy, monopodial growth is present. Sympodial growth occurs when the apical bud stops growing. This can be due to a number of reasons such as death, absorption, abscission. Depending on how many lateral buds are determined to be the next apex, the terms mono-, di- or polychasial are used. To define the order of outgrowth buds, we use several terms defined by (Barthélémy & Caraglio, 2007). Apical dominance as the suppression of directly outgrowing lateral buds by the apical meristem. Acrotony, mesotony and basiotony as topological arrangement (*ac*) and dominant development in distal, middle and proximal parts. Epitony, amphitony and hypotony as spatial orientation (*ep*) and privileged development in the upper, lateral and basal part of the parent axis. High apical dominance produces a proleptic growth pattern. This means that the lateral buds are delayed in initiating growth and go through a period of dormancy. Low apical dominance creates a sylleptic growth pattern where lateral buds grow immediately. This effect is spatially limited in trees and only affects the lateral buds in the current growth year. Once apical dominance is established, there are also buds that must go through a period of dormancy. Only when the conditions are right, the dormancy will break and budding can take place. This process can be understood as the sum of supportive and suppressive influences. As a result of the dormancy break, new lateral axes are created along the vertical parent axis.

Notes S3

Parameter and environment settings for the generated trees (GT)

All generated trees use the same environment settings with voxel size v_{size}=5cm, voxel depth v_d=20, s_w=0.5, shadow throw intensity a=0.33 and reduction per voxel distance b=1.25. The variation of trees based on the initial settings with nodes per sucrose NN=10, internode length ρ=5cm, branching angle $\theta = 60$ and same size buds at creation and during lifetime $r = 1.5mm$. 450 trees are used to compare the effect of the parameters. Therefore we used the spiral pattern ($N = 1$, $\varphi = 137.5$) for 10 and 15 iterations and the opposite decussate pattern ($N = 2$, $\varphi = 90$) for 10 iterations as base settings. For all three settings we generate 30 trees for each tropism and self-regulation parameter $(\gamma, \nu, \beta, \lambda, \kappa)$, for a range from 0 to 1. A further 108 trees are generated to represent the four species Picea, Pinus, Populus and Quercus. They are based on the spiral pattern and individually chosen values for tropism and self-regulation. For each species we vary the parameters ν±0.05, β±0.05, κ±0.1 to get a set of 27 examples per species. The linear interpolation between species combinations includes the last 162 trees. 27 examples are generated for each of the six combinations.