Safe Soil Saves Trees

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Brian is the author of the recent booklet, "The Why, What & How of Bonsai Soil." It's available from the ABS bookstore.

Repotting season approaches! One of the surprising truths faced by new bonsai practitioners is that trees growing in tiny pots need a medium unlike conventional potting "soils". The small volume allocated for the root mass requires special strategies to maximize efficient use of that limited volume. While virtually all bonsai enthusiasts understand that "bonsai soil" must be used, they may not fully grasp exactly why this is true or how to select a good soil. This article attempts to (at least partially) bridge that gap.

Figure 1 summarizes chemical (and solar) input to and output from foliage and roots for a healthy tree. While water and nutrients are absolutely necessary for root function, air and airflow are the most difficult to guarantee over the long term when planting in small containers. Maintaining airflow for years to roots confined to a small pot requires that the soil be:

Granular, with granule size between 1/16" and ¼" (about 2-6 mm), because smaller sizes restrict air flow. Granularity is achieved by manually screening out particle sizes larger and smaller than the desired range.

Stable in physical and chemical structure over time, to avoid fine particles obstructing airflow. In practice this means avoiding either fine-grained or quickly decomposing organic ingredients.

Rigid enough to resist compression and settling, which would also restrict airflow.

Porous, able to hold both water and air after being unrelentingly doused with water.

Fertile, able hold and release nutrients, although this need is secondary to those above, and less fertile soils can be mitigated with fertilizer

Together, these requirements exclude conventional houseplant soils or those that occur in nature.

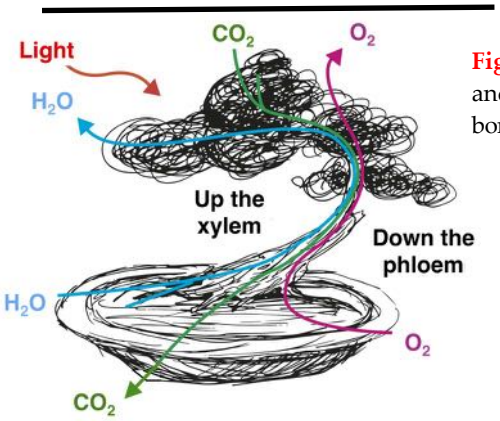


Figure 1. Flow of light, water, oxygen (O_2), and carbon dioxide (CO_2) into and out of a bonsai tree. (Illustration by Lydia Shea)

Too frequently, specific selection of bonsai soil is an afterthought, and the default is what someone else recommended. There is an alternative to that approach described in an ABS booklet[1] and journal articles.[2,3] This approach requires knowing or measuring two characteristics of any soil mix: *field capacity (FC)*, the ability of a soil medium to hold water, and *saturation porosity (SP)*, the ability of the medium to maintain open airflow pathways. Both FC and SP represent a percentage of the soil volume taken up by either water (FC) or air (SP) after flooding the soil in a pot and after the gravitational (excess) water has drained out. Together FC and SP characterize the water and airflow properties of the soil. Bonsai soil should have (FC, SP) located inside the green oval in Figure 2 (next page) , where the FC and SP of various individual ingredients and mixes are shown. An ingredient or mix located inside that region can provide adequate moisture and flow of oxygen and carbon dioxide, as long as it is watered frequently enough. Outside the oval shown in Figure 2, the soil may either dry out too quickly on hot or windy days, causing potentially fatal dehydration, or, in the opposite extreme, be too wet, depriving the roots of sufficient oxygen. **"Safe soil saves trees" is a truism if "safe" is taken to mean favorable FC and SP.**

How does one know the water and air holding capacities (FC and SP, respectively) of any given ingredient or soil mix? It's pretty easy to measure[4] yourself, as explained and encouraged in the booklet and articles referenced in the footnotes. All you need is a container, some duct tape, and a digital kitchen scale.

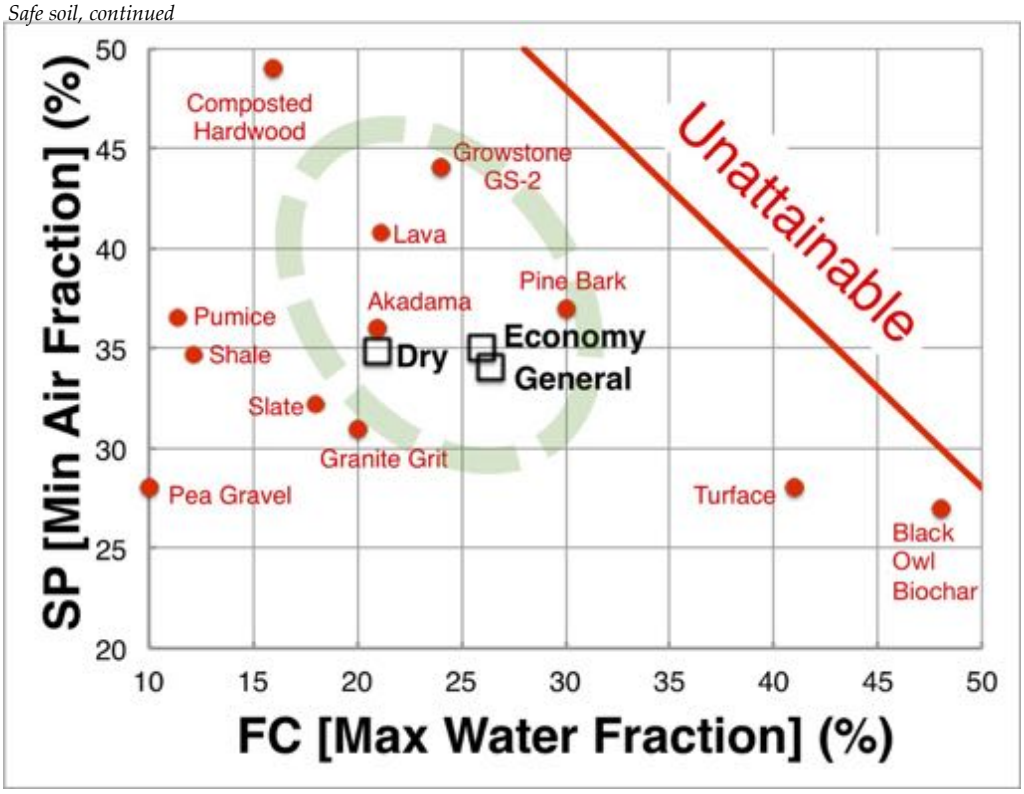


Figure 2. Plot of saturation porosity (SP) vs. field capacity (FC) for various ingredients (circles) and mixes (squares). SP is a measure of airflow capability and FC of water-holding capacity. **The green oval marks the "sweet spot" for bonsai soils**: a region of FC and SP that promotes healthy trees.

Some take the view that: *Cost and availability be damned, bonsai soil should always consist of high quality akadama, lava, and pumice!* (See Figure 3, next page) But there are other non-traditional recipes that can also yield excellent FC and SP, with the added benefits of having ingredients that are easier to find and afford. The ingredients and mixes below are only examples; there are others.

Turface® is the brand name for calcined clay, and is used to absorb excess moisture on athletic fields. If properly screened for granule size, it can act as a water-holding and fertile component of a bonsai mix. However, by itself it would be too wet (high FC, low SP) and should be limited to no more than 20% by volume of the mix. It is relatively inexpensive and available at many farm and garden stores.

Growstone® GS-2 is a highly porous manufactured product made from recycled glass (Fig. 4, left). It can be ordered online for a reasonable price or obtained in some garden stores. It absorbs a reasonable amount of water (good FC) while maintaining a very high level of air content (high SP). It is physically and chemically stable. Its primary drawbacks are its low mass density, lack of fertility, whitish-gray color, and propensity to kick up dust while screening. However, if properly screened, it can be a very useful component to keep air flowing, but at no more than 30% by volume.

Biochar is a specially prepared horticultural charcoal that has spectacular water-holding capability (very high FC, very low SP), stability, fertility, and interior spaces that are favorable to beneficial microbes. Its small granular size (see Fig. 4, right) and peculiar internal structure allow it to retain water exceptionally well. Unlike organics, it is chemically stable. Its drawbacks include very low mass density and messy handling: even biochar with the granule size shown in Fig. 4 has powdery content that can become an airborne respiratory hazard and housekeeping nuisance. It should constitute no more than 20% by volume of any mix.

Pine bark and **composted hardwood** are extremely cheap and easily found in garden stores as mulch, but require a great deal of labor to screen for granule size; over half of mulch volume is discarded as either too fine or too coarse. They are organic and therefore have good fertility. They will also, over time, eventually break down into smaller particles, but typically only after 3-4 years or longer.

Pea gravel and **granite grit** are cheaper still and also widely available at garden stores, but may require screening and/or washing. These are not porous whatsoever; nor are they fertile. But they do provide ballast to counteract lighter materials and hold only a tiny amount of water between adjacent granules (low FC and low SP).

The possibilities for devising "safe" recipes for bonsai soil mixes are endless. Importantly, they can be adjusted to meet specific needs of a particular microclimate, watering regimen, or species' preferences. Below are examples of three such mixes. In the right combinations, individual ingredients which have far from optimal water or air holding characteristics can, together, form a "safe" mix. Only the costs of materials are listed. The costs are less than half that of commercial bonsai soils (because they omit labor and profit). Note from Figure 2 (previous page) that all three mixes lie within the favorable oval of water- and air-holding capacity.

Economy Mix: 30% lava, 20% composted hardwood, 10% Growstone GS-2, 10% Turface, 10% biochar, 10% pine bark, 10% pea gravel. $1.70/qt.
General Mix: 50% lava, 30% akadama, 10% Growstone GS-2, 10% biochar. $3.30/qt.
Dry Mix: 40% lava, 20% slate, 10% pumice, 10% shale, 10% GS-2, 10% biochar. $2.60/qt.

The General Mix might be best used for mature trees; the Dry Mix might be used for pines and any other trees that have a high risk of root rot or prefer a drier soil; the Economy Mix might be used for tropical and other rapidly growing trees that will be repotted in less than 4 years, or when cost is a primary concern. If they so choose, members of regional clubs can prepare good soil mixes for members, taking advantage of efficiencies of scale to keep costs down and availability up.

This novel approach bypasses the usual squabbling over "best" soil recipes. ***The Why, What, & How…*** ABS booklet (see last page) explains how to quantitatively characterize any soil mix with simple measurements that anyone can perform. Ingredient selection can be adjusted to produce desired characteristics of water retention, airflow, density, and cost. Easy to follow instructions empower hobbyists and professionals alike to develop and refine soils that meet their own needs. Give it a read to take control of your own safe soil!

Figure 3. Close-ups of some of the main soil components mentioned in this article.

REFERENCES
1 Brian Heltsley, *The What, Why, and How of Bonsai Soil,* American Bonsal Society booklet (2018).
2 Brian Heltsley, "Water Retention and Drainage in Bonsai Soil", *Journal of the American Bonsai Society*, Volume 48, Number 4 (2014), p. 18
3 Scott Barboza, "Soil Concepts" (Parts 1-4), *Journal of the American Bonsai Society*, Volumes 51-52, (2017-2018).
4 Jack Wikle, International Bonsai, 2011 No. 2.

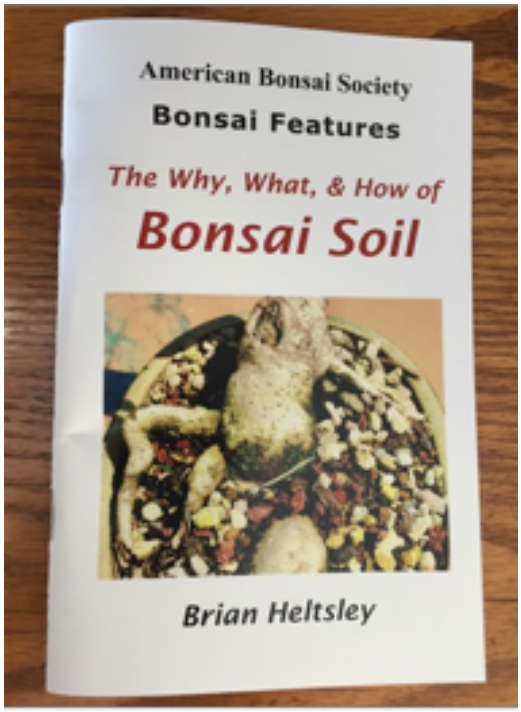
Editor's note: All .pdf documents have a tool bar which includes a zoom function, in case you want to enlarge images or Figures.

From the American Bonsai Bookstore

The Why, What, & How of Bonsai Soil

Author: Brian Heltsley
Pages: 44
Publication Type: Softcover
Year Published: 2018
Product Size: 5.5” x 8.5”

Bonsai growing media must encourage and support a highly ramified network of fine roots in a very small volume. This booklet takes a novel approach to achieving that goal, bypassing the usual squabbling over “best” recipes. It explains how to quantitatively characterize any soil mix with simple measurements that anyone can perform. Ingredient selection can be consciously tuned for water retention, airflow, density, and cost. Easy to follow instructions empower hobbyists and professionals alike to develop and refine soils that meet their own needs.



Along with other instructional materials, available from the ABS bookstore at

http://absbonsai.org/product-category/books