Are fast-grown trees of low quality?

A primer on tree growth, wood properties and the value of wood products

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This publication is intended for foresters, loggers, landowners and others with an interest in how forest management can affect the commercial quality of wood products.

Forest management can affect the quality of wood products. Foresters can influence the *growth rate* of individual trees, for example, by suppressing weeds and controlling the number of trees per acre. The *species* of trees in the forest is controlled by planting desired species or with other techniques that influence the regeneration of select species. Another important forestry decision is the *rotation age*; the age of the tree at which it is ready for harvest. These forestry decisions are often interrelated; for example, the choice of rotation age is influenced by growth rate and tree species.

Often in commercial forestry operations, the objective is to increase individual tree growth rates, so as to maximize the volume of wood in select tree species and minimize the rotation age. But can fast-grown trees from plantations and managed forests produce good wood? Answering this question requires some consideration of tree biology, the characteristics that define wood quality, and how tree age and growth rate affect wood products.

Why do trees grow faster? Basics of tree biology

Tree requirements

Trees need light, water and nutrients to grow. If any one of these is in short supply, the growth of the tree is limited. Light and water are needed to produce sugars through photosynthesis. These sugars are then used as an energy source for all tree processes. If either the building blocks or the light energy is limited, the tree will not grow at its maximum rate. Nutrients are the building blocks of new tree growth, because phosphorous, nitrogen, calcium and magnesium, along with 14 other elements, are important components of new cells.

Species differences

Each species has a genetically determined maximum rate at which it can collect and make use of light, water and nutrients. This determines the sites that it will grow on and its potential growth rate. *Pioneer species* usually have high rates of photosynthesis and are very efficient at collecting water and nutrients. As a result, they are able to grow very quickly, may reach reproductive age early and may have a relatively short life span. In contrast, some species have adaptations that allow the tree to grow in partial shade or where water and nutrients are limited, but these adaptations often limit their maximum growth rates.

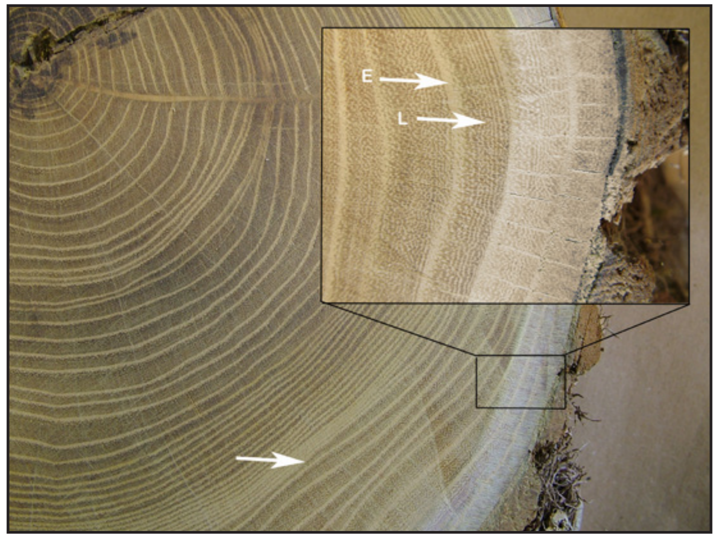
Carbon allocation

Photosynthesis incorporates carbon from the air into sugars; these can be used immediately or stored for later use. The most immediate need of the tree is met first: the maintenance of living cells. The second most critical need is new leaves and roots, because over time these lose their capacity to photosynthesize and collect water and nutrients, and must be replaced. Reproductive structures, if present, draw considerable energy, particularly during seed development. Energy remaining after these immediate needs are met is directed to storage compartments in roots and stems. While some new wood is produced each year, it is only after the tree's other needs are met that energy is directed to wood growth. Rapid-diameter (wood) growth generally indicates that the tree has more than enough resources to meet its basic needs.

Growth rings

In temperate forests, seasonal wood production results in annual growth rings. Some *ring-porous* species such as oak and pine produce wood of low density in spring (earlywood), and high density in summer (latewood). This results in annual rings that are easily visible, as the denser latewood appears visibly darker in many species. In *diffuse-porous* hardwood species, (such as poplars and maple), the wood produced is similar in density and anatomy year-round, and the growth rings are less distinct.

Because young trees have more leaves relative to stem and root volume, and because they may experience less competition for resources in plantation settings, young trees often produce more energy than is needed to meet their immediate needs; this results in more wood production and wide growth rings. As trees age, energy demands increase, less energy remains for wood production, and growth rings are often relatively narrow. However, there are often wide fluctuations in growth-ring size within and between trees, reflecting changes in the availability of light, water and nutrients.



Growth rings are clearly visible, with earlywood (E) appearing as thin white lines. The dark bands are latewood (L). Rings become narrower with age, until a stand thinning (arrow) increased resource availability to this tree and it grew more rapidly. All but the outermost two growth rings are heartwood in this sample.

What makes wood 'good'? The characteristics that define wood quality

Wood quality can be defined as its suitability for a given use. Because of the many potential uses for wood – from firewood to fine furniture – there are a number of criteria that can be used for evaluation. The following are a few of the more important factors.

Species

Tree species is one of the most important factors determining the quality and value of wood products. A species' inherent properties result from chemistry and anatomy, which are mostly controlled by genetics. For example, black walnut is generally considered to be a good-quality wood because of its attractive appearance and good wood-working properties. Because beauty is subjective, and tastes change, preferences in wood species change over time and can differ from market to market.

Geographical origin

Differences in regional supply characteristics can influence wood quality and value. For example, American hardwood lumber in the East is stratified into three groups: Northern, Appalachian and Southern and, in general, Northern hardwood lumber sells at a premium. Wood is sold internationally with these designations to assist customers who require consistent material from one purchase to the next.

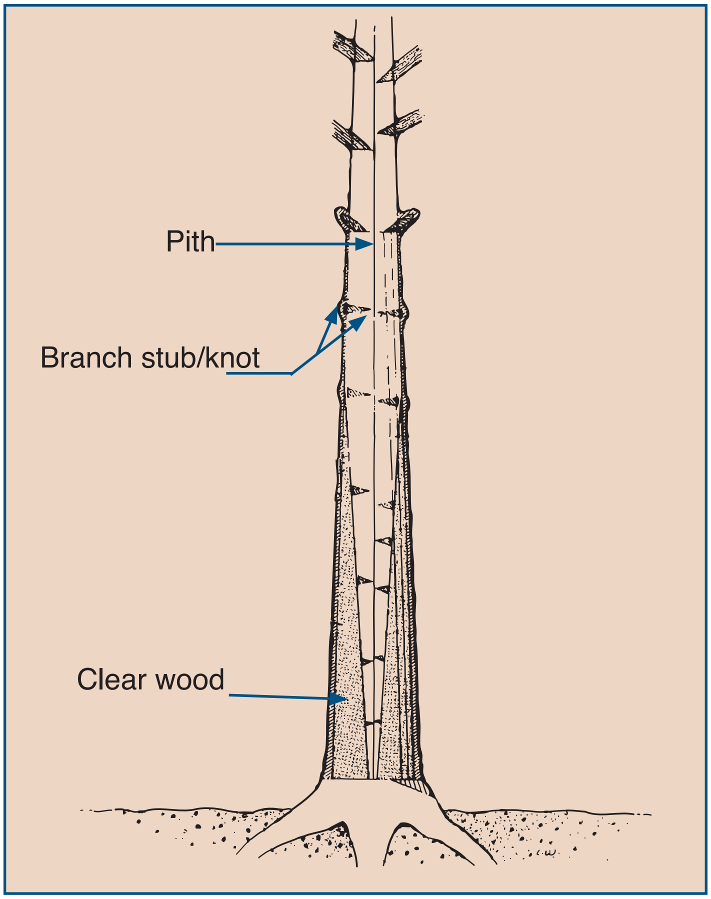
Log size

Excluding consideration of major defects, larger logs are, in general, more valuable than smaller logs. There are a number of reasons for this, including processing characteristics and product possibilities. For example, a supply of larger logs will require fewer log loading and handling steps. Also, larger boards usually have higher value. The grading rules for hardwood lumber require that the best grades of lumber be relatively wide and long. Of course, wider lumber requires larger-diameter logs. In many cases, silviculture operations are intended to produce (sufficiently) large logs in the shortest possible time (rotation age).

Clear wood

Another reason that relatively large logs are more valuable is because they are likely to contain more *clear wood.* Clear wood is free of defects such as knots. In addition to requiring larger boards, the hardwood lumber grading rules require greater proportions of clear wood in the higher, more valuable grades. Clear wood is also important for strength and aesthetics of softwood lumber and veneer.

As trees get older, there is increasing tendency for old branches to die and fall off, especially near the base of the tree where light levels are lower (and where trees are larger in diameter). In the years after this natural *self-pruning,* clear wood layers will form over the branch stub. Self-pruning can be affected by tree spacing; pruning can also be done manually. The branches closer to the base of the tree (i.e., in the 'butt' log) tend to be smaller because they started growing on the young, small tree. The small knots associated with these smaller branches reduce the wood quality less than the bigger knots that are higher up the tree.



At the base of growing trees, knots tend to be smaller and covered by thicker layers of clear, mature wood.

Abnormal wood

There are significant wood-quality variations within individual trees. *Juvenile wood* refers to the first 5-15 years of wood growth within a growing stem or branch. Juvenile wood has different (usually inferior) properties than the *mature wood* that forms in subsequent years. Juvenile wood is not visibly different, but it can have shorter, weaker and less dense wood cells. Structural differences within the cells of juvenile wood can result in abnormal shrinkage characteristics that result in warped lumber.

Reaction wood is wood that forms in leaning trees. Reaction wood is of two types: softwoods form *compression* wood on the underside of leaning stems, while hardwoods form *tension* wood on the upper side of the stem. Compression and tension wood are chemically and structurally different from normal wood. These differences can affect the in-service performance of reaction wood.

Heartwood

Heartwood is the completely dead inner core of wood in a tree trunk. In contrast, the *sapwood* is the outer band of wood that contains some living cells and conducts water in the living tree. Heartwood properties are highly variable, but the heartwood of some species contains naturally occurring chemicals that can give the wood distinct characteristics including color, odor, resistance to fungal and insect attack, and reduced permeability.

There are many instances in which the heartwood of the tree is the more valuable component. Only the heartwood of ebony is black, for example. The heartwoods of cedars, white oak and cypress are valued for their resistance to rotting and termites. The sapwood of all species is not resistant to fungi and insects. In other cases, the sapwood of the tree is preferred for products. For example, only the sapwood of hard maple displays the bright white color preferred for many products, and only the sapwood of pines and other softwoods can be effectively penetrated with chemicals to make treated lumber. (The heartwood resists these treatments.)

Only the heartwood of naturally durable species is rot- and insect-resistant. In this old eastern redcedar post, most of the light-colored sapwood has been destroyed by insects and decay. The reddish-colored heartwood portion is still sound.

Density

Wood density varies among and within species and even within individual tree trunks. Species differences in density, strength and other wood qualities are well-known and important to their usefulness and value. Dense oak is hard and good for flooring. Walnut (medium density) is a beautiful and easy-to-work material for furniture. Balsa is an extremely low-density wood that is useful for carvings and models (for example, model airplanes). As mentioned above, juvenile wood is often low-density, so the wood near the pith is often less dense than the wood nearer to the bark. Similarly, density can change with height within a tree. Denser wood tends to be stronger and stiffer. However, denser wood will also tend to shrink and swell more and can be more difficult to work with. Thus, depending on the application, denser wood may not always be as desirable.

Heart Pine

You may hear people proudly describing the 'heart pine' floors or other components in an old building.

Technically, "heart pine" is simply the heartwood of pine trees. Most pine lumber that is cut today comes from trees that are too young to produce much heartwood. Thus, heart pine generally means pine from old, large trees that were cut long ago. Wood from old pine trees may have desirable properties; for example, it may have few knots, straight grain and narrow growth rings, but these attributes have nothing to do with the wood being heartwood.

Rings per inch

Growth rate is used as an indicator of wood quality for a number of products. Some of the softwood structural lumber grading rules specify a minimum number of growth rings per inch (i.e., limit on growth rate). This is probably due to the coincidence of growth rate, tree age and wood density and strength discussed above. Logs that are to be peeled for high-value veneer products are also often evaluated for the *consistency* of their growth rings; logs with uniform growth rate are preferred.

Age before beauty! How tree growth rate affects wood products

Growth rate can affect the wood-quality characteristics introduced above. However, genetics and the tree's age also have a big impact on the quality of wood products.

Some of the fast-growing **species** that can colonize open areas quickly (e.g., poplars) are of relatively low quality and value compared with some of the more slow-growing species such as oaks and hard maple. However, inherent species differences (wood quality characteristics, appearance and abundance) are what determine the value difference, not the growth rate *per se*. And because a wood is 'low-value' does not mean that it is useless; inexpensive woods such as poplar are well-suited to making inexpensive commodity products such as oriented strandboard (OSB).

In the wood trade, **geographic origin** differences are attributed to differences in color, stain and insect damage. The marketplace consistently recognizes these differences with price premiums and discounts. However, there are few data to substantiate measurable quality differences associated with these regions. The differences that exist could be related to growth rate due to climate variation (north/south), but genetics may be more important.

Because **larger** logs tend to be more valuable, older trees tend to be more valuable than young ones, if growth rates are equivalent. The corollary to this concept is that faster-growing trees of the same age will tend to be bigger, and thus more valuable. However, as explained below, bigger doesn't always mean better, because other quality characteristics may be more important.

When trees grow in open areas, natural branch pruning may be delayed and the lower branches can become quite large. In this case the greater amounts of **clear wood** expected in the larger butt logs may not be present. These open-grown trees, which face less competition for resources, may also grow relatively quickly. This would be an instance where fast growth and lower wood quality could coincide.

The gradual transition from **juvenile wood** to mature wood is controlled by age and not size. Thus, younger trees will contain proportionately more juvenile wood than older trees, regardless of their growth rate. It has been reported that **reaction wood** is more likely to form in rapidly growing trees.

These two tree stems are roughly the same diameter but the slower-grown sample (left) will have a lower proportion of juvenile wood.

In very young trees – and in the young parts of all trees – all the wood is sapwood. After a number of years, sapwood is converted to **heartwood**. Different tree species have thicker and thinner sapwood bands because their sapwood rings 'live' for more or less time. Within a species, the sapwood thickness is fairly consistent as the tree grows older, so older trees will accumulate more and more heartwood over time. Thus, older trees have proportionately more heartwood. The rate of tree growth has no clear effect on heartwood proportion or quality.

For a given species, it is often assumed that rapid tree growth results in low **density** wood. This is a misconception. Many softwoods (i.e., conifers such as pine) will form denser wood as they get older (see juvenile wood discussion above). Such softwoods are often grown in 'even-aged' forests characterized by rapid initial tree growth and slower growth as the individual trees begin to compete for resources. In this case, the younger, faster-grown parts of the tree will be less dense than the older, more slowly grown wood. However, research has shown that this is a coincidence – fast growth doesn't cause low-density wood.

In the ring-porous hardwoods such as oak and ash, faster growth can actually increase wood density (within limits). The lower-density earlywood portion of the annual growth ring maintains a fairly consistent thickness, while the denser latewood band increases in thickness in faster-growing trees. This is why there are different dry kiln schedules for lowland red oak (wetter sites = faster growth = denser, harder-to-dry wood) and upland-sourced material.

In diffuse porous species such as poplars and maple, growth rate does not appear to affect wood density at all. In summary, species differences and genetic differences among trees of the same species have more influence on wood density than growth rate.

Conclusion

Good forest management generally results in healthy and productive trees. Healthy trees grow more quickly, but this does not necessarily imply a reduction in wood quality. For a given species, larger and older trees are usually the most valuable for wood products.

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