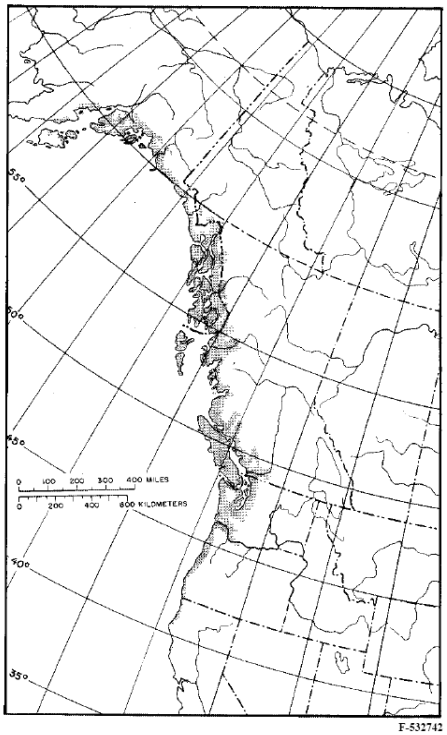
Sustainability and Musical Instruments

All musical instruments are made of materials of some kind. Stringed instruments (*e.g*. guitars, members of the violin family, mandolins, pianos, harpsichords, etc.) as well as certain wind instruments (*e.g*. clarinets, oboes, bassoons, …) and many percussion instruments (drums, marimbas, xylophones/vibraphones…) are made of wood, – more specifically, ***tonewoods*** – *i.e*. wood from a certain ***limited*** number of species of trees that have ***musica***l, ***aesthetically pleasing tonal properties*** – whereas wood from many other species of trees is either tonally ***neutral*** (*i.e*. "blah"-sounding) or downright musically unpleasant and/or even nasty-sounding. Brass instruments (*e.g*. the trumpet, saxophone, French horn, tuba, …), the harp, the snare & kettle drum, cymbals, gongs, bells are made of metals – *e.g*. musical brass, musical bronze – certain alloys that also have "good" musical/tonal attributes, as opposed to other metals which again are (again) either musically neutral or downright musically unpleasant and/or even nasty-sounding.

The detailed physics associated with the materials that go into the construction of a musical instrument – how sound propagates through a vibrating piece of wood or metal, its absorptive/ dissipative properties, and as a function of frequency dictate whether or not the material will or will not have musically interesting, and therefore musically useful properties or not. For example, wood has a 3-dimensional anisotropic grain structure (the 3-D elasticity of which can be described *e.g*. by a 6×6 matrix, in the generalized anisotropic version of Hooke's law). The 3-D orientation of the grain – how it is used in a wooden musical instrument matters greatly in the tonal properties of the instrument, not to mention its structural/strength properties. The density (*i.e*. tightness) of the grain, the speed of propagation of sound (the higher the better – from a stiff, but light piece of wood), the elasticity *vs*. dissipative/absorptive properties of the tonewood, the harmonic emphasis – i.e. the frequency dependence of these latter quantities, what the soil conditions were where the trees that are used for tonewoods were growing, the climate, ***etc***. all matter, musically. High-end clarinets & oboes use grenadilla – a dense, stable hardwood, *aka* African blackwood.

Sitka spruce – *e.g*. used as the soundboard in acoustic guitars – comes from a narrow strip of Pacific coastal region from $61^{o}\,N$ in south central Alaska to $39^{o}\,N$ in northern California, as shown in the RHS figure. In order to have good musical qualities, acoustic guitar soundboards must be knot-free and have a tight, uniform grain, which is oriented parallel to the strings. The "best" musical-sounding Sitka spruce does (did) come from Alaska – where the climate is cooler – i.e. slower tree growth per year, resulting in a tighter grain (compared to growth in a warmer climate, such as California). However, because of the increasing rate of logging over the past century, there is little of the original "old-growth" Sitka spruce left in Alaska, so much so that acoustic guitar companies such as C.F. Martin, Taylor Guitars, Gibson, Fender and Yamaha to mention a few have become increasingly concerned about long-term supplies of Sitka spruce and other tonewoods, that they have become actively involved in the conservation of this species of wood, and preservation of what remains of the old-growth stands of Sitka spruce in Alaska, as well as other tonewoods growing elsewhere on our planet. Tonewood supplies are rapidly dwindling with time.



Supplies of Sitka spruce have been rapidly diminishing in the past 50 years. The following graph (from the US Forest Service, FS-265) shows that just in an 11-year period from 1969-80, exports of Sitka spruce from Alaska (which is used primarily for lumber and pulp) declined by more than a factor of 2×:

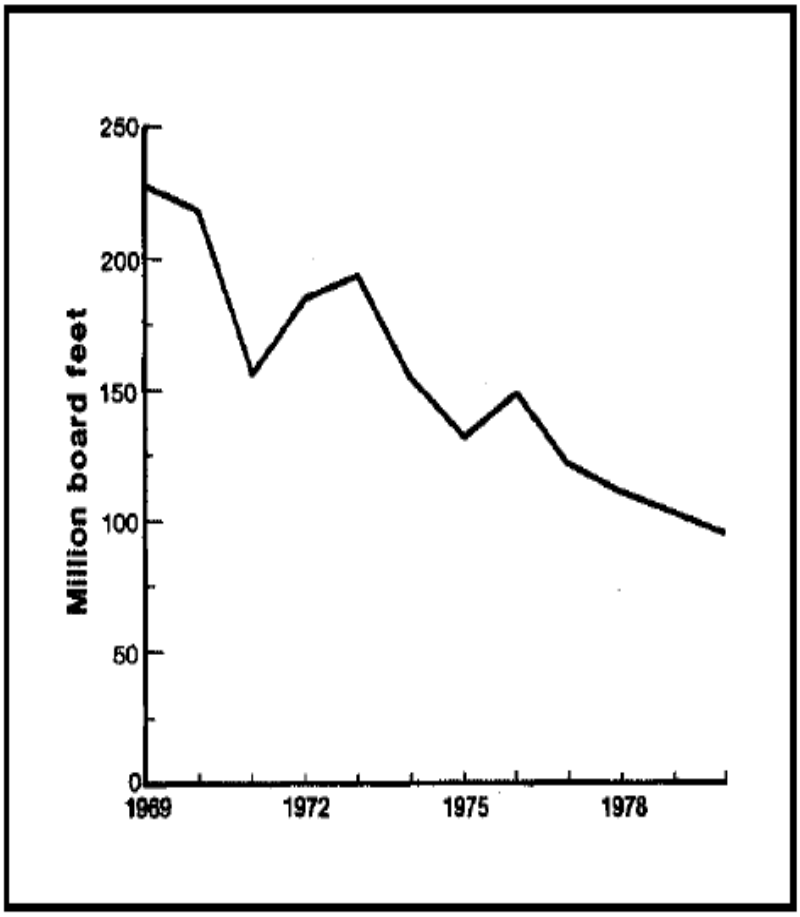


Figure 4–Sitka spruce lumber exported from Alaska ports, 1969-80.

Wide logs of Brazillian rosewood – used for the backs of acoustic guitars were no longer available in significant quantities after 1965, prompting *e.g.* C.F. Martin to make 3-piece backs on their guitars after that. However, shortly thereafter, in 1969, Brazil embargoed exports of their rosewood entirely, forcing acoustic guitar makers e.g. to instead use Indian rosewood. Today, supplies of Indian rosewood are now rapidly diminishing as well. Rosewood is also used in acoustic and electric guitars for fretboards; it has warmth/mellowness, e.g. compared to bright, snappy-sounding ebony or ***e.g.*** maple fingerboards on electric guitars.

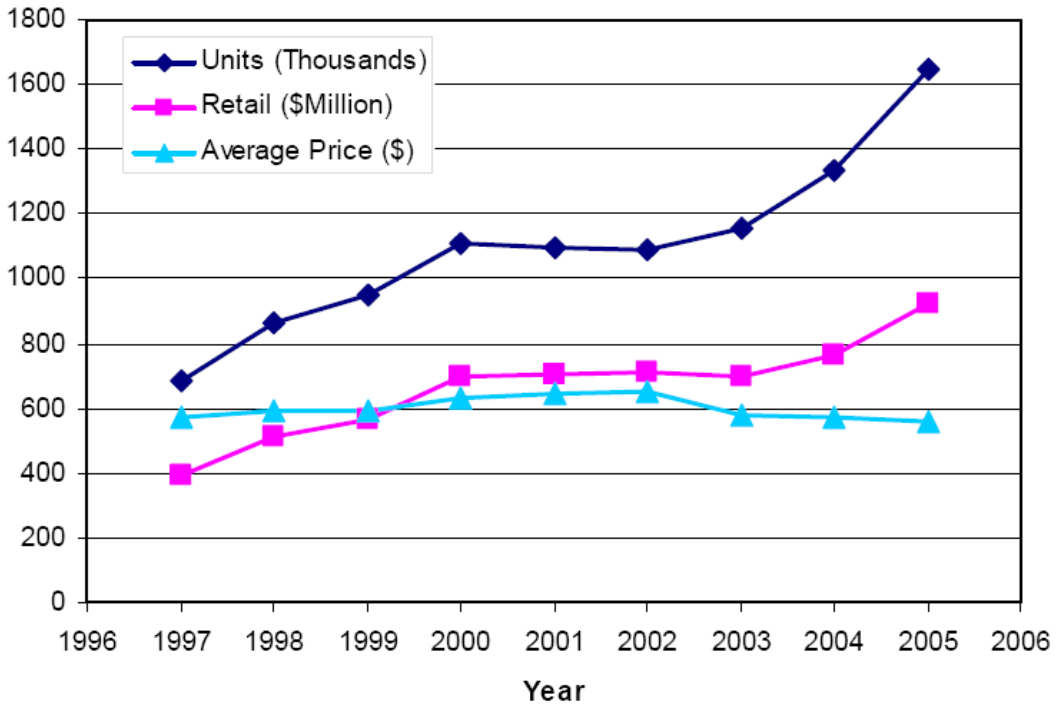
Another example – for centuries, ***the*** best-sounding wood used for making violin, viola and cello bows has been pernambuco heartwood. Bows made of pernambuco are prized and revered for their perfect combination of weight, density, balance, and resiliency for advanced playing qualities. Its combination of rigidity, flexibility, density, beauty, and ability to hold a fixed curve are properties which make Pernambuco a unique material for bow-making. This slow-growing tree grows in the Brazilian Atlantic forest region. Today, Brazillian pernambuco, like their rosewood is also protected, *i.e.* it is illegal to export it from Brazil. Needless to say, this has left violin/viola/cello bow-makers in quite a quandary, not to mention the professional musicians who play these instruments for a living!

The amount of lumber used by acoustic guitar makers is relatively small – for example, Bob Taylor of Taylor Guitars estimates they use ~ 50 Sitka spruce logs per year – which is what a typical lumber mill can process in one 8 hour shift. Much of the production of lumber from Sitka spruce is used in the housing and pulp (*i.e.* paper) industries.

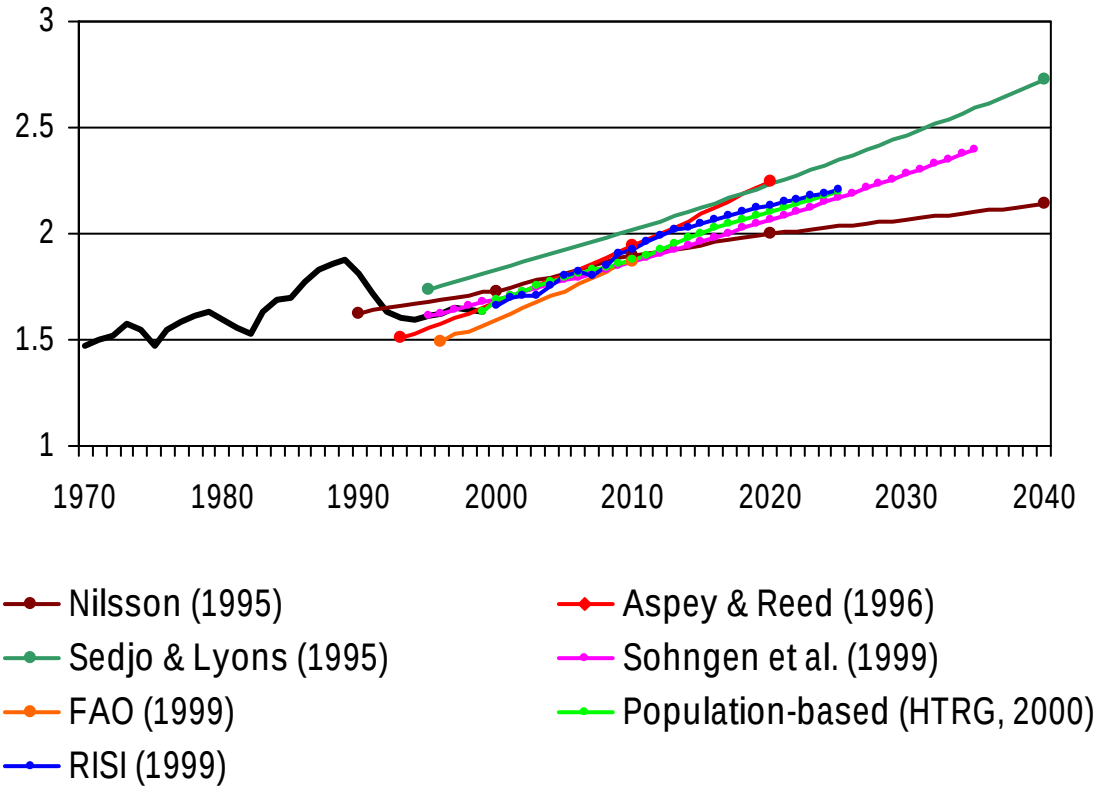
Because of the effects of global warming, musical tonewoods from new-growth trees does sound noticeably different in comparison to from tonewoods obtained from old-growth trees. Old-growth trees grew slowly, whereas new-growth trees, replanted by timber companies after *e.g.* clear-cutting vast areas of centuries-old old-growth forests, grow differently in the now nutrient-poor soil – clear-cutting drastically alters the ecological environment – serious erosion can occur, timber companies are now increasingly additionally using herbicides in the aftermath of clear-cutting to kill off unwanted species of plants before replanting new trees – see pix below.

New-growth trees used *e.g.* in electric guitars is systematically heavier/denser and less resonant than old-growth wood. It also tends to have higher mineral content. The grain in new-growth Sitka spruce tends to be wider than in old-growth Sitka – its warmer now than it used to be a few centuries ago – thus tree ring growth per year is commensurately more also… New growth Sitka spruce also tends to have significantly more knots than old-growth Sitka – soundboards must be knot free…

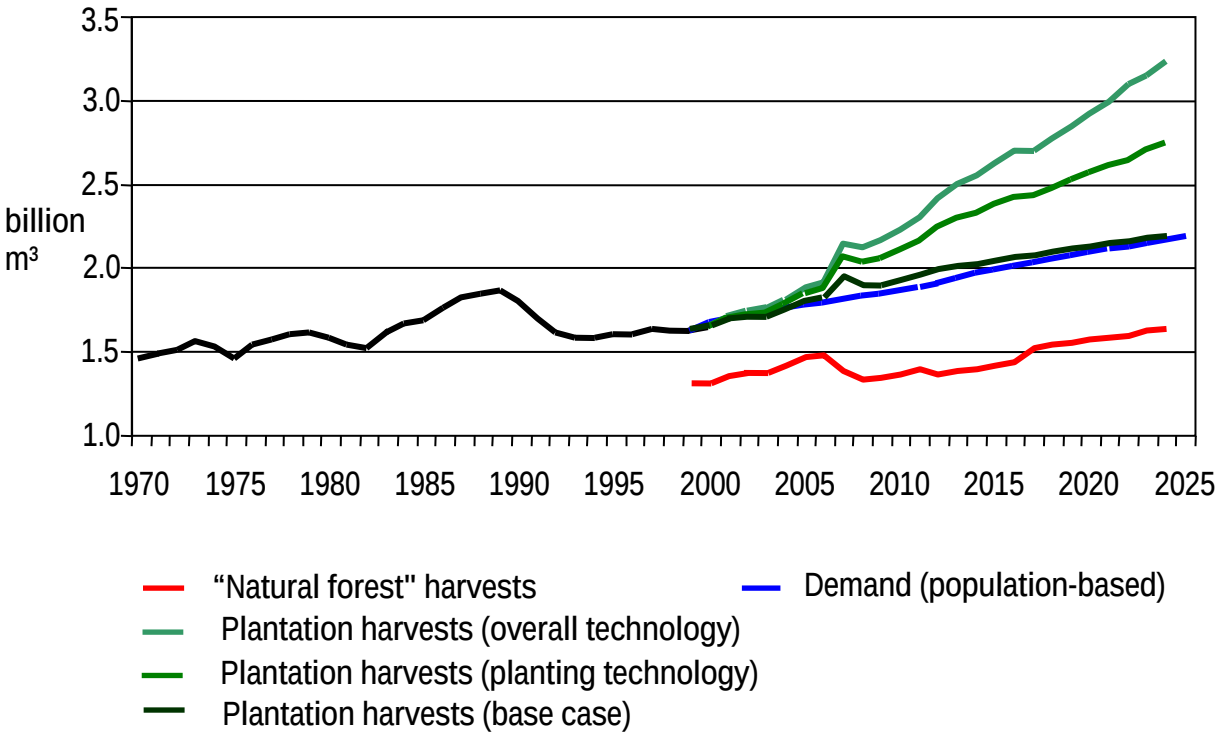
World-wide, there is ever-increasing demand for lumber, for use in building new houses, for furniture, paper, boats as well as musical instruments. Just for the latter category alone, saw nearly a tripling in U.S. production of all guitars in the decade from 1996-2006:



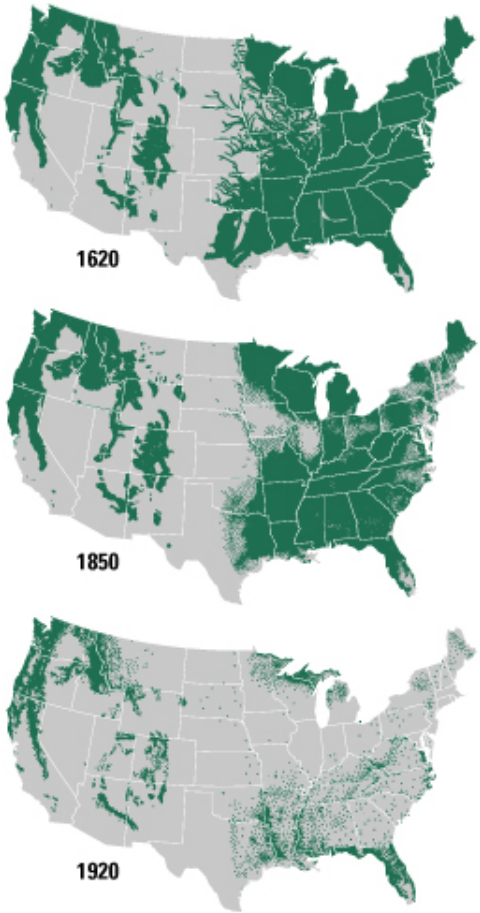
Global Industrial Roundwood Demand – Past, Present and Future:



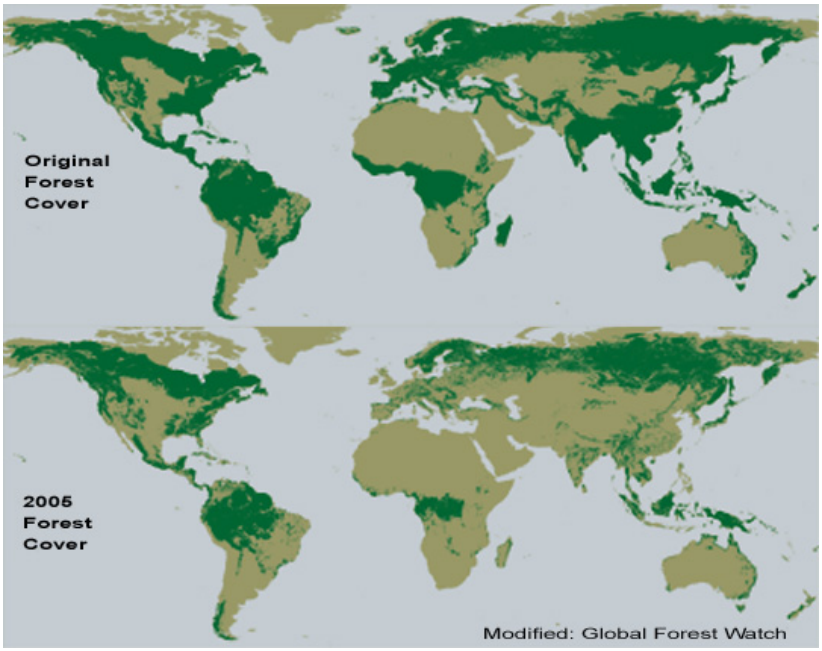
Global Demand vs. Supply:



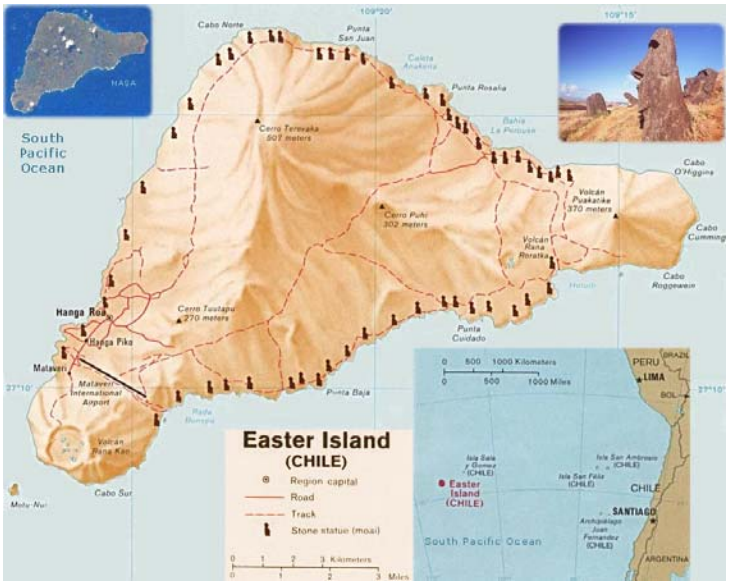
<u>Deforestation in the U.S. vs. time</u>:



Planetary Deforestation:



Fast-forward a century or two into the future – when the demand for lumber outstrips the rate at which nature can produce it (some predict this will occur by 2030!) - will there be ***any*** trees left on our planet? We have already seen countless examples in human history, where we ***have*** gone to extremes – Easter Island, stripped completely of all of its trees by its one-time human inhabitants before/as their finally society collapsed, is a profound example of this:



Will there come a time when new musical instruments will no longer be able to be made out of the traditional natural materials they have been built with in the past? It's already happening now…
So what *will* *e.g.* 22nd – 23rd century all-man-made (*e.g.* recycled plastic?) Fender Stratocasters and/or Gibson Les Pauls sound/play like, in comparison to the real-deal original ones of the 1950's-60's? Likewise for violins, violas, cellos, pianos, drums, clarinets, oboes, *etc*….???

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