Varietal pines boom in the US South

Charles Sorensson[1]

Abstract

Over a 29-day period I represented the NZ Institute of Forestry on a Balneaves Travel Award, meeting with an array of US professionals involved in various ways with varietal (clonal) southern yellow pines. The seven companies that hosted me have a significant footprint, with combined worldwide annual revenues exceeding $50 Billion NZD. Varietal pines are new to the US South, but are attracting widespread commercial interest, and are being viewed as a way to both customise the wood supply, and improve the US's competitiveness in global wood supply markets.

The principal economics are straightforward: varietal pines grow faster and have better rust resistance and stem quality than traditional family pines, which should raise the frequency of saw-timber in mature crops by 50% or more. Saw-timber is currently 67% more valuable than the next best timber grade, so stumpage revenue and Bare Land Values will rise, in some cases enough to justify keeping valuable land in forest production. About 6 MM varietal pines are being established this season ('06/07) in the US South, rising towards 50 MM two years from now.

Introduction

The objective of my award travel was to clarify the economic justification underpinning commercial deployment of clonal pines in the US South. When we last described clonal forestry of NZ Radiata pine (Sorensson & Shelbourne 2005), we were hearing rumours that the clonal pine forestry was expanding rapidly in the US South, even in the face of considerable industry volatility. Some of these changes sounded familiar, e.g., the break up of formerly large forestry holdings into smaller parcels, the expansion of TIMO and REIT forestry investors with a generally lower-risk lower-return philosophy than most large corporates, and an increase in land ownership by small investors and others that could have investment timeframes as short as a decade.

I met managers, foresters and scientists from five large forestry companies (Temple-Inland, Weyerhaeuser, MeadWestvaco, Rayonier, Plum Creek), two forestry biotech companies (CellFor and ArborGen) and staff at land-grant universities in North Carolina, Georgia and Florida that have large forestry programmes, and at the Southern Research Station of the USDA Forest Service. Interest in pine varieties is widespread and generally strong, particularly amongst foresters who have worked in South American eucalypt clonal forests.

Most of whom I met, although not all, prefer the gentler term "variety" over "clone", so I have generally used it below. "Variety" is a common horticultural term, and refers to well tested *individual* plants that are then mass-propagated vegetatively in order to improve the quantity, quality and consistency of crop yields. All varietal pines referred to herein are "somatic seedlings", produced via somatic embryogenesis, and cryo-stored as immature seed tissues to stop the ageing process while the candidate varieties are field-tested. The essence of this manufacturing process is identical to that used here for Radiata pine clones.

"Saw-Timber Potential"-based economics

Although there are a myriad of possible benefits, the principal economic justification for varietal pine forestry in the US south proved surprisingly simple: better tree growth and stem quality increases the frequency of sawlogs in the mature crop, and sawlogs are two-thirds more valuable than the next best log grade, "Chip-N-Saw" (Table 1). With excellent silviculture, the best Loblolly pine varieties appear capable of achieving mean annual increments of 10 to 12 or more tons/acre/yr (23 to 28 m3/ha/yr) over 25 years, which is *more than two or three times* the norm. Using varietal pines, saw-timber incidence in the final crop will increase 50% on average (CellFor 2005 pamphlet) and, in some instances, should *double* saw-timber frequency from 35% to 80% (Wright and Dougherty 2006a). Internationally-recognised breeders like Steve McKeand at North Carolina State University who have been involved in tree improvement for decades support the accuracy of these gain estimates,

Table 1. US South-wide pine stumpage prices in 11 south-eastern states (source: Q1 '06 Timber Mart-South, www.tmart-south.com/tmart/).

	SawTimber (ST)	**Chip'n Saw (CNS)**	**PulpWood (PW)**
Stumpage (USD/ green ton)	$41.0 (100%)	$24.5 (60%)	$7.1 (17%)
Stumpage (NZD/m^3) §	**$73.4**	**$43.9**	**$12.7**
Timber Specification (Borders & De La Torre 2006)			
Min DBH (inch)	*12.5 ‡*	*8.5*	*4.5*
Max DBH (inch)	*40.0*	*12.5*	*8.5*
Min Top DIA (inch)	*8.0*	*6.0*	*3.0*
Min DBH (cm)	31.8	21.6	11.4
Max DBH (cm)	101.6	31.8	21.6
Min Top DIA (cm)	20.3	15.2	7.6

§ converted from US units: green log density of 975 kg/m3. Currency: $0.60 per USD.
‡ some foresters I met indicated sawtimber could go down towards ten inch (25 cm) LED.

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Table 2. Partial list of forestry companies actively establishing plantation forests with varietal pines in the US South. Revenue and staff numbers for REITS exclude that related to mills, which are separate business entities.

Company	US forest holdings ha (ac)	South plantation pine land ha (ac)	No. of employees worldwide†	Annual revenue (USD yr-1)
Temple-Inland C-corp	0.8 MM (2.0 MM)	0.6 MM (1.5 MM)	15,500	$4.7 Bn
Weyerhaeuser C-corp	2.6 MM (6.4 MM)	1.7 MM (4.2 MM)	54,000	$22.6 Bn
MeadWestvaco C-corp	0.45 MM (1.1 MM)	0.36 MM (0.9 MM)	22,200	$6.0 Bn
Rayonier REIT	0.66 MM (1.6 MM)	0.43 MM (1.1 MM)	2,000	$1.2 Bn
Plum Creek REIT	3.3 MM (8.2 MM)	1.8 MM (4.4 MM)	2,100	$1.6 Bn
TOTALS	**7.8 MM (19.3 MM)**	**3.2 MM (12.1 MM)**	**95,800**	**$36.1 Bn**

† *The NZ forest products industry employs 26,500 people directly (forestry and first-stage processing) and about 100,000 indirectly (NZFOA 2005).*

whilst noting that gains of this order are possible only by building on top of hard-won tree improvements achieved by the "big three" pine breeding coops coordinated by the Texas Forest Service, the University of Florida and North Carolina State University.

Increasing Saw-Timber Potential not only *visibly* raises crop performance and value of elite southern pines, but the additional revenue is actually *required* if foresters wish to consider keeping high value land in production. In one analysis, the mean annual increment required to provide a 7% return after tax increased more than four times if land value increased from US $500/acre to $3000/acre (*ibid*). High performance varietal pines thus offer foresters a *double-whammy* of improved crop and land value returns on land that will likely someday be removed from forest production. Others point out that it is the utilisation of these boosts in productivity from varietal pines to revitalise their forestry and position it forward that are truly important.

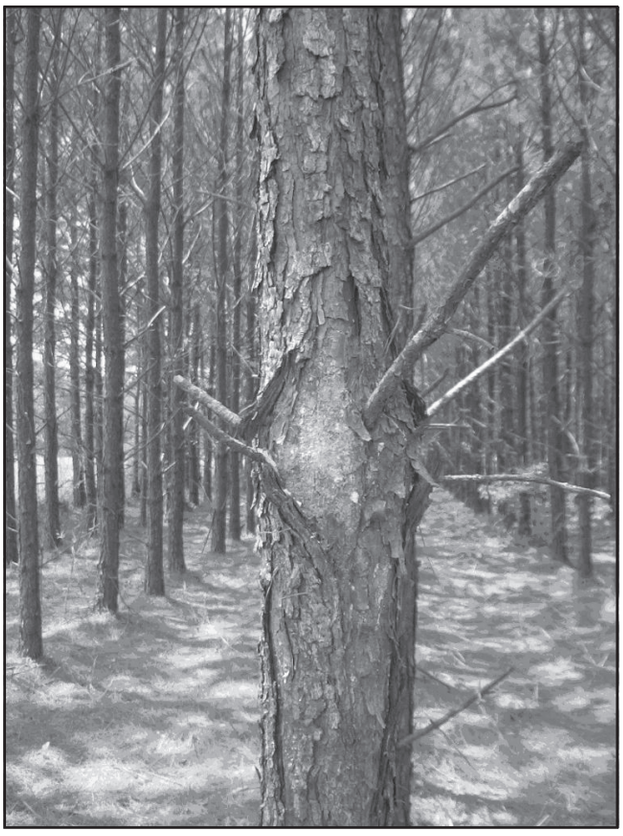
The single biggest criticism of varietal pines was their price, and most took the view that if varietal prices ever plummeted, that there would be an explosive uptake of the new varietal pines. In mid-2006 the price for limited purchases of varietal somatic seedling ranged between 36 and 40 cents USD (57 to 63¢ NZD), whereas prices I saw advertised for normal loblolly pine were 4.2¢ USD per 1.5-generation orchard seedling (OP), 4.6¢ per 2.0-generation seedling (OP), and 5.4¢ per genetically-elite 2.0-generation seedling. [1] Thus, the price premium for limited purchases of varieties is currently between 31 and 35¢ USD (49 to 56¢ NZD), which corresponds to an additional $180 per acre if planted at 550 spa. Although this premium is roughly twice the cost for herbicide applications that range from $35 and $100 an acre, and weed control can also boost volume growth as much as 100% *over that without any weed control* (Clark *et al.* 2006), only genetic improvement can reduce rust infection and improve stem qualities.

CP ("Mass Control Pollinated" in US terminology) seedlings, which are heavily utilised in New Zealand, are not generally available on the open market in the US South. Indeed only MeadWestvaco has sold CP seedlings externally. MeadWestvaco prices its MCP seedlings at about 10¢ USD each (D. Gerwig, July 2006, pers. comm.) and is quite genetically aggressive, deploying 100% MCP or varietal pines on its core forestlands in Virginia, South Carolina, Georgia and Alabama (John Johnson, July 2006, pers. comm.).

Considerable progress in the past two years has occurred in generating realistic analyses of investment from planting of varieties. Value improvements from varieties are estimated as the sum of value added of four key components: growth and yield, rust reduction, stem forking reduction and stem size uniformity. Discount rates are usually set at 8% (range 6% to 10%) and rotations at age 25 or so. Benchmark genetics are 2nd-generation OP seedlings (which in NZ Radiata pine would be rated about GF17 to GF19). Improvements in tree growth are estimated with stand growth models by raising site index. While this approach is crude, results are proving conservative, in part due to the over-estimation of stem mortalities, e.g. from rust (Huber *et al.* 2006). Optimum economic rotation regimes

[1] *Prices of OP treestocks in the US are suppressed, and could rise. State-run nurseries were subsidised by state governments and ran their-nurseries on a cost-recovery basis. Forest companies wrote off investments in treestocks as deductions in their tax, hence the cost of the genetic research was not passed on as seedling sales (G Peter, July 2006, pers. comm.).*

Figure 1. Rust gall-causing malformation on age-10 Loblolly pine. Photo courtesy Charles Sorensson.



tend to use Bare Land Value as the chief financial criterion. On that basis, middle-of-the-road results indicate BLV could increase from $742 USD/acre to $1,178/acre (+ 59%).[2] Break-even costs for somatic seedlings were approximately twice their current sales price (Pait 2006).

Some foresters told me they wished to lower saw-timber rotations below 20 years. Achieving this may be possible, but would require massive genetic improvements in both stem growth *and* wood stiffness that would only be feasible in the short term from elite varietal genetics. Interestingly a poster at the IEG40 conference by Fikret Isik and others showed that some of the fastest growing Loblolly varieties also had significant improvements in wood density. This is not often seen in Radiata pine clones.

Growth of southern yellow pines

As a NZ forester, I needed to gain a better appreciation for the factors governing the growth rates of the southern pines, both for their principal species Loblolly pine (*Pinus taeda*) and for slash (*Pinus elliottii*), which does better on poorly drained soils within its natural range. The following points offer part of the explanation why NZ radiata grows about twice as fast as the southern yellow pines (i.e., nationwide MAI averages 23 to 28 m3/ha/yr, and up to 50 m3/ha/yr for family Radiata pine):

- To understand the southern pines, one must first appreciate how important fusiform rust disease is (*Cronartium fusiforme*). Stumpage losses from rust cost $28 MM USD yr^{-1} (Phelps and Czabator 1998). Genetically-improved loblolly tends to have infection rates of 25 to 50% on sites with moderate rust pressures, whereas the best varieties would have only 1% to 5% infection (e.g. Pait 2006). Remove rust pressure and growth jumps, as well as tree survival and freedom from stem malformation caused by galls (Fig.1). Improving "rust resistance is a key to boosting volume gain" (Dudley Huber, June 2006, pers. comm.). US South site productivity is primarily described in two ways: Site Index and Rust Hazard level.

[2] *Site Index base 70, adjusted Site Index 87, real discount rate 8%, rotation age 24 yrs, Marginal IRR 13.0%.*

Figure 2. Mature commercial stand of Loblolly pine in Georgia, USA, about age 25, on a productive site. Photo courtesy Charles Sorensson.

- NZ forest soils are generally geologically younger and more fertile regarding soil nitrogen, and our rainfall is more even throughout summer and fall. Competition from hardwoods was evident in all but the most intensively managed southern pine plantations (Fig. 2). The growing season for loblolly pine ranges from 240 to 300 days (north to south), whereas much of our radiata pine crop is believed to grow year round.
- Historically many southern pine crops were managed for pulpwood, but this has reversed dramatically and most stands are now being established under a sawlog regime. Even so, initial stocking levels remain higher in the US than in NZ, with initial stockings averaging about 550 trees per acre (1350 sph) compared to stockings of 800 to 1000 sph common here.
- Current annual increment (CAI) peaks a few years earlier in loblolly pine in the US south than in NZ radiata pine. This is probably a true species difference. It may have some relationship to the self-pruning habit of the southern yellow pines. Radiata pine does not self prune.
- NZ pine growers are genetically aggressive, deploying seedlots rated below GF20 (MAF Policy Info. Feb. 2006) only 23% of the time. Thus, close to half the NZ resource is established from control-pollinated genetics, in sharp contrast to the US where the only significant deployment of CP is within a handful of companies that periodically get good CP seed crops. The vast bulk of southern pines are established with 1st or 2nd-generation

Figure 3. Fifty thousand somatic seedlings in a precision planted bed, two months after outplanting with miniplugs. Inset: good root development in a somatic seedling of Loblolly pine two months after outplanting (CellFor variety Q7766). Photo courtesy Charles Sorensson.

open-pollinated seedlots, and there is as yet little price differentiation for the better quality seedlots (McKeand *et al.* 2003; Steve McKeand 2006 pers. comm.). The bare-root cuttings technology used commonly in NZ to mass propagate scarce genetically elite CP seed has never become commercially successful with southern pines.

Product Developers

Two large product developers are actively manufacturing varietal pine seedlings for the US South. The largest and oldest is CellFor (www.cellfor.com/home.html), a company of 75 employees (Pait 2006). Their somatic seedling lab is situated in British Colombia. There, somatic seedlings are derived from somatic embryos grown from seed tissue, and stored cryogenically in liquid N until needed for manufacturing. Somatic seedlings are shipped as miniplugs in polystyrene flats each year to nurseries in the southern USA and precision machine sown (currently with a modified lettuce planter at rates up to 70,000 plants hr^{-1}). CellFor first sold varietal pines commercially in 2002, and if all goes to plan, they should float an IPO within the next three years.

CellFor's somatic seedling crop is grown by six partner nurseries on contract. I visited one of these nurseries in Georgia. Somatic seedlings are outplanted into nursery beds in spring (mid May) and lifted that following winter between December and February (or, if lifted earlier, "hot planted" within 72 hours after lifting). These are then trucked to customers throughout the south. Plant spec for somatic bare-root seedlings is a root collar diameter of 4 to 5 mm and a top height of 25 cm. The varietal pine nursery

Figure 4. Phil Dougherty (left) (MeadWestvaco) and Jeff Wright (ArborGen) in a high-performance age-8 varietal block of loblolly pine in South Carolina. Photo courtesy Charles Sorensson.

crop at this nursery was 450,000 plants in 2006, and will exceed a million seedlings in 2007. The total production capacity of this nursery was 34 MM pines in 2006 from 30 hectares (75 acres) and a fulltime staff of five people. The manager there had generated over 2 Bn pine seedlings in his 38-yr-career.

ArborGen (www.arborgen.com/splash/) is a newer participant in somatic pine manufacturing than CellFor, but it already has a strong commercial presence. It has screened 1,900 candidate varietal lines already, and will sell its first commercial varieties this year, a year quicker than initially expected (Wright & Dougherty, *in press*). Its somatic-seedling manufacturing lab is located in South Carolina. Neither ArborGen nor CellFor typically own the IP of the varieties they generate, at least at present. Instead they provide a service to companies who provide them their own elite seed, and work together to intensively field-screen the candidate genotypes. If super elite varieties are found, the companies owning the IP can take a role in marketing, if they like, in order to both attract royalties from product sales as well as to positively influence local growers to improve the nature of their local fibre resource, which their mills could later purchase. ArborGen has a particularly innovative approach to field-testing called the ArborGen Testing Service. The ATS allows participating clients to not only critically observe field performance of varieties they own the IP for, but also compare these in the same test against varieties owned by other companies.

Phil Dougherty of MeadWestvaco caught my attention

in that he serves both as a commercial *customer of varieties* and *as a product developer* (Fig. 4). Together with ArborGen Marketing Manager Jeff Wright, Phil often is asked to give tours to visiting foresters like myself of their extensive network of genetic tests (varietal, CP, OP, unselect). After hearing Phil's talk on economic returns from varietal pines, given to a packed hall at the IEG40 conference in Jacksonville, Florida (and noting that Phil both invests personally in forestry blocks, and has worked in both university and industry as a silvicultural expert), I came to regard Phil as perhaps *the premiere voice* in the southeastern US advocating varietal forestry. Phil puts it simply and pragmatically *without* an exclamation point: "Grow good varietal crops, so you can let both the crop and the land accrue in value… there are real <investment> opportunities if you just buy carefully".

While not actively selling varietal pines externally, Weyerhaeuser deserves mention. Weyerhaeuser has worked for more than a decade on an artificial seed technology for somatic seedlings that promises to radically cut costs of somatic pine manufacturing. 'Manufactured Seed Technology' manager Paul Gaddis and I spent an intense hour pouring over video footage of this largely robotic process. Somatic embryos are produced, sorted, and encapsulated in an artificial seed rather like a large pill. Paul says that MST is on track for completion, but could not say when it is due for completion. Interestingly, ArborGen has already licensed MST.

Varietal Plantings Will Boom

Are varietal pines in the USA *significant* yet? In one sense, no: NZ has deployed about 14 MM varietal pines (Sorensson and Shelbourne 2005), *or about twice* that deployed to date in the USA. Privately corporate owners certainly *do* worry over the extra up-front investments required when using varietal pines. And it is early days, with most varietal field-tests at crop ages of three to five years (the older tests of age 13 to 17 were largely established with rooted cuttings by International Paper, MeadWestvaco and Weyerhaeuser). Perhaps 20% of US South forestland is managed very non-intensively, with a considerable proportion of that forest crop arising from regen, and less than 20% of all US South pine forests are managed intensively in plantations.

Nevertheless from what I saw, read, and heard, both from company staff and academics, the US is on a sharp upward trend in deployment of varietal pines with no end in sight. By mid-summer 2006, CellFor had pre-sold 70% of its 2006 winter (December) crop of 6 MM varietal pines to about 30 different customers (Pait 2006) and has pre-sold much of its 20 MM 2007 winter varietal crop. After this 2006 crop is established, there will be over 8,000 ha of Cellfor varietal pines established in the US South. CellFor expects production to more than double between 2007 and 2008, reaching 50 MM somatic seedlings in 2008 (Pait 2006). In a very short time, the US varietal crop will greatly exceed that in New Zealand. ArborGen's first commercial varietal sales occur this year (2006) and are predicted to rapidly expand thereafter.

Given the total potential market size for varietal pines in the US South is perhaps 10 times larger than it is in NZ (calculated as 20% of the 900 MM pines established annually for intensive plantation use & initial stockings of 500 spa), one can conclude confidently the opportunities to achieve large *scale* are attractive. This potential would undoubtedly have figured prominently in justifying the millions of dollars that somatic product developers have (and continue to) poured into fully commercialising new somatic manufacturing technologies.

Temple-Inland, which is based in eastern Texas, is one of the three remaining larger vertically integrated forestry companies in the US, and my impression was that it was conservative in its corporate philosophy. To date, it has established 160,000 varietal pines, many in field-tests. However, Nicholas Muir, a former kiwi who himself is an aggressive advocate for varietal pines, notes that varietal pine establishment will jump towards 1 MM this year, 4 MM in 2007, and at least that many each year after that. Said another way, by 2009 Temple-Inland alone expects to have planted about 14 MM varietal pines, as many as present in the whole of New Zealand. Nick emphasised that "the cost of planting stock is a minor contributor to the cost of growing timber…" and "we need to get away from the fixation on the COST of varietal seedlings, and focus on the *VALUE* which that tree is delivering to our forest".

Temple-Inland is not alone in its positive stance towards varietal forestry. Early McCall of Rayonier, for example, told me that about 3% of their loblolly planting stock in 2006 was from somatic seedlings, and that they would initially aim to raise this to 15% of either somatic or cross-pollinated stock. This equates to something over 10 MM varietal or MCP pines. Rayonier is also making a strong push into varietal Slash pine.

Concluding Remarks

Although sounding a cautionary note because of its newness in the US, the prognosis for varietal forestry of southern yellow pines seems surprisingly good. Although the chief justification for varietal pines is that they will produce more saw-timber, many privately believe that the full economic justification for varietal forestry will only slowly emerge over time as the benefits of increased consistency of stem size and fibre type are fully appreciated through the supply chain. These are benefits that are simply not possible by intensifying silviculture alone. Here are some final points:

- Southern US forests are productive, representing over 75% of the nation's tree planting, 60% of the wood harvested in the US, and 15% to 16% of the world's timber production (Wear & Greis 2002; McKeand *et al*. 2003). The South seems better positioned generally to remain in intensively managed plantations than the US Pacific Northwest or Canada, blessed with a good labour force, relatively low environmental pressures (Red Cockaded Woodpecker notwithstanding), proximity to large markets, and some state-based tax incentives. There is also some excitement about the use of pinewood or waste to produce Syngas biofuel (*e.g.*, www.treepower.org).

- The emergence of TIMOs and REITs has recently eroded long-term R&D funding for activities such as tree breeding in both the US and in NZ. But as forest ownership has devolved and many more individuals now own forestland, this has enabled market forces to re-adjust land value. Such was the case with International Paper Company lands that sold recently at $1200/acre for 5.1 million acres (sold to private investors who outbid the REITs), but which might have commanded $200/acre a decade ago. *Managing higher value lands is now a core activity* for most or all the large forestland owners. Unfortunately, if crop revenues do not keep pace with increasing land value, *such lands cannot be retained in forestry*.

  The new pine varieties produce significantly more productive crops from a young age (McKeand *et al.* 2003) and may offer silvicultural efficiencies like reduced mechanical thinning requirements, as well as opportunities to reduce rotation age. Faster growth increases the proportion of young wood, however, so rotation ages are unlikely to drop dramatically without proportionate genetic improvements in the stiffness and dimensional stability of that juvenile wood.
- US South nurseries are experienced at producing many millions of bare-root trees, typically 20 to 65 MM or more trees per nursery, so good delivery systems for somatic seedlings already clearly exist. Somatic seedling manufacturing arguably needs some additional improvement, but prospects seem good due to the competition amongst the big technology developers (CellFor, ArborGen, Weyerhaeuser).

  Once manufacturing costs for somatic seedlings *can* be reduced, they surely *will* if done in tandem with an expansion in varietal sales that better spreads out fixed costs of product development. The resulting win-wins of value share amongst product developers, forest owners and processors should further boost market pull for varieties. This should be welcomed both by industry, which has suffered periodic economic setbacks (Kellison 2005), and by local politicians eager to engineer economic growth in the poorer parts of the South. Policy factors can certainly overshadow the decision to replant forests more than market drivers, including timber prices (Beach *et al.* 2005). Unfortunately concerns over anti-trust have hampered US varietal developers from building a unified political voice such as that of the non-profit Institute of Forest Biotechnology (which is gathering US $30 MM for pine genome research).
- Varietal pines are also reaching smaller land holders, through purchases to individual consultants and *private landowners* (J. Pait, Aug. 2006, pers. comm.). And it has been a long-standing practice of the integrated forest companies to assist private landowners to *replant their sites with advanced genetic materials* as an incentive in negotiating favourable stumpage purchases. Since most processors source the *bulk* of their fibre from outside their own company land, it is in their collective best interest to encourage private landowners to establish plantations using high-performance treestocks.

Figure 5. Hunting clubs license access to forest lands to hunt turkeys, whitetail deer, pigs, pheasants, ducks and quail. An abundance of other wildlife is found in some forestland including bobcats, armadillos, snakes, alligators, amphibians, birds and nutria (a large rodent). Photo courtesy Charles Sorensson.

- Every forester I met with who was actively testing the new varieties in their estates *independently* took effort to show me particular varieties they felt were showing promise for producing small branches even if established at low initial stockings. It will take another five years to prove whether this is actually the case, but if this opportunity IS real, the lower stockings will both reduce costs of establishment and mechanical thinning. The grass between widely-spaced tree rows should also enhance the quality of hunting blocks at least for the first half of the rotation (Fig. 5), which provide $8/acre in annual lease revenues (Borders & De La Torre 2006).
- As in New Zealand, appraisers in the US have tended to ignore the genetic rating of an improved but immature pine forest. However, site index is widely accepted as a key driver in their analyses of expected land productivity (and forest value). I heard that some land appraisers were revising upwards the estimates of site index based on direct observation of the mean crop height of young varietal stands. In these cases, appraisers are indirectly incorporating the improved crop value from genetics, even though it actually matters little to them what the fundamental cause is for the improvement. Just as in New Zealand, the challenge now is to ensure there is confidence in these value additions. An industry valuation methodology standard is probably required to achieve this.

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