

INTRODUCTION TO CONSULTING FORESTRY

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**DEDICATED TO
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a former State Forester, and
a contributor to this book**

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A BRIEF HISTORY OF FORESTRY CONSULTING

According to Holtz (1983), "A consultant...can be properly defined as anyone who can and does render advice and/or related services in any skill area of at least a quasi-professional nature, at some fixed fee or rate, on a contractual basis." The Association of Consulting Foresters (ACF) defines a consulting forester as "a professional forester who devotes a majority of their working time each year to performing...technical forestry work...on fee or contract basis" whose services are offered "to the public rather than to a single full-time employer."

Surprisingly, the history of the forestry consultant in the United States is as old as forestry itself. Dr. Gifford Pinchot hung out his consulting shingle in 1892. He and Henry S. Graves collaborated in writing forest management plans for the Steward Webb and Whistney Estate forests. Bernhard E. Fernow, one of the first truly qualified foresters in the U.S., set up as a consulting forester in New York City in 1903 (Clepper 1957). However, for the next 50 years the number of consulting foresters grew slowly, and many states (e.g., Massachusetts, West Virginia) had only one consultant by 1950.

Forests, particularly in the eastern and southern United States, had been so devastated by the heavy cutting without provision for regeneration and the uncontrolled fires that occurred around the beginning of the 20th Century that recovery appeared doubtful (The resiliency of our forests was greatly underestimated.) A commonly held view by the U. S. Forest Service during the Pinchot-Graves regimes was that federal regulation would be necessary to implement forest management on private lands. Most foresters today would agree that it is good that our nation did not follow that path.

For many years, any private landowner seeking forestry advice or service, and a distressingly few did so, contacted a state forestry organization. Often, those organizations provided timber marking service free of charge. Forestry students through the 1950's rarely considered the possibility of private consulting as a career. Most employment opportunities were with state and federal organizations. ACF was organized in 1948 with 15 charter members. That organization, from its early days, has endeavored to stop proposed legislation or change present laws that provide free (tax-payer funded) forest management services to landowners.

There is no firm statistical data indicating the percentage of consulting foresters that are members of ACF. Membership requirements are rather rigorous, including graduation from a recognized professional forestry degree granting program, two years or more of practical forestry experience, and providing forestry consulting services is the principal work. To advance to full membership, members must comply with ACF's professional and ethical standards, obtain specific work-relating continuing education credits every year, plus complete a designated consulting forestry course.

According to Larson (2000), "Some years ago John Miles described the progression of activity in our profession. First was the period dominated by foresters working on public lands, when only the Government could afford to practice forestry. Next was the period when industrial foresters were predominant. The third stage, developing now, is when practitioners

serving non-industrial private forests (NIPF) will have the most important role. This, group, NIPF, has always been the greatest challenge in pursuing the mission of good care for the Nation's forestland, which also means they represent the greatest opportunity." Today, private forest lands provide over 80% of our wood needs. The proper management of those forests is of concern to government, the general public, but most importantly, to private landowners themselves. The day of the consultant has arrived.

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ESTABLISHING THE BUSINESS

with contributions by
William R. Maxey and Steven Wilent

Foresters considering becoming a consultant would be wise to read and abide by both the ethic statements of the ACF and the SAF organizations. These statements are very general, but should prevent most ethical errors in establishing and conducting a sound business reputation. Consulting as a professional forester is not for everyone. To be successful you must be honest, a self-starter, a hard worker, efficient in allocating your time and efforts, and excel in field as well as office work. Bookkeeping and office skills are required for such necessities as keeping appointments, billing clients, preparing agreements, writing management plans, preparing inventory reports, etc. Time must be allocated for continuing forestry education by attending workshops or formal courses and participating in professional organizations such as the ACF and SAF.

Know Your Location

Initially you should survey the area in which you plan to operate (your "working circle") to find out if there is a need for another forestry consultant. Sources of information include the ACF, other consultants, state university and forest technology colleges in the area, and other foresters. State and federal forestry organizations may be especially helpful. Most established forestry consultants are willing to give you sound advice and, initially, they may have some work to contract to you to keep you afloat until you develop your own business. Another consultant may employ you as a permanent forester, which, in many cases, leads to a partnership or ownership upon their retirement.

Do your own survey of all types of forest landowners to ascertain condition, amount and location of forested acreage (including obtaining the most recent USFS FIA forest survey data as to the forested acreage by species and volumes of all types of owners) and the need of a forestry consultant by the following ownerships:

- Nonindustrial private forest owners (Sources: tax maps in court houses, USDA Farm Services, SCS, Farm Bureau, lawyers who specialize in real estate, bank trust officers and state and federal forestry offices).
- Landholding companies: forest industries, trusts, railroads, utility companies, such as: gas, electric, oil and coal.
- The amount and location of state, county, municipality, and/or federal forest ownerships in the proposed "working circle" of the consultant. Generally these owners will not be in need of professional forestry assistance. If the majority of forestland is in these ownerships, it is not the most likely location for starting a business.
- The location, capacity and types of markets for all wood products, i.e.; where is each manufacturing unit in proximity to your working circle? Also, the price these markets pay delivered to their mill or woodyard. The annual production of each (in board feet, tons, cords, etc. of each sawmill, chip mill, OSB plant, rail/fence, pallet, treated timber, veneer, concentration yard, pole, firewood plants or other wood using facilities).

- The types and specification of markets, include the species, such as whether all hardwood species or just soft-textured hardwoods are accepted, what species they will not accept (paper companies at one time did not want walnut or eastern red cedar). Also, investigate the specifications as to size, i.e.; 10 inches inside bark at small end of log, maximum/minimum diameters inside bark at the large or butt end of the log, acceptable log lengths (including 3 or 4 inches for trim allowance), amount of defect such as requiring a minimum of 6 inches of solid wood around hollow at butt end, and in regard to knots. Veneer buyers usually require a minimum of three clear faces, and if it is a peeler veneer company - no hollow logs are acceptable. This market is very species specific. On the other hand a pallet mill might accept knots on all four faces, take some hollow butt logs and take all hardwood species. Southern pine and cypress pole/pile markets accept only very long, straight, knot and defect free stems. Certain markets, such as Paulonia buyers, require a certain growth rate such as a minimum of 6 or 7 growth rings per inch of diameter. Many wood manufacturing plants have a maximum butt diameter limit that will clear an overhead debarker or fit through a pulpwood chipper throat (22 inches is a common maximum butt-end diameter that can fit through this equipment). The previous are but a few market examples and there are many others of which a consultant should be aware. Markets for chips, sawdust and bark have become very important, not only allowing the manufacturer to use the entire stem, but by better utilization it increases the overall return to the mill and in turn, increases the amount the plant can pay (your clients) for their raw materials.
- It is equally important to know of the logging and transportation costs and how these vary by distance from the delivery point, topography, weather conditions (winter vs. summer) and product being hauled (such as, pulpwood vs. sawtimber) and by value (for example: pulpwood vs. sawtimber vs. veneer). A consultant should determine if it is practical for a logger to build the necessary roads to enable them to harvest the timber. Can the logging chance be operated in inclement weather (winter jobs) or due to aspect, steepness, and large creeks or rivers could this property only be logged during dry seasons? Accessibility is extremely relevant, not only physical barriers like roads, cliffs, etc. but also if a temporary or permanent right-of-way to the forested area for ingress and egress is available to your client. Homes or other developments immediately below or adjacent to the clients' property may make the liability too great to consider logging.
- Most states require a business license and professional forester's registration prior to your operating as a consultant.

Personnel

Because of the physically demanding requirements of forestry work, a consultant should make sure the prospective employee is fit for the job. It would be wise to require a physical examination and a drug test prior to considering an applicant for work. When interviewing a prospective employee it is best to describe the job requirements in detail, especially such things as being required to work alone, safety considerations, working in inclement weather, and (assuming it is a salaried position) let the prospect know if 10 hour days are common and whether you expect them to work Saturdays, etc. Tell them all of the difficult or undesirable aspects or expectations that the job may entail so the employee will not be unduly surprised

when facing forest fire control, stepping on poisonous snakes or marking timber alone in a steep, rocky area with snow on the ground. Emphasize the bad features. Retention of employees depends not only on the salaries, benefits, nature of work, personalities but also on knowing they are respected, trusted and contributing in a professional manner. It pays to keep the employees informed and to communicate their strengths and weaknesses with them. Weekly performance appraisals are desirable for the first month or two. Then quarterly reviews will pay big dividends and finally a thorough annual performance appraisal is a must.

One of the most difficult jobs is disciplining and firing an employee. Discipline should be meted in private with a timely follow up in writing, spelling out what the employee did wrong, how they should correct this action, and any penalty (if any) as a result. If appropriate, a time line for correcting a serious shortcoming should be given.

If you must release an employee, you must use caution that there is not (or doesn't appear to be) an age, sex or race related reason for the discharge. Unless an employee is being fired for an obviously valid reason, it would behoove you to have documented all shortcomings and to document that you advised the employee of work related infractions as they occurred. Such documentation should include any warnings or remedial demands along with dates and with the employees' signature on the appraisal statement. It would also help if you could have recommended a course of study that would give the employee an opportunity to become competent or refer them to an appropriate doctor, etc. if the employee exhibits a mental or other health excuse.

Even in the case where you feel there is a very valid reason to discharge an employee, such as for theft of your funds or equipment, you should not accuse them of the theft even if the courts had convicted them of this. You may be sued by the employee for defamation of character, etc. This might require you to go to court, and, even if you win, it is expensive, time consuming and nerve wracking. Therefore, it is recommended that an undesirable employee be discharged because you no longer require their services, can no longer afford them, or for some other non-confronting reason. Again, any money and effort in interviewing, testing or requiring physical emanations prior to hiring a prospective employee, is well spent.

Expanding the Business

The decision to expand your business should not be based only on an expanding workload, even with very successful profits, but you must recognize that the wood industry economy fluctuates over time. During the period of 1960 to 1980, the wood industry went through 5 to 8 year cycles of boom and bust. From 1980 until 2000, there was one of the longest upswings in the history of wood industries. However, the economy slumped during the next few years. Often, sawmill owners expand their mill and hiring of employees after several years of growth and good profits only to see their business bubble burst with little or no advance notice. Wise mill owners lay away sufficient funds, limit the amount of capital tied up in timber and take other steps to prepare for these "sure to occur" downturns. Typically, the forestry consultant's business parallels these same cycles. Therefore, if your business has grown to the extent that you need help, you should first consider subcontracting some of the jobs and/or hiring temporary help. Consider expansion only when your business has prospered to the extent that you have

sufficient and liquid cash reserves to withstand severe downturns and that your personal family needs are met. Forming a Limited Liability Company (LLC) provides a protective shield over your personal (family) assets.

Legal Matters

It is imperative that you seek the advice of a lawyer and a CPA who specializes in formalizing businesses. To begin your consulting business you may wish to operate as a sole proprietor. You may still wish to form a limited liability company (LLC) following the advice of a lawyer. Doing this would limit your risk to the capitalization you have in the business and would not jeopardize your private assets such as home and family vehicle. If you decide to form a more formal business as a partnership or corporation, definitely do so in consultation with both a lawyer and CPA.

Unless you can afford an employee who is willing and knowledgeable as a "bookkeeper", it pays to have a professional CPA to keep your books and file your taxes. Initially, you may wish to have an office in your home. Check with your CPA on tax deductions for your office and all other ramifications unique to your particular business. Presently, the IRS allows a large onetime allowance of about \$18,000 for a home office or the entire cost of your home office can be written off over time. Check the IRS regulations as to the deductions for having an office outside your home where the entire costs (rent or purchase) is handled as a business expense.

Determine from the nature of your particular consulting interest as to the office and field supplies, machines and equipment you will need. Keep all receipts and a written record of everything acquired for your business needs. These include computer hardware and software (such as scanners for mapping and software for mapping to scale; forest inventory programs, etc.). Of course you will need all of the basic timber cruising tools and clothing, a vehicle (ascertain if it is logical to use family vehicle for business or perhaps you should decide if you should rent, purchase or lease an appropriate vehicle according to the extremes of terrain and weather that you will encounter). Again all decisions of this nature should be in consultation with a good CPA and checking with other consultants in the business. You may obtain objective assistance/advice of this nature from the ACF if you are a member.

It is also wise to have sufficient liability and property damage insurance to protect you and your business in case you are sued for such things as a person being injured on a client's property during a logging operation. Even though you may have included a clause in the consulting agreement between you and the client that held you blameless in such cases, the injured party may, and usually does, sue all parties no matter how remote their involvement or what "save harmless" clauses may be in legal agreements between them and their client.

It is imperative to have all agreements in writing and approved by a lawyer. Verbal agreements are very risky and are not advised, no matter the trust or friendship you may have with a client.

Responsibility of designating clients' property lines should be dealt with in the agreement between the client and you. If you are not a registered surveyor in the state where the property is

situated and you do not hire a professional surveyor to establish these boundaries, then, you should include a clause that will make the client solely responsible for any trespass or property line disputes. In regards to any consulting agreement between yourself and the client (using a standardized form you may have prepared) it is always advisable to suggest, in writing, that the potential client have his own lawyer review and approve it. It is even more important to have clients' lawyer approve a standardized timber sales contract that you have furnished the client, relating to agreements between you, your client and the successful buyer of clients' timber.

It is important to establish the fact that you are acting in the capacity of an inspector/advisor to the client and not as the clients' agent. You should never give direct instructions or orders to a logging contractor's personnel. It is not advisable for a consultant to instruct the logger or his personnel as to how a particular tree should be felled or where to put in water bars, etc. If the timber feller should follow your advice and the tree should kick back onto the logger and kill or injure them, then you would be liable. If it is necessary to correct the logger then advise the owner of the logging company of your concern but never their personnel. It is good business to keep the owner/client informed of all deviations from the contract, especially if the client is an absentee owner (which is more and more common). Serious violations of the logging contract should be given, in writing, to the logging contractor or mill owner (if appropriate) with a copy to the client. It is good business to keep the client informed as logging proceeds with good and bad reports.

Conflicts will arise from your consulting business, such as the client not being satisfied with damage that they may consider unreasonable or demands made on the logging contractor by you or the client. Conflict resolution should be expected and mediating clauses incorporated in consulting agreements and timber sales contracts.

Excelling as a Consultant

Steve Wilent wrote this section as an article in the July 2001 *The Forestry Source*, and it is used here by permission.

Consulting foresters wear more than one hat: They are foresters as well as business people, and they often have to switch caps on the fly as they deal with landowners, loggers, government officials, neighboring property owners, and concerned citizens. Forestry schools and work experience provide a foundation for playing these different roles, but many foresters pay little attention to the "people skills" they need to be successful.

Jim Ficke, a forestry consultant based in Steamboat Springs, Colorado, says those people skills are every bit as important as a background in resource and business management. Those people skills include several supporting roles:

- Salesperson: Selling yourself and your services, as well as making a case for responsible forest management.
- Communicator: Expressing yourself clearly and listening to the landowner and other concerned parties.
- Negotiator: The art of bringing two or more parties to a consensus.

- **Diplomat:** Tact and skill in dealing with people. The ability to foresee, prevent, and defuse anger and hostility. This is closely related to and often required during negotiation.

Yet the lack of people skills is a traditional shortcoming for foresters, says Philip Siarkowski, a consultant based in Saranac Lake, New York. "Foresters are not by nature salespeople," says Siarkowski. "As a forestry consultant, you have to sell forest management to skeptical clients."

Although many of his clients are reluctant to allow harvesting on their property, Siarkowski says he also understands that loggers need to make money. "It's a balancing act between people who think that logging is barely acceptable and people who log for a living," says Siarkowski. "You do a lot of hand-holding and explaining to both loggers and landowners. You end up being quite the diplomat, and forestry school doesn't qualify you for that at all."

Ficke says consultants can often best serve their clients by playing the "bad guy" in contentious situations. In this case, the consultant is less a diplomat than an intractable advocate for the landowner's objectives: The consultant takes the heat for making a decision the logger disagrees with, while the landowner plays the "good guy" by "reluctantly" going along with the consultant's recommendation. "It really pays off to have the landowner play the good guy when you're dealing with loggers or other contractors," says Ficke. "It cements the relationship with the client and helps build credibility with potential future clients."

Show Me

One of the best ways to practice people skills is in the client's forest. "By taking a client into the woods, you can point out things they probably wouldn't recognize, such as stand conditions, pathogens, fungus, and that sort of thing," says Ficke. "It gives you a chance to demonstrate your knowledge and skills as a woodsman." Ficke also says it's a good opportunity to listen to clients describe their goals and to explain what can be accomplished with sound management.

Dan Pittman, owner of Forest Resources of Montana & Associates, LLC, in Clancy, Montana, agrees that a walk in the woods is a good place to engage a landowner. "I have a very diverse clientele, and a lot of times I have to keep my mind open and listen very carefully to learn their goals and objectives so that I can educate them about what will benefit them and benefit the land," he says. "It takes time to build a relationship, to build trust," says Pittman. "Sometimes it takes three or four years before I get a contract put together and actually start to work on the ground."

Darcie Mahoney, a consulting forester in Elk, California, found that a forest tour also helped her build credibility with local citizens. To demonstrate her forestry practices to a town council generally averse to timber harvesting, Mahoney invited members of the council to inspect some of the land she managed. "They liked what they saw," says Mahoney. "Now I feel like I have the support of the community."

Even if an on-the-spot meeting with a landowner cannot be arranged, a consultant can use other means to inform the client. "A picture is worth a thousand words," says Mike Robinson, a consulting forester in Hilo, Hawaii, who is helping to lead the Hawaii Forestry and Community Initiative. "If you can't do it in person, then you can do it via videos, photographs, and other visual aids."

Choose Clients Carefully

Sometimes saying "no" also helps build trust. Mahoney has learned to be selective in taking consulting work. "When I first started my business I was worried about making money and having enough work, and I took almost any job I could get," says Mahoney. "I found that I was often being pushed to the edge of what I thought of as proper forestry. I thought, well, I'm either going to change this or not be in forestry anymore."

Some foresters said she would never get enough business to survive, but others encouraged her to choose clients whose philosophy more closely matched hers.

"I found that this went a long way toward getting along with clients," says Mahoney, "and I really haven't had a problem since then."

Robinson, too, is careful in accepting work. "I've had clients who don't care about the forest—they just want to make money. But I've had other clients who care a lot about the forest and, for them, the money is of peripheral benefit. I tend to shy away from the former, because I don't think they share my passion for forestry."

"Be honest," says Mahoney. "Tell it as you see it, and people will either trust you or they won't."

APPROPRIATE COMPENSATION FOR THE CONSULTANT

The appropriate compensation for consulting is a delicate subject, but one of utmost interest to both the consultant and the client. Poor decisions made on this issue can easily lead to serious consequences for the consultant, including loss of business and eventual failure of the consulting enterprise, if not worse.

There are obviously two extremes, charging too little or charging too much. Surprisingly, foresters have a built-in tendency to error at the first extreme. Historically, foresters have not earned high salaries, and as a result they do not appreciate the uniqueness and value of their knowledge. To illustrate this, give the average non-forester a d-tape and a map and ask him or her to inventory a 100-acre tract of timber! Yet, this is not a great challenge for the average forester.

Compensation Considerations

The consulting forester has a college education and is expected to continue that education through short-courses and professional meetings. Business-related taxes must be paid, there are professional dues, office expenses, even if it is a home office, and other business-related expenses (health insurance and vehicle use, for example) that must be included in a reasonable fee schedule. One contentious aspect involves professionals who provide consulting services on a part-time basis. In many cases, the office and vehicle expenses are not included as overhead costs and thus provide an avenue for underbidding the competition. This poses some ethical issues concerning just compensation and is a topic normally addressed by professional organizations such as the Association of Consulting Foresters.

A logical step-by-step approach is:

- Ascertain the yearly salary that seems appropriate in view of your education, experience, and expertise. We will use \$50,000 as an example.
- Any business should show some profit, which may be reinvested, above expenses and salaries. Assume yours is a one-person operation, and a 10% return is acceptable. The figure is now $50,000 + 0.10 \times 50,000 = 55,000$
- You have health insurance, retirement investments, and office expenses. This could easily be \$25,000 per year. ($55,000 + 25,000 = 80,000$)
- The number of billable days per year will probably be between 100 to 200, closer to the lower figure when beginning your business. Assume 150 days. A reasonable daily rate in this example is $80,000/150 = \$533$.

Some consulting will be billed on an hourly rate; simply use the usual daily rate divided by 8. Keeping a fair account of the number of hours spent on a project can be somewhat perplexing, as there will be interruptions in your work. Some attorneys keep hours to the nearest quarter-hour, which is workable if not considered a bit excessive.

Charging a percentage of the amount a timber sale brings (often 10%) when working for a client is common and, frankly, the most lucrative for many consultants. This approach is often

criticized as leading consultants to recommend cutting stands too heavily in order to increase their “take”. The argument can be made that the timber sale provides a period of cash flow for smaller clients who normally could not or would not invest in timber management services. Frequently, this income is used to offset the cost of previous or future management activities. Also, this approach encourages the consultant to obtain the best price possible for the client. In the final analysis, this is an ethical decision which will affect the long-term reputation and income of the consultant

It is generally recommended that compensation rates be fixed and not adjusting depending on the client. However, when a consultant must put their reputation and expertise on the line in legal cases, a higher than usual rate is not unreasonable. Some consultants charge twice the daily rate for any day or part of a day spent in court and have not had difficulty with this policy.

Invoicing

Undoubtedly most consultants would prefer to have some portion of the amount they expect to receive for a job paid up front. This, however, makes many clients uneasy. A more palatable approach is to bill at intervals as the work progresses. Before work begins, a one-page document describing the work you plan to do for the client and signed by both parties is usually sufficient to guarantee payment. An invoice should include the addresses of both parties, a description of the work completed with dates, days or hours being billed, other expenses billed, and the total to be paid with, perhaps, a penalty for payment late by 30 days.

Problems

Problems will arise, and the best one can hope is that they can be minimized. A business-like approach, honest dealing on the part of the consultant, and a clear written understanding of the services the consultant will provide will preclude most problems. If a client refuses to pay, legal steps may be required, but those cases are rare. Invoicing at intervals for long-term jobs will help minimize loss from the rare dishonest client.

CONSULTING NICHEs

Forestry consultants will find it particularly rewarding to develop unique niches for their talents. Expert witnessing is an obvious opportunity, but there are other equally rewarding possibilities. International consulting adds prestige to your business, can be financially attractive, and will undoubtedly become more and more common with increasing free trade and commerce. Utility companies, electric, gas, etc., often require forestry expertise. Part-time teaching positions at community and technical colleges can provide a steady portion of the consultant's income. Municipalities, especially those too small to hire their own urban foresters, have forestry needs. There are numerous others, but we will limit our discussion to these.

International Consulting

A principal key to becoming a player in international consulting includes establishing a reputation in a specific and high-demand area of forestry. Strive to become one of the acknowledged experts in use of GPS and GIS, in adaptive and useful sampling techniques (e.g., 3P, importance sampling, the centroid method), in a "new" silvicultural technique (e.g., crop-tree management), in hazard tree identification, etc. This type expertise can be developed by doing graduate work, attending short courses, and intensive outside reading and web-searching. The reputation you must develop will not be done quickly, but a concentrated effort and diligent study are required. Larger consulting firms, with a wide variety of expertise, normally will be best positioned to obtain international opportunities, but consultants with notable skills are certainly not excluded.

It would be helpful to develop basic skills in an appropriate foreign language. The likely opportunities in forestry suggest Chinese, Spanish or Russian might be appropriate. Again, considerable determination and targeted effort are essential.

Utility Companies

The maintenance of rights-of-way and improving their wildlife and aesthetic appeal involve forestry expertise. Become the local expert in the identification of forest herbs, wildflowers, and shrubs. Read ecology textbooks and other publications. Get to know the utility foresters in your area and let them know of your availability and spend a day in the field with him/her if possible. Keep up-to-date on herbicides and obtain the necessary certifications to use them.

Teaching Opportunities

Numerous technical schools and community colleges offer course work in forestry. If you have a master's degree, or a lot of experience with a bachelor's degree, you may want to inform them of your availability to teach on a part-time basis. As a consultant, you will have the advantage of real, on-the-ground forestry, and that usually fits nicely within the goals of those programs.

Urban Forestry

Smaller municipalities rarely employ foresters full-time, but you may find them interested in consultants, especially if you have taken formal coursework or short courses dealing with urban forestry, hazard trees, etc. The liability issue makes it prudent to have tree surveys and to remove those which pose a significant risk. You may find work related to tree planting, proper species selection, etc. It is suggested that you visit the mayor's office or other related officials, expressing your interest and availability. You will want to leave a business card and brochure, if you have one, and drop by every year or so as the personnel change in those offices frequently.

THE TIMBER CRUISE

The ability to cruise a tract of timber and make a reasonable estimate of timber volume and value in a relatively short period of time is one of the most important and unique skills foresters possess. Mensuration textbooks are available which describe the techniques utilized in great detail, but here we will concentrate on some less well-known aspects.

When to Sample

Cruising generally involves obtaining a sample of sufficient size to make reasonable estimates of a population of trees. However, if the tract is small enough, a 100 percent tally, where each tree of interest is measured or estimated, is the more efficient approach. The complete tally is particularly appropriate if the timber estimate is done in anticipation of a timber sale. Also, it must be remembered that there is no statistical sampling error when a complete tally is done (Other errors, such as use of an inappropriate volume table or poor field techniques impact all estimates, of course). The forester is best qualified to select the trees which should be removed to obtain the silvicultural objectives desired.

A reasonable question is, in what size tracts is a complete tally efficient time wise? It would be helpful if foresters did more “time and motion” studies for their own use. For instance, the time to do a timber cruise (T) can be calculated as:

$$T = n * (t + m)$$

where:

- n = number of points or plots required,
- t = average travel time per plot (minutes),
- m = average measurement time per plot (minutes).

The average travel time through the woods is usually near 2 mph (2.7 chains per minute). For a square-grid pattern, the distance between plots in chains (d) for a tract with ‘A’ acres (times 10 to convert to square chains) is:

$$d = \left(\frac{(A * 10)}{n} \right)^{0.5}$$

If A = 300 and n = 100, d = 5.5 chains. Average travel time is:

$$\begin{aligned} T &= 5.5 / 2.7 \\ &= 2 \text{ minutes} \end{aligned}$$

Assuming m = 6 minutes,

$$T = 100 * (2 + 6)$$

$$= 800 \text{ minutes (13.3 hours)}$$

Using a similar approach, the time to do a complete tally can be calculated as:

$$T = N * A * (t + m)$$

where:

- N = average number of merchantable trees per acre,
- A = acres in the tract,
- t = average travel time per tree (minutes),
- m = measurement and tally time per tree (minutes).

Again, using the example above, if N is assumed to be 30, the distance between trees in chains (d) is estimated as:

$$d = \left(\frac{10}{30}\right)^{0.5}$$

$$d = 0.6$$

$$t = \frac{0.6}{2.7}$$

$$= 0.2 \text{ minutes}$$

If m is expected to be 1 minute per tree,

$$T = 30 * 300 * (0.2 + 1)$$

$$= 10,800 \text{ minutes (180 hours)}$$

If one ignores the silvicultural advantage of the complete tally, the decision time wise is obvious in this instance.

Cruise Layout and Statistics

We will keep things simple at this point and assume the tract is completely forested and similar throughout. Plots or points can be located in a completely random fashion, but this is the exception rather than the rule, and not without good cause. Systematic location of sample plots or points, unless one is unfortunate enough that the pattern coincides with a periodic pattern of timber in the forest (not really likely), will tend to give a better mean estimate and an inflated sampling error as compared to completely random sampling. Both those facts are advantages in the usual situation.

Some foresters space cruise lines farther apart than plots (a rectangular pattern), but the time saved over using a square-grid pattern is generally not worth the complication this

procedure introduces. With a rectangular pattern, cruise lines should cross topographic contours, which is very difficult in many terrains, but that is less of a concern with the square-grid pattern.

The number of points or plots should always be determined based on the variability between points or plots. Sample size needed (n) is calculated as:

$$n = \frac{t^2 * CV^2}{E^2}$$

where:

- t = t-value (use 1 for 68% level of probability, 2 for 95% level),
- CV = coefficient of variation as a percent (standard deviation/mean *100),
- E = sampling error desired as a percent (standard error/mean*100).

or

$$n = \frac{t^2 * S^2}{SE^2}$$

where:

- S = standard deviation,
- SE = standard error

Forestry has progressed past the stage where cruise data is not kept separate by points or plots so that these statistics can be calculated. A reasonable CV for sample size calculation can be obtained from:

1. doing a preliminary cruise on the tract.
2. experience in a similar area and timber type.
3. guessing the lowest and highest point or plot volumes expected, dividing by 4 gives a rough estimate of the standard deviation.

The forester should get a “feel” for the CV expected in given areas and timber types. This information is invaluable.

Calculations for the cruise are simple, and a ridiculously small data set for 5 tenth-acre plots (n=5) on a 30-acre tract will serve for illustration.

	<u>V=vol. in cords</u>	<u>V²</u>
	5	25
	20	400
	16	256
	0	0
	11	121
Totals	52	802

Mean 10.4

$$\begin{aligned} S &= ((\text{sum}V^2 - (\text{sum}V)^2/n)/(n-1))^{0.5} \\ &= ((802-52^2/5)/(5-1))^{0.5} \\ &= 8.1 \end{aligned}$$

$$\begin{aligned} SE &= S/n^{0.5} \\ &= 8.1/2.24 \\ &= 3.6 \end{aligned}$$

$$\begin{aligned} CV &= (S/\text{mean}) * 100 \\ &= (8.1/10.4) * 100 \\ &= 77.9 \% \end{aligned}$$

$$\begin{aligned} \text{Sampling error} &= (SE/\text{mean}) * 100 \\ &= 3.6/10.4 * 100 \\ &= 3.5 \% \end{aligned}$$

Multiplying the tenth-acre mean and SE by 10 gives per-acre values, of course, and those values multiplied by 30 give the total estimates. The sampling error as a percent does not change with expansion.

Stratified Sampling

If information is available, stratification is always advisable. Removing non-timber areas, meadows, lakes, and other areas that do not contain merchantable timber, from the forested acreage is a first step. Next, delineation of timber stands by species and/or product classes (pulpwood, sawtimber, etc.) is helpful. Stratification increases the chance that sampling will properly represent the population of interest.

The allocation of points or plots in different strata (a given stratum may involve geographically separated areas on the tract) can be done several ways, but in almost all cases the forester will not have sufficient information to do other than proportional allocation. If a given stratum contains 10 percent of the acreage of the tract, it gets 10 percent of the total number of points or plots. The statistics found in some publications look terribly complicated, but if calculations are made for each stratum as shown in the previous section, the mean and sampling error is easily calculated. Assume for a 100-acre forest with 70 acres in stratum A and 30 in stratum B, cruised using a total of 50 tenth-acre plots, calculations are as follows:

	<u>Stratum A</u>	<u>Stratum B</u>
N = acres	70	30
n	35	15
mean	10	20
S	8	12

The mean for the stratified sample is weighted by the area in the strata:

$$\begin{aligned}
\text{Mean} &= (\text{sum of acres in stratum} * \text{mean for stratum}) / (\text{total acres}) \\
&= (70 * 10 + 30 * 20) / 100 \\
&= 13
\end{aligned}$$

Similarly, the standard error involves weighting by stratum size:

$$\begin{aligned}
\text{SE} &= ((1/(\text{total acres})^2) * (\text{sum of } (N^2 S^2) / n))^{0.5} \\
&= ((1/100^2) * ((70^2 * 8^2) / 35 + (30^2 * 12^2) / 15))^{0.5} \\
&= 2.02
\end{aligned}$$

Again, points or plots can be located randomly in strata, but the advantages of systematic location still apply. Stratification can be done after a cruise is completed, called post stratification.

Double Sampling

Double sampling can provide acceptable estimates and sampling errors, while reducing field time. A variable closely related to volume, usually basal area, is easily estimated using point sampling and is determined at all points, while at a randomly selected number of the total points, the usual measurements are made (dbh, logs, etc.). It is recommended that at least 30 points have complete measurements. Actually, if the number of logs on “in-trees” is recorded instead of basal area, a better result can be obtained.

The statistics, again, are easily calculated, as is outline in the chapter, “Timber Trespass Inventories.”

Points or Fixed-Area Plots?

With point sampling, sample trees are selected proportional to their basal areas, and since basal areas are closely related to volumes, point sampling tends to be more efficient than fixed-area plots when sampling for volume determinations. On the other hand, trees are selected proportional to the frequency at which they occur in the population using fixed-area plots. For that reason, when the main objective is to estimate number of trees by species or diameter classes, fixed-area plots are better. This is a bit of a dilemma for foresters as both volume and frequencies are important. Advances in instrumentation are reducing the higher costs traditionally ascribed to fixed-plot sampling, and some prefer fixed-plot cruises as training of field workers tends to be easier and mistakes in techniques less frequent than with point sampling.

Whatever the choice, there is an optimum point-sampling factor or plot size which will provide the sampling error desired with a minimum amount of field time. Some work indicates, at least for sawtimber in the eastern United States, a BAF of 20 or plot size of 0.1-acre is near

optimum. Careful field work is essential. Failing to include just one “in-tree” in a cruise can easily represent your wages for a day in the field!

Partial Plots or Points

If a plot or point falls at the edge of the forest, at a meadow for example, the easiest procedure is to first measure the “in-trees” to the edge, then pace the distance from the point or plot center to the edge. Second, proceed along that line the same distance into the meadow, and measure the trees that would be included in the woods from that location (many of which you’ve measured before; they get counted twice!). Add the two volumes to obtain the estimate for that plot or point.

CONDUCTING TIMBER SALES

with contributions by
William R. Maxey and Steve Wilent

Conducting a timber sale should be a rewarding experience for the client, the consultant, and the timber buyer. Often it is a first-time experience for the client, perhaps a once-in-a-lifetime occurrence. It is important that the consultant remember this and be certain the type harvest and outcomes are those desired by the landowner.

The Timber Sales Contract

Steve Wilent, in one of his articles in the July 2001 issue of *The Forestry Source*, wrote the material in this section dealing with the timber sales contract, and we use it here with the kind permission of that publication.

Timber sale contracts are central to the work of most foresters, but even experienced ones have been known to miss dotting every i and crossing every t. Consulting with an attorney familiar with timber sales is often advisable, and foresters who have a working knowledge of the best practices for writing contracts are at an advantage. Basic points to address include:

- The names and addresses of buyer, seller, and any other parties to the contract.
- Legal description of the property.
- Description of the timber and type of product (sawtimber or pulpwood, for instance) and how it is marked or otherwise designated.
- Beginning and ending dates of harvest.
- Time period covered by the contract.
- Payment schedule, amount and method.
- Establishment and administration of a performance bond.
- Penalties to the buyer if undesignated trees are cut or if residual trees are damaged.
- Assignment of liability for losses due to fire if caused by the buyer or his or her agents.
- Provisions for protection of soil, water, and recreational values.

Contracts typically range from a few pages to near book length and may contain many other details - so many that the obvious can be missed. "Believe it or not, the time in which the timber is to be cut is sometimes overlooked," says Hayes D. Brown, an attorney in the Birmingham, Alabama, law firm of Monroe, Johnston, Tripe & Brown. Hayes is also a graduate of the Auburn University School of Forestry <<http://www.forestry.auburn.edu/>>. "In Alabama, if you do not mention a time frame in your contract, the time frame is considered to be 10 years." (It should be noted that laws pertaining to timber sales often vary by state).

Hayes says some contracts fail to list all of the parties involved. "You not only need to look at the title to the property, but also at who else may have some sort of interest in the timber," says Brown. "In some cases, for example, you may have to have a spouse sign or a

financial institution, if there's a mortgage or a lien on the property and the lender considers the cutting of timber to be damaging to the value of the property."

William G. Apger, a California Registered Professional Forester and attorney practicing in Oroville, California, says a common cause of disagreements between buyers and sellers is over the designation of trees to be harvested. Apger says a contract must clearly state how trees are to be marked and who may mark them. He also says a contract should indicate who is allowed to possess marking paint in the sale area. "If a landowner or forester has already marked the trees, then if the buyer or any of the buyer's employees, including timber fellers, are found with marking paint in the woods, it's assumed that the only reason is for theft," says Apger.

Log accountability should also be addressed in the contract. For instance, trip tickets may be required on each load of logs that leave the landing, to allow for the tracking of logs. "I always insist on sequentially numbered trip tickets," says Apger. "If any of the tickets are missing, odds are that a load went somewhere else, and you didn't get paid for it. I make it a very serious offence in the contract if a load of logs leaves the landing without a trip ticket. I assume the intent is theft."

A contract should also inform the parties to a contract that the estimated timber volume might not equal the amount harvested. You have to use a disclaimer that the measurements and methods used to determine these values are based on statistical sampling," says Apger, "and that the true volume may be more or less than indicated in the contract. You can state that there's no warrantee other than that the cruise was performed using the best industry practices."

"She said, he said", according to Brown, is one of the most common points of contention involves the expectations of what the site will look after the harvest. One seller might feel that too much timber has been cut, while another may think not enough has been removed, especially if unmerchantable trees left by the logger are prominent in the seller's view of the property. To help prevent such disappointments, a contract should include a description of the desired condition of the forest. This may include explanations of how the trees will be harvested and yarded, how the slash will be treated, and which trees will be left standing. Still, such words can paint only part of the picture.

"It's subjective-there's virtually no way to spell out exactly what a site will look like," says Brown. "This is where public relations and a careful explanation can go a long way to helping the seller understand what the property will look like once harvesting is completed."

Performance bonds, funds that are set aside to pay for any damage to residual trees and roads, as well as unfinished work such as slash disposal or road maintenance, should be detailed in the contract or in a separate agreement. "You have to spell out very clearly in the contract what your desired outcome is," says Brown, "and say that the bond would cover any of the provisions of the contract that are not met. In that way, you can cover a number of possible undesirable scenarios."

Hayes says contracts should define three other points: damage to residual trees, when work must be halted because of weather, and the meaning of "best management practices." Damage may be defined based on whether the tree can recover from a scar or other damage, by

the number of "sides" of the tree that are damaged or by the area of cambium removed, measured in square inches or as a percentage of the circumference (a girdled tree would have 100 percent cambium damage). "I like to use a percent of damage or removal of cambium," says Brown. "Say, if one-third of the cambium is removed, then that is a damaged tree."

Most disputes over damage involve the worth of the trees rather than merely whether damage has occurred. "You can put in what's called a 'liquidated damage provision,' where each tree is worth X dollars, or establish a mechanism to determine the value of the tree, such as evaluation by the seller's forester or another third party," says Brown. "But it won't just be the value of the tree, it'll be a multiple of the value of the tree, such as three times the value. Otherwise, there's no incentive not to damage the tree." However, Brown says liquidated damage provisions need to be worded very carefully, so that it isn't seen as a penalty by a court. If such a provision calls for more than the reasonable value of the tree, plus the cost of harvesting it, then a court might disregard the claim of damage.

One point of disagreement is wording about harvesting in certain weather or soil conditions. A contract may prohibit harvesting in "wet weather" or "wet conditions" but fail to describe what "wet" means. Brown says one definition is the depth of the ruts made by logging equipment. "I've used nine inches as a benchmark," he says, "but of course that doesn't apply to all sites. This is a modest attempt to try to quantify what 'wet weather' is."

Be specific about management practices. Avoid calling for adherence to so-called best management practices, which often lack specific directives appropriate for a particular timber sale. Says Brown, "Best management practices (BMPs) were not written with the tight contractual language that we think they were written in. They are usually intended as guidelines. They have words like 'should,' 'minimize,' and 'whenever possible.' These are lawyer full-employment words." Best management practices may call for minimizing stream crossings, for instance. In a timber sale contract, however, it's best to describe where each stream crossing is to be located and how it may be constructed. "Until you say, 'There will be one stream crossing, and here's where it will be,' you have not applied the principles spelled out in the best management practices," says Brown. Franz Kafka once defined lawyers as "persons who write a 10,000 word document and call it a brief." A timber sale contract may not be brief, but in today's increasingly litigious society, it is a necessity.

Designating Trees to be Harvested

The consultant may mark the leave trees or the trees designated for harvest. The choice usually depends on which can be done most efficiently. Marking should be done with a high visibility paint. The paint marks should all face in the same direction on level to rolling land and marked on the down hill side on steep slopes. Or, if the skid roads are already constructed, you may wish to mark trees in the direction they are to be felled. One advantage to individual trees being marked is that the diameters and heights by species may be recorded as the marking proceeds and no statistical sampling error is reported if volume is estimated for each tree.

Two marks should be placed on each tree, one near the ground below the customary stump height and the other at eye level. The low mark gives the consultant and client assurance

that the tree was supposed to be cut. If there is a concern about the timber buyer painting trees that were not conveyed in the timber sales agreement, the consultant should have their paint chemically analyzed. The eye-level mark is chiefly for the benefit of the prospective buyer and the timber cutter but also helps the timber marker keep the proper residual stocking distance.

An optional method of designating trees that are to be harvested is to set varying diameter limits by species and/or species groups. There may be a requirement to fell or deaden all but a few den trees also. Those trees may be marked with ribbon or a ring of paint completely around the tree at eye level. Such diameter-limit cutting is discouraged by many foresters, as it can lead to high grading. If the limits are correctly specified by species, however, this method can provide desirable residual stands.

Some consultants prefer to set a minimum inside-the-bark diameter limit at ground level on the uphill side of the tree. This gives the consultant and client positive proof that this tree was suppose to be cut. This system saves valuable time in preparing a timber sale and therefore, allows more time for the consultant to inspect the construction of roads and check to see that the residual timber is not unduly damaged. The latter two concerns are much more important to securing good forest stewardship than whether a tree or two is cut that should not have been. Also, there is a safety factor to consider. In rocky, steep and/or frozen terrain the timber marker is more likely to be injured by falling.

Overseeing the Harvest

Often, but not always, the contract between the consultant and the client includes agreement that the consultant will inspect the logging operation. The frequency of inspections is dependent upon the rate of timber removal; however, it is usually advisable to make at least one inspection every week when logging is active. The inspection should be thorough, that is, not just visiting the log landing but walking over all areas not previously inspected to make sure that all necessary contract provisions are being followed. It goes without saying, that any violation of state or federal law pertaining to logging must not be tolerated.

When addressing BMPs, the emphasis here should be on what is actually "necessary". It requires careful diplomacy to be firm, but reasonable. If there is no reason for requiring a logger to apply a certain BMP - don't. The logger should not have to implement any BMP that is not necessary when closing out a particular logging job. For example, when the terrain is practically level, is not subject to erosion, and the owner did not specify that all roads were to be graded, cross drained, seeded and mulched, then those BMPs are not required.

Regardless of any possible hardship on the potential logger, it is the consultant's responsibility to protect their clients' property from erosion. Beginning around 1960 logging road and skid road construction was revolutionized with new standards related to the topography. Since that time, everywhere possible, the truck roads have been constructed on grades not to exceed 5% and skid roads not to exceed 10% (unless the terrain or ownership may compromise these more gentle grades). After logging, most of these roads have been retired with cross drainage, mulching and seeding. As a result, these roads systems will still be in place for future

logging. This will make the next harvesting operation less expensive and reduce the environmental impacts of initially building the roads.

The consultant should first advise the logger to correct any harvesting practice that violates state or federal laws, BMPs, or terms in the timber sales contract between their client and the logger. Should the logger be able to correct the violation in a reasonable time, there would not be any reason to report this to the client. If federal or state regulations or contractual agreements are violated, after the logger has been informed then the consultant should advise the client of the nature of the violation and advise them how to correct the problem and/or how to notify the proper authority in a timely manner if that is necessary. In order to limit liability, a consultant must be discrete when advising a contractor so as not to even give the appearance of being their supervisor.

Economic Considerations

A consultant must constantly keep updated on the market prices for all of their clients' forest resources. There are several publications, such as the Appalachian Hardwood Report, to aid in this endeavor. Also, consider the seasonal variations in demand by type of market. For instance, there is usually a limited demand for timber after a mill has made it through the winter. Quotas are more common on accepting logs during this period and prices somewhat lower. Logs are damaged from insect and fungus infestations if stored through the spring and early summer, and mills try to minimize this loss. In the mid-Atlantic states most mills begin to accumulate logs for fall and winter by the first of July. Quotas are fewer and prices generally better after this.

A forestry consultant must keep abreast of overall economic trends and be especially attuned to mergers, new mills being built, plant downsizing or closings, changes in production and changes in raw material specifications within the wood industries. Be aware of any current or potential threat from forest insects and disease which might prevent certain species from being shipped out of a quarantined area.

Unlike most financial investments decisions, most timber sales can be timed to occur when the markets are at or near their peak. If there is a significant downturn in raw material prices most timber sales can be delayed from a year to several years to coincide with better prices. Generally, by waiting, the timber will only be larger and thus more valuable. Unfortunately, if a client has an estate which has to be closed at a particular time, needs immediate income for education, health or other reasons, timber has been affected by a severe forest fire or blow down or an impending epidemic of insects or disease threatens, then the sale may have to be prepared without delay.

The Bidding Process

Most forest land owners do not know the value of their timber or how to attract potential buyers to a prospective sale. Consultants can obtain addresses and telephone numbers of sawmills and other timber markets and usually advertise an upcoming sale in newspapers and other publications. Timber owners generally receive higher offers through the bidding process than from an individual buyer who negotiates the sale. It is recommended that consultants not

directly negotiate sales for their clients. This helps keep the transaction above suspicion and secures the best returns for their client. Even if a negotiated sale is done in the best interest of the client, this process is suspect. Should the owner/client have granted a prior right-of-first-refusal to a company or timber buyer, it is still recommended that a widely advertised bid sale be made and the company having the right-of-first-refusal would have to match or exceed the high bid.

GROWTH PROJECTIONS

Consulting foresters are often called upon to conduct forest inventories. Unless the inventory is desired for an ensuing timber sale, chances are that the client may request some indication of the potential volume and/or value at some future time period. It would pay to consider how you would handle this situation prior to conducting the inventory even though your client may not have indicated an immediate interest. Being ready to assist your client if additional requests are made goes a long way toward building good client-consultant relationships. Knowing how you will handle a request to project growth from a standard inventory should motivate you to ensure that sufficient data is collected during the inventory to make this possible. Usually, the additional data collection needs do not significantly change the standard inventory time or cost. However, it does greatly expand the utility of the data collected.

Types of Growth Projections

The goal of any growth projection project is to provide the client with the most accurate estimate possible depending upon their needs and the constraints of time and money. Having a good idea of what the client is trying to accomplish may be the most important aspect of your project as it may dictate the approach and/or expected accuracy of the outcome.

Growth and Yield Simulators

Having an ongoing permanent plot system with remeasured plot data on the property in question would provide the most precise estimate, but few are afforded such a luxury. A working knowledge of available growth and yield software programs that are applicable for your timber type and locale is invaluable. Be sure that you thoroughly understand how the program was developed, where it is applicable, and whether your stand conditions fall within the range of the data used to develop the program. You should also investigate whether the program provides some measure of error based on the differences between the data used to fit the models and program estimates. Realize that projection precision is improved if the program permits the user to enter an actual stand table. Most growth projection simulators restrict the user to the entry of stand level estimates of trees per acre, age, basal area and site index. Simulators that provide diameter class distributions at a future age normally predict the initial diameter distribution using some mathematical equation. If the simulator permits the entry of initial stand table data, enter it rather than having the simulator predict it. Another advantage of using growth and yield models is that some estimate of growth can be obtained even if you do not have a current inventory. This means that you will have to enter your perception of the average stand parameters for your “virtual” stand.

Stand Table Projection Systems

In the absence of applicable growth and yield models, a stand table projection technique can be used. In this situation you will normally be required to collect diameter increment data, estimate tree mortality by diameter class, have the ability to estimate tree height for the surviving trees and then apply a volume equation to each surviving diameter class. Though this may seem

a bit daunting at first, with the collection of tree increment data during the inventory you normally have all the components necessary for this procedure except the mortality function. One nice attribute about a stand table projection system is that the diameter increment and height data are tied to the specific area inventoried. One should keep the projection intervals as short as possible since we know before we start that stand age, density, climatic conditions and the natural biological growth of a tree tell us that the next periodic increment will not match the previous increment. With that said, how do you apply this approach? The first step would be to estimate the number of trees that will die during the projection period by diameter class. Check current professional journals for appropriate models for your area or determine what growth and yield simulators use by checking their references. Realize that most models provide for a higher level of mortality for smaller diameter classes. Apply the mortality rates to your existing stand table and predict the future stand table using standard stand table projection techniques as described in most mensurational texts (Burkhart and Avery 2002). Once the predicted stand table is obtained, you will need a method for predicting the average volume for each diameter class. The easiest approach would be to employ the use of a local volume table. For an individual diameter class, the tree volume for the mid-point of the class expanded by the number of trees per acre for that class will provide your estimate of volume per acre. Another approach used by many growth and yield systems involves the use of a height prediction equation that can be used to obtain a more accurate estimate of individual tree volume. In the absence of regional models (Cao et al. 1982, Borders et al. 1999) you can use the height data collected during the inventory to fit a height model in Excel. A model form that has been used extensively for height data is:

$$\ln(HT) = \beta_0 + \beta_1 \left(\frac{1}{DBH} \right)$$

This model can then be used to predict the average height of the surviving trees. All that is left to do is apply a volume equation to the height, diameter, and trees per acre to estimate future volume.

Also note that Shiver and Borders (1996) provide an alternative method of computing the future stand table using a constant basal area growth approach rather than a constant diameter growth approach, which more closely resembles the actual biological growth of a tree. A simple illustration of stand table projection is provided in the Appendix.

Published Growth and Yield Simulators

The following represents a partial list of many of the computer based growth and yield simulators that have been developed. Realize that most simulators were developed for DOS based computer operating systems and these may not run properly on Windows based operating systems. The following list is divided by region and major species. Note that the TWIGS models are currently being incorporated into the USDA Forest Service's Forest Vegetation Simulator project (FVS) (<http://www.fs.fed.us/fmnc/fvs/index.php>):

Southern Pines

- TAUYIELD: Growth and yield of thinned or unthinned cutover, site-prepared loblolly pine plantations (Virginia Polytechnic Institute and State University).
- PTAEDA2: Southern region-wide individual tree growth and yield of planted loblolly pine on cutover, site-prepared areas. Program includes a thinning and fertilization algorithm (Virginia Polytechnic Institute and State University).
- GaPPS: Growth and yield of planted loblolly and slash pine in the Piedmont and Coastal Plain regions. System includes a thinning and fertilization algorithm (The University of Georgia).
- S1988f: Growth and yield of mid-rotation fertilization of planted slash pine. This program was developed at The University of Georgia in cooperation with The University of Florida (The University of Georgia).
- SE-TWIGS: Individual tree regional growth and yield system for southern conifers and hardwoods (USDA Forest Service). Currently being incorporated in the USDA Forest Vegetation Simulator (Meldahl and Bolton 1989, 1990, 1990b).
- ECONHDWD: A growth and yield model for the economic assessment of reducing hardwood competition in unthinned loblolly pine plantations (Virginia Polytechnic Institute and State University).
- PCWTHIN: Whole stand and diameter distribution models for thinned, old field planted loblolly pine in the Virginia Piedmont and Coastal Plain regions (Virginia Polytechnic Institute and State University).
- COYIELD: Southern region wide whole stand and diameter distribution models for unthinned, unimproved loblolly pine plantations on cutover sites (Virginia Polytechnic Institute and State University).
- NATLOB: Natural stand loblolly pine diameter distribution growth and yield system (Virginia Polytechnic Institute and State University).
- NCSU: North Carolina State University managed pine plantation growth and yield system. Includes models for loblolly and white pine (North Carolina State University).
- SLPSS: Individual tree growth model for natural shortleaf pine in western Arkansas and eastern Oklahoma (Oklahoma State University).
- ACORM: A growth and yield system for planted loblolly and slash pine in the Piedmont and Coastal plain regions. The program is designed to provide economic analysis of various site preparation treatments as well as the influence of herbaceous weed control. Originally released in 1997 by American Cyanamid.
- MSU: Mississippi State University offers several growth and yield systems including cutover loblolly pine, old field loblolly and cutover slash pine plantations. They also provide a natural longleaf pine simulator.

Northern Pines

GROWPINE: Whole stand growth and yield system for unthinned old field white pine plantations of southern and eastern Ohio (USDA Forest Service).

Southern Appalachians Hardwoods

G-HAT: An individual tree, distance independent growth and yield system for Southern Appalachian mixed hardwood stands following thinning. (Virginia Polytechnic Institute and State University).

Northeast/Mid Atlantic Hardwoods

GROAK: Whole stand system for growth and yield of even-aged upland oak stands (USDA Forest Service).

FIBER: A matrix growth and yield model for simulating the management and growth of forest stands in the Northeast. (USDA Forest Service a variant available as part of NED-SIPS).

OAKSIM: Individual tree growth and yield system for upland hardwood stands of southern Ohio and eastern Kentucky (USDA Forest Service - a variant available as part of NED-SIPS).

SILVAH: Growth and yield of Allegheny hardwoods (USDA Forest Service - a variant available as part of NED-SIPS).

NE-TWIGS: Individual tree regional growth and yield system for northeastern hardwoods (USDA Forest Service – a variant available as part of NED-SIPS). Currently being incorporated in the USDA Forest Vegetation Simulator (Hilt and Teck 1989).

NED-SIPS: Includes a variant of the FIBER, OAKSIM, SILVAH and NE-TWIGS growth and yield systems (USDA Forest Service).

Lake States

LS-TWIGS: Individual tree regional growth and yield system for lake states species (USDA Forest Service). Currently being incorporated in the USDA Forest Vegetation Simulator (Minor et al 1988).

Central States

CS-TWIGS: Individual tree regional growth and yield system for central states species (USDA Forest Service). Currently being incorporated in the USDA Forest Vegetation Simulator (Minor et al 1988).

Western Forests

- CRYPTOS: Individual tree growth and yield system for California coastal redwood and fir forests.
- CACTOS: Individual tree growth and yield system for California mixed conifer types.
- ORGANON: Individual tree growth and yield system for western Oregon conifer and hardwood types.

For more extensive list see <http://www.for.gov.bc.ca/research/gymodels/refs/refs.htm>.

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BOUNDARY SURVEYS

with contributions by
William R. Maxey

A forestry consultant is fortunate when he finds the client's property has properly surveyed property lines and good permanent corners. Unfortunately, all too often the client is not certain of a single line or corner. Few forestry consultants are registered surveyors, but most have a good working knowledge of the principals of surveying and the desirability of well-located property lines.

The landowner is in a bit of a catch 22. They would like to know the location of their property lines, but often the value of the timber they may wish to sell or the potential value of tracts they wish to manage do not seem to justify the expense of a licensed surveyor.

When is a Survey Necessary?

A consultant recently said to a class of forestry students, "The greatest source of error in our timber cruises is in the estimate of tract size." It certainly does seem ironic that foresters have developed such sophisticated sampling techniques for estimating tree volumes, know how to measure trees accurately, and yet have had to base estimates on a very uncertain area figure. The development of accurate GPS units is greatly reducing this difficulty assuming reliable property lines can be found in the field.

Otherwise, you will need to go to the appropriate courthouse and get a copy of pertinent deed(s). You should first go to the assessor's office to determine from the tax map the index number of the property in question. Usually that index card will not only have the most current owner but all known previous ones. It should be noted that assessor's tax maps are often inaccurate and are mainly for indexing purposes. However, these maps can give you the general outline of the property in question and do give reference numbers which, in a card catalog or computerized program will give the deed book and page numbers. It is good business to also plat the adjacent properties to ascertain if there seems to be any boundary conflicts. The assessor can provide you with the reference to the most current deed book and page number enabling you to locate the deed description in the clerk's office. If the current deed located under the Grantee's Index does not have the courses and distances (metes and bounds) or the U.S. Public Land Survey description it will be necessary to look up the grantor's name in the Grantee's Index (in other words abstract the ownership back until you find suitable metes and bounds of their property).

If this search does not yield results, it may be necessary to check the other records, such as the will's and/or the tax delinquent or court action files for further references. Finally if all of this searching fails, it may be necessary to hire an attorney. Of course you will need your clients' approval if this is an additional expense that the owner has not approved. The client may also

want you to use their own attorney who may have abstracted the ownership for the client when the property was purchased.

If the consultant is developing a management plan for the client, accurate estimates of area are not necessary. However, if thinnings or harvest cuttings are to be made, the client, the forester, and the logger can have legal difficulties if boundary lines are uncertain. Leaving a buffer of uncut timber is a poor choice, but many times it is the best one can do. A better choice is to seek agreement with adjacent landowners as to location of boundaries, but that is obviously not feasible in many cases. A legal survey with well-marked lines and corners is the best situation. In timber trespass cases, of course, accurate surveys are necessary before going to court.

Advising the Client

Title searches at the courthouse can be a very involved process, but often the consultant is only concerned with finding a deed with a property map and survey information. Once that is done, the forester, like the surveyor, is “trying to trace the steps of the original surveyor.” If you find it necessary to advise the client to obtain the service of a surveyor, you should recommend that they employ one of good reputation, properly licensed, and one familiar with the area, if possible. It would be prudent to indicate, perhaps in some written correspondence with the client, that rough lines you locate have no legal standing and are only to be used for approximating purposes. The use of compass and pacing is pretty much of historical interest these days. All forestry consultants need to be educated and experienced in use of GPS instruments and GIS software.

TIMBERLAND APPRAISAL

by Steve Wilent from the April 2002 issue of [The Forestry Source](#)

How much is your forestland worth? How much will you pay for your next timberland acquisition? Landowners and foresters often need to determine the value of their or their clients' holdings. Many consulting foresters provide appraisal services to individuals and corporations. Professional appraisers, who usually have expertise in real estate or business investment appraisal and in forestry, offer specialized services to landowners, forest managers, and timberland investment management organizations that make investments on behalf of pension and endowment funds.

An appraisal may be needed for tax purposes, to establish collateral value for a loan, to determine the value of a property for sale or when a property is transferred as part of an estate or divorce settlement, or in the analysis of timberland acquisitions for investments. An appraiser may simply calculate the current market value of a single parcel of timberland or compute the rate of return on an investment in a portfolio of geographically diverse holdings over decades. At either end of the spectrum, says Richard W. Courter, a forester and owner of GeneTechs, a forestry consulting firm in Portland, Oregon, appraisers must have solid timber-cruising, mapping, and other forestry field skills. An accurate appraisal, he says, is based on good data. "I have lost appraisal jobs because of that philosophy," says Courter, who focuses on relatively small properties. "Other appraisers came in at a much lower rate, because they weren't going to put as many plots out in the field. They might spend a half-day in the field, while I would have spent two days to get a more thorough cruise."

Appraisers use one or more of three methods:

- Component valuation: The appraiser calculates the value of each separate component of the property and then adds the values together.
- Sale comparison: An appraiser evaluates the sales of similar properties to arrive at an estimate of the market value of the subject property. Appraisers make adjustments for time, size, amount, and type of timber; the land's marketability; and other factors.
- Income Projection: An appraiser calculates the rate of return on an investment in timberland over time.

Jeff Wikle is a long-time forester and member of the Appraisal Institute who specializes in forestland appraisals for large institutional investors. "It is crucial in taxation and investment issues that the depletion accounts for all of the allocated components of timberland be established via some sort of credible appraisal process," says Wikle. Values are calculated for components such as standing timber, different types of land, water resources, mineral rights, roads, structures, and other improvements.

In projecting income for institutional investors, appraisers must base their calculations on a specific management plan. "It's important that appraisers articulate to everybody involved just how we're going to produce that income," he says. "We tell investors that we'll spend, say, \$100

million on timberland, and we're going to hold that timberland for 15 years. We project timber sales and replanting and all silvicultural expenses. We calculate the value of the timber and the land at the end of 15 years and project that it can be sold at a certain price, and when we put it all together it shows that we expect to produce, say, an 8 percent return rate."

As part of projecting return rates, appraisers of timberland must consider past forest management practices. "What was the forest management philosophy on that property? Have they let it grow? Have they highgraded it? Have they done diameter-limit or stand-improvement cuts? Have they used fertilizer or post-harvest weed control? You may be looking at 30 or 40 or 50 years of management," says Wikle.

Courter says appraisers must also consider federal, state, and local forest practice laws, regulations, and zoning ordinances in assessing timberland. "The basic assumption we have to make is that we can harvest every stick of wood on the property on the day we appraise it," says Courter. "But if you can't harvest everything on that day, how do you assign a value?"

Federal law requires state licensing of real estate appraisers, including those who specialize in timberlands. Organizations such as the Appraisal Institute promote professional ethics and adherence to standards of practice. Wikle says competent appraisal services are an integral part of long-term timberland management.

TIMBER TRESPASS INVENTORIES

Forestry consultants are often called upon to determine the amount, quality, and value of timber removed from a tract, presumably without permission. The very nature of a trespass implies evaluations will be difficult, as the trees in question have been cut and some portion of the merchantable material has usually been removed from the site. Additionally, legal proceedings may well ensue.

Evidence

One usually finds at least the stumps after a trespass, although not always (e.g., on land stripped for mining). The tops for some or all of the trees may be where the trees were felled. Logs may be present, especially if the trespass was detected at an early stage of harvest. The area involved may be small or very large, and the length of time since the cutting and the opportunity to collect evidence can vary greatly. All these factors influence the procedures which may be appropriate.

Procedure

In view of the likelihood of legal action, some general guidelines should be remembered:

- Use generally accepted methods that are not too difficult for non-foresters to comprehend.
- Keep good records and a diary of your work.
- Photographs of the area and field procedures may be helpful.

In the most extreme case, when even the stumps have been removed, the best evidence is that obtained from trees on nearby and similar sites. If photographs of the site before harvest are available, that would be helpful to estimate the sizes and quality of the timber. Aerial and satellite imagery may indicate previous conditions, such as areas of similar density and crown width, and may be obtained from web-based resources.

Basic measurements

When stumps are present, the following is generally recorded for all or a representative sample:

- stump height, on the uphill side if on a slope
- stump diameter, usually outside bark (if stumps are 1 foot high or more, TCH* recommends measuring stump diameters at a standard height, at 1 foot)
- species

Estimating tree volume

If tops can be found that are undisturbed since felling occurred, the distance from the stump to the top can be measured to estimate the length of the bole which was removed. All that is required to estimate volume is an estimate of dbh. Publications, such as those by Bylin (1982), Wharton (1984), and McClure (1968), provide equations for estimating dbh from stump height and diameter measurements.

If undisturbed tops cannot be found, the usual situation, local volume tables may be developed from uncut trees on nearby apparently similar sites. Those trees, selected to represent the species involved in the trespass, can be measured for volume estimates using the appropriate standard techniques. In some instances, it may be possible to derive local volume tables for each species involved in the trespass, a better approach when feasible. With volume as the Y-variable, the X-variable can be dbh as predicted from stump measurements or stump diameter preferably at a standard height. In the past, linear regression was generally used to develop the prediction equation, using as the X-variable the square of dbh which will tend to have a linear relationship. As an alternative, free programs (e.g., CurveExpert) can be downloaded from the web which makes a perhaps more easily understood graph for presentation in court. Simpson and Wiant (1992), however, found local volume tables made from adjacent portions of a stand could give estimates which differed from less than 1% to over 50% from the actual volume of the known trespass volume.

Cruise Design

If the area is large, approximately 20 acres or more, fixed-area plots or strips may be used. For smaller tracts, a 100% tally will be appropriate. If plots or strips are used, there is some optimum plot or strip size that will give the sampling error desired with the minimum amount of time in the field. This has been studied for eastern forests (Gambill et al. 1985, Wiant and Yandle 1980) for cruising of standing timber, and similar work would be useful in trespass situations. Until such research is done, it is likely that tenth-acre plots on a square grid pattern is a reasonable design. In plantations, a rectangular plot with corners half way between tree and row intervals will be most accurate.

A form of double-sampling or 3P-sampling is worthy of consideration. Wiant and Hager (2002) used 3P sampling on a tract in Appalachian hardwoods, where the estimated volume (E-value) of 3P selected trees was that obtained from local volume equations derived from FIA inventory data. It will be rare, however, that 3P sampling will be convenient (see Wiant (1976) for an easy-to-follow guide to using 3P sampling).

Double sampling can be used in this case. Although trees with undisturbed tops will not lend themselves to truly random selection, they can be assigned as the M-values (the measured values) in the inventory, and the volume estimate which should work well would be:

Total volume estimate = (sum E-values for all stumps)*(sum M-values for undisturbed trees/sum E-values for undisturbed trees)

The sampling error can be calculated as is done for regular double sampling, recognizing that the selection of measured trees violates assumptions of random selection (see Super Simple Guides in the Appendix).

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EXPERT WITNESSING

Consulting foresters are often called upon as expert witnesses, especially in timber trespass cases, but also in boundary disputes, woods-related deaths or injuries, contract disputes, and numerous other cases. Rather than view those occasions with dread, the consultant should recognize that they are an opportunity to serve clients and build a reputation which provides many rewards, not the least being respectable remuneration. An excellent book you would profit from reading is “Succeeding as an Expert Witness” by H. A. Feder. Tageh Press, 2000.

Preparation

The consultant must ascertain clearly the issues in the case and confirm with the attorney the aspects for which his/her expertise is required. It is essential that field notes and office correspondence be organized and accurate. Recommended procedures for trespass cases are discussed in another chapter. Keep accurate field notes, take photographs when needed, and most important, study your data to be certain your conclusions are warranted. If statistical analysis is included, use techniques that are generally accepted. Prepare and provide written reports to your attorney only if requested to do so. A report in preparation should be labeled “Draft” or, better yet, “Draft for Internal Review Only...Analysis Incomplete and Ongoing”. Such reports must be accurate, clear, and concise. In fact, it is best to keep written communication to a minimum, and written reports may not be desirable. Your attorney will advise you on this.

Some Do's

Remembering that the opposing attorney may attempt to question your expertise, confuse you, lead you into areas in which you are not knowledgeable, and twist what you say, you must:

- Be confident, which you should be if you have studied your data closely.
- Be courteous (if you get angry, the case and your reputation will suffer).
- Be attentive (ask for the question to be repeated if you need additional time to compose your thoughts).
- Be truthful.
- Be precise in your answers and do no more than answer the question asked.
- Be nice (hopefully, that comes naturally for you).
- Do not attempt to answer questions outside of your areas of expertise. “I don't know.” Is a very acceptable answer in those instances. Professional ethics requires that you inform your client when asked to do work outside your area of expertise and suggest other professionals who would be more appropriate. Use language understandable by non-foresters. If technical terms must be used, explain their meaning clearly.

Some Don't's

Do not ramble. You may find you are enjoying “having the floor”, but don't let that euphoria come back to haunt you. It is very easy to venture into areas which you have not thought out and leave yourself open for embarrassing questions.

Do not play to the jury, if it is a jury trial. However, talk to the jury or judge, make eye contact, and observe their reactions. Remember, they will be the decision makers. When you have answered the question, turn your attention back to the attorney and carefully listen to the next question.

Some Examples

As an expert witness in a timber dispute case, a consultant was asked to testify as to the volume and quality of timber removed from a 90-acre tract. A judge was hearing the case, and he was obviously impressed with the sophistication of the tenth-acre-plot cruise (we foresters do not recognize how scientific our work appears to the layman) and the equations used to estimate dbh-values from stump measurements. The attorney the consultant was working for had already decided to have him testify as to volume, but have a local lumberman testify as to value of the timber removed. The case seemed to be going well until the local lumberman was called to the stand. The opposing attorney asked him, “Did you visit the site?” When the lumberman answered, “No.”, the case was obviously in trouble. The consultant suggested to the attorney that he be put back on the stand as he had, on his own, estimated the grade of the trees removed using USDA Forest Service equations and the value using published figures for that area. His calculations, fortunately, did not differ greatly from those the lumberman gave, and, again, the judge was impressed. The case was won for the consultant's client. The lesson:

Study All Facets of Your Data!

To be fair, it should be pointed out that the consultant could have had difficulty had his estimated value been very low compared to that of the lumberman and had the opposing attorney asked if he had made an evaluation. The figures the consultant would have been obligated to reveal would have disappointed his client.

In Liverpool, England, the opposing attorney in a utility right-of-way vegetation sampling case asked a consultant if he had examined the contract on which the survey was based. He answered, “I did not study it as my expertise is not in contracts but in sampling.” The attorney left that area of questioning. The lesson:

Don't Claim Expertise When You Do Not Have It!

A coal company refused to pay a logging company which it contended did not follow the contract specifications for acceptable forestry practices. The coal company had a non-forester checking on the logging operation from time to time. A suit ensued. A consultant hired by the coal company was questioned by the opposing attorney during a deposition. He was asked if the coal company's representative should not have pointed out the contract problems and

unacceptable forestry practices promptly. “Yes,” the consultant replied, “but non-foresters could not be expected to recognize what is or is not good forestry.” The dispute was quickly settled out-of-court. The lesson:

A “yes” alone is often not sufficient, and the consultant may need to request the opportunity to expand on an answer if necessary.

Fees

Foresters, unfortunately, tend to underestimate the value of the education and knowledge they have acquired. To some extent, law firms tend to evaluate your worth based on the fees you charge and obtain. In the legal arena, the consultant is risking credibility and should not hesitate to charge a higher fee schedule than in normal day-to-day consulting. The fee you can charge depends greatly on the reputation you have established and the effectiveness you demonstrate in the courtroom. It is reasonable that the fee schedule is increased for any day or part of a day spent in court, perhaps as much as double the normal daily rate.

FOREST STEWARDSHIP PLANS

by Steve Wilent from the March 2001 issue of [The Forestry Source](#)

For many nonindustrial, private forestland owners, forest stewardship plans provide a roadmap to achieving specific goals for their holdings. Such documents, often prepared with the aid of a professional forester, set out step-by-step guidelines for maintaining forest health and productivity, enhancing fish and wildlife habitat, protecting water quality, improving aesthetics, and other objectives.

Most states require landowners to enlist the aid of a consulting forester or to work with state or university extension foresters to develop the plan; some states allow landowners to develop their own plans after attending a plan-writing workshop. Ole Helgerson, a [Washington State University](#) extension forester, presents management plan-writing classes for landowners in southern Washington. He says a forest owner's overall goals are the focus of a plan.

"The first thing I tell woodland owners is to write down what they want from their woods," says Helgerson. "Whether it's financial return, aesthetics, wildlife habitat, or other goals, they need to get that down on paper."

Goals can be outlined in a brief statement (such as "I want to establish a tree farm on 75 percent of my property and improve wildlife habitat so I can hunt for deer.") or in a list of specific objectives, ranked in order of importance, such as:

- improve black-tailed deer habitat
- decrease risk of wildland fire
- provide annual income from timber sales
- protect stream banks from erosion

After identifying their long-term objectives, landowners need to describe their property. "The next step is to figure out what you've got," says Helgerson. "You can use an aerial photo to identify different management units and then list what's there. This can be fairly simple, such as 'A mix of Douglas-fir and red alder, about 30 years old.'"

Helgerson says a timber inventory or other survey is not required in many cases. However, plans created by professional foresters often provide a more-detailed resource assessment, including the:

- volume of merchantable timber
- descriptions of soils
- the history of previous harvesting
- an analysis of wildlife habitat and other information

Foresters can also suggest a range of alternative treatments that would accomplish the overall goals and comply with environmental laws and forest-practice regulations. Stewardship planners will also benefit from looking at conditions on adjoining properties and even enlisting the cooperation of neighbors. Jim Stiehler, a forest stewardship coordinator with the [Pennsylvania Bureau of Forestry](#), says doing so can save time and money. To attract eastern bluebirds to a 50-acre woodlot, for instance, a landowner might clearcut a small area, seed clover

in the opening and the access road, and install a handful of birdhouses in the area. But a look at adjacent parcels might suggest alternatives to that potentially costly activity.

"If the neighboring property is a hay field," says Stiehler, "maybe the best thing the landowner could do would be to erect 30 bluebird boxes along the property boundary."

Although landowners are not required to address neighboring properties in stewardship plans, establishing a connection with neighbors during the plan-writing process can lead to cooperation and mutual benefits.

"It's often possible to find economies of scale, such as when a neighbor can do prescribed burning on their property at the same time," says Alan J. Long, associate professor at the [University of Florida's School of Forest Resources](#) and conservation and technical coordinator of [Florida's Forest Stewardship Program](#). "And with treeplanting, it can be more efficient to get a contractor to plant two or three properties instead of one."

Ultimately, the plan must set out management recommendations for each unit and a timetable of activities to be carried out over five to 10 years.

"Things change," says Long. "There's no point in planning out all of the detail over 20 years when there is the risk of hurricanes, fires, bugs, market changes, and so on."

Stiehler says a stewardship plan is more than an action-item list. He advises foresters to include 13 stewardship bulletins published by the [University of Pennsylvania](#) (available free at <http://pubs.cas.psu.edu/forestry.html>) as supplements to each plan. Plans should also include maps of the property, soil surveys, and other related information.

"You give the landowner a specific book written about his property and about forestry in Pennsylvania in general," says Stiehler, "That's a very useful document for the landowner."

Very useful software, called StewPlan, for preparing stewardship plans can be downloaded at:

<http://www.fs.fed.us/ne/burlington/ned/specs.htm>

ETHICS

There is much debate in society today concerning ethics or lack thereof in political, business, and personal arenas. It is a topic of special relevance to foresters as they deal with the public, and this is especially true for consultants. The private landowner often has little knowledge concerning proper forest management or the value of timber, and the opportunity for unethical behavior is always increased when informed buyers and uninformed sellers interact. The consultant is often in the middle of these transactions, and even with the best intentions needs guidance as to appropriate ethics.

Association of Consulting Foresters

We will examine the Code of Ethics of the Association of Consulting Foresters (ACF) first. Here is their code:

Code of Ethics

These canons formulate the guiding principles of professional conduct for ACF Consulting Foresters in their relations with each other, their employers, the public and with other foresters. Observance of these canons secures decent and honorable professional and human relationships, establishes enduring mutual confidence and respect, and enables the profession to give its maximum service.

These canons have been adopted by the membership of the Association and can only be amended by the membership. These canons apply to all membership categories. Procedures for processing charges of violation of these canons are available from the ACF National Office. All members upon joining the Association agree to abide by this code as a condition of membership.

Professional Life

- 1. ACF Consulting Foresters will utilize their knowledge and skill for the benefit of society.**
- 2. An ACF Consulting Forester will cooperate in extending the effectiveness of the forestry profession by interchanging information and experience with other foresters and by contributing to the work of forestry societies, associations, schools, and publications.**
- 3. An ACF Consulting Forester will advertise only in a dignified manner, setting forth in truthful and factual statements services offered prospective clients and the public.**
- 4. Professional work should come to ACF Consulting Foresters on the basis of their experience, competency, and reputation. Solicitation by criticism of competitors, self laudation, or lobbying is degrading to the profession and is unethical.**

Dealing With The Public

5. **An ACF Consulting Forester will strive for correct and increasing knowledge of forestry and the dissemination of this knowledge and will discourage and condemn the spreading of untrue, unfair, and exaggerated statements concerning forestry.**
6. **ACF Consulting Foresters will not issue statements, criticism, or arguments on matters connected with public forestry policies, without indicating, at the same time, on whose behalf they are acting.**
7. **When serving as an expert witness on forestry matters in a public or private fact finding proceeding, an ACF Consulting Forester will base testimony on adequate knowledge of subject matter and render opinions based on honest convictions.**
8. **ACF Consulting Foresters will refrain from publicly expressing opinions on a technical subject unless informed of the facts relating thereto, and will not distort or withhold data for the purpose of substantiating a point of view.**
9. **Forestry plans and reports should be definite and specific and should have no double meaning.**

Dealing With Clients, Principals, and Employers

10. **ACF Consulting Foresters will be loyal to their clients and to the organization in which they are employed and will faithfully perform their work and assignments.**
11. **ACF Consulting Foresters will clearly present the consequences expected if their professional forestry judgment is overruled by non-technical authority when they are responsible for the technical adequacy of forestry or related work.**
12. **ACF Consulting Foresters will not voluntarily disclose information, received in confidence, concerning business affairs or their employers, principals, or clients, unless express permission is first obtained.**
13. **An ACF Consulting Forester must avoid conflicts of interest or even an appearance of such conflicts.**
14. **ACF Consulting Foresters will not, for the same service, accept compensation of any kind other than from their clients, principals, or employers, without full disclosure, knowledge, and consent of all parties concerned.**
15. **ACF Consulting Foresters will engage, or advise their clients or employers to engage, other experts and specialists in forestry and related fields whenever the clients' or employers' interests would be best served by such actions, and will cooperate freely with them in their work.**
16. **An ACF Consulting Forester should not undertake work at a fee that will not permit a satisfactory professional performance.**
17. **ACF Consulting Foresters will not use association with a non-forester, a corporation, or partnership as a cloak for unethical acts, but must accept responsibility for their acts.**
18. **Under no circumstances should ACF Consulting Foresters undertake to make an appraisal when their employment or fee is contingent upon the amount of their estimate of value.**
19. **It is unethical for an ACF Consulting Forester to pay or claim a fee or commission for the purpose of obtaining or referring employment.**

Dealing With Professional Foresters

20. **An ACF Consulting Forester will at all times strive to protect the forestry profession collectively and individually from misrepresentation and misunderstanding.**
21. **An ACF Consulting Forester will aid in safeguarding the profession against the admission to its ranks of persons lacking good moral character or adequate training.**
22. **In writing, or in speech, ACF Consulting Foresters will be scrupulous in giving full credit to others, insofar as their knowledge goes, for procedures and methods devised or discovered, ideas advanced, or aid given.**
23. **An ACF Consulting Forester will not intentionally and without just cause, directly or indirectly injure the reputation or business of another forester.**
24. **If ACF Consulting Foresters have substantial and convincing evidence of unprofessional conduct of another forester, they will present the information to the proper authority for action.**
25. **An ACF Consulting Forester will not attempt to supplant another forester in a particular employment, after becoming aware that the latter has been definitely engaged.**
26. **An ACF Consulting Forester will base all letters of reference, or oral recommendation, on a fair and unbiased evaluation of the party concerned.**
27. **An ACF Consulting Forester will not solicit or collect financial contributions from subordinates or employees for political purposes.**
28. **An ACF Consulting Forester will uphold the principle of appropriate and adequate compensation for those engaged in forestry work, including those in subordinate positions, as being in the public interest and maintaining the standards of the profession.**

Adopted by the Association of Consulting Foresters by Member Referendum, November 11, 1976, replacing the Code adopted November 11, 1948. The 1976 Code was amended May 31, 1992.

This Code is very specific and should be studied carefully, especially by the new consultant, but should be reviewed regularly by more experienced consultants to remind them of the high level of ethics expected of all of us.

Perhaps no section of this code has generated more disagreement than number 18. Consultants often mark timber for harvesting and check the operation at intervals to be certain logging operations are conducted wisely. Some contend that it is not possible to base the consultant's fee or the value the landowner receives without influencing the consultant, perhaps unconsciously, to cut more heavily than might be best for the forest.

Others counter that such a fee ensures that the consultant will be even more diligent in the effort to obtain the greatest financial return for the landowner.

There are obvious differences in the code developed by the Society of American Foresters.

Society of American Foresters

SAF Code of Ethics

Preamble

Service to society is the cornerstone of any profession. The profession of forestry serves society by fostering stewardship of the world's forests. Because forests provide valuable resources and perform critical ecological functions, they are vital to the wellbeing of both society and the biosphere.

Members of the Society of American Foresters have a deep and enduring love for the land, and are inspired by the profession's historic traditions, such as Gifford Pinchot's utilitarianism and Aldo Leopold's ecological conscience. In their various roles as practitioners, teachers, researchers, advisers, and administrators, foresters seek to sustain and protect a variety of forest uses and attributes, such as aesthetic values, air and water quality, biodiversity, recreation, timber production, and wildlife habitat.

The purpose of this Code of Ethics is to protect and serve society by inspiring, guiding, and governing members in the conduct of their professional lives. Compliance with the code demonstrates members' respect for the land and their commitment to the long-term management of ecosystems, and ensures just and honorable professional and human relationships, mutual confidence and respect, and competent service to society.

On joining the Society of American Foresters, members assume a special responsibility to the profession and to society by promising to uphold and abide by the following:

Principles and Pledges

1. Foresters have a responsibility to manage land for both current and future generations. We pledge to practice and advocate management that will maintain the long-term capacity of the land to provide the variety of materials, uses, and values desired by landowners and society.
2. Society must respect forest landowners' rights and correspondingly, landowners have a land stewardship responsibility to society. We pledge to practice and advocate forest management in accordance with landowner objectives and professional standards, and to advise landowners of the consequences of deviating from such standards.
3. Sound science is the foundation of the forestry profession. We pledge to strive for continuous improvement of our methods and our personal knowledge and skills; to perform only those services for which we are qualified; and in the biological, physical, and social sciences to use the most appropriate data, methods, and technology.
4. Public policy related to forests must be based on both scientific principles and societal values. We pledge to use our knowledge and skills to help formulate sound forest policies and laws; to challenge and correct untrue statements about forestry; and to foster dialogue among foresters, other professionals, landowners, and the public regarding forest policies.
5. Honest and open communication, coupled with respect for information given in confidence, is essential to good service. We pledge to always present, to the best of our ability, accurate and complete information; to indicate on whose behalf any public statements are made; to fully disclose and resolve any existing or potential conflicts of

interest; and to keep proprietary information confidential unless the appropriate person authorizes its disclosure.

6. Professional and civic behavior must be based on honesty, fairness, good will, and respect for the law. We pledge to conduct ourselves in a civil and dignified manner; to respect the needs, contributions, and viewpoints of others; and to give due credit to others for their methods, ideas, or assistance.

The Society of American Foresters' Bylaws specify processes through which a member's violation of the code may lead to reprimand, censure, expulsion from the Society, or other disciplinary action. Any two persons, whether or not SAF members, may charge a member with violation of the code. Such a charge must be made in writing to the SAF President and must refer to the specific Pledges alleged to have been violated.

Adopted by the Society of American Foresters by Member Referendum, November 3, 2000, replacing the code adopted June 23, 1976, as amended November 4, 1986, and November 2, 1992. The 1976 code replaced the code adopted November 12, 1948, as amended December 4, 1971.

This code is much more general and stresses stewardship and societal values. Most would conclude there is no conflict in the codes of ACF and SAF, and consulting foresters should adhere to both.

Conclusions

In the final analysis, codes cannot make a consultant honest. Honesty or dishonesty is a character trait formed by upbringing, religious convictions, and personal relationships over a lifetime, but especially during childhood and early adulthood. We would hope that all foresters, consultants or not, are honest, but we recognize that is not true in any profession. Both codes indicate we have a responsibility when dishonest professional conduct comes to our attention. That is a difficult responsibility and one that is rarely exercised.

APPENDIX

SUPER-SIMPLE GUIDES

Many of the following guides are based on the excellent book, “Sampling Techniques for Forest Resource Inventory” by B. D. Shiver and B. E. Borders (pub. 1996, John Wiley & Sons; ISBN 0-471-10940-1). This book should be in every forestry consultant’s library.

STRATIFIED SAMPLING

This super-simple example shows calculations to use with this method which should be used if you know the acreage of strata in a forest (either before or after a cruise):

Stratum	No. acres (Ac)	Tenth-acre volumes (V)	ΣV	ΣV^2	n
A	30	5,6,10	21	161	3
B	70	2,4	6	20	2
Σ	100				5

$$\begin{aligned}\text{MeanA} &= (5+6+10)/3 \\ &= 7\end{aligned}$$

$$\begin{aligned}\text{MeanB} &= (2+4)/2 \\ &= 3\end{aligned}$$

$$\begin{aligned}\text{StratMean} &= \text{means weighted by acreages} \\ &= ((\text{AcA} * \text{MeanA})+(\text{AcB}*\text{MeanB}))/\Sigma\text{Ac} \\ &= ((30*7)+(70*3))/100 \\ &= 4.2\end{aligned}$$

$$\text{Variance for a stratum} = (\Sigma V^2 - (\Sigma V)^2/n)/(n-1)$$

$$\begin{aligned}\text{VarianceA} &= (161-21^2/3)/(3-1) \\ &= 7.0\end{aligned}$$

$$\begin{aligned}\text{VarianceB} &= (20-6^2/2)/(2-1) \\ &= 2\end{aligned}$$

For each stratum we calculate $(\text{Ac}^2 * \text{Variance})/n$, which we'll call X

$$\begin{aligned}\text{for StratumA, } X_a &= (30^2*7)/3 \\ &= 2100\end{aligned}$$

$$\begin{aligned}\text{for StratumB } X_b &= (70^2*2)/2 \\ &= 4900\end{aligned}$$

$$\begin{aligned}\text{StratSE} &= (1/\Sigma\text{Ac}^2 * (X_a+X_b))^{0.5} \\ &= (1/100^2 * (2100+4900)) \\ &= 0.7\end{aligned}$$

STRIP CRUISE

Strip cruises, with strips randomly or systematically located and running across contours, are often of unequal lengths. In that case, a ratio estimator is appropriate. Assume 3 chain-wide strips (n) are used on a 150-acre (A) tract which is 100 chains (N) wide:

Strip	Length(chains)	x=Area(ac)	y=volume(mbf)	x ²	y ²	xy
1	14	1.4	10	1.96	100	14.0
2	12	1.2	8	1.44	64	9.6
3	10	1.0	5	1.00	25	5.0
Σ	36	3.6	23	4.40	189	28.6

ratio (ratio is vol per acre):

$$\begin{aligned}
 r &= \Sigma y / \Sigma x \\
 &= 23 / 3.6 \\
 &= 6.39
 \end{aligned}$$

vol on forest:

$$\begin{aligned}
 \text{vol} &= r * A \\
 &= 6.39 * 150 \\
 &= 958.5
 \end{aligned}$$

variance (var) and standard error (SE) for total volume:

$$\begin{aligned}
 \text{Su}^2 &= (\Sigma y^2 + r^2 * \Sigma x^2 - 2 * r * \Sigma xy) / (n - 1) \\
 &= (189 + 6.39^2 * 4.40 - 2 * 6.39 * 28.6) / (3 - 1) \\
 &= 1.576
 \end{aligned}$$

$$\begin{aligned}
 \text{var} &= A^2 * 1 / (A/N)^2 * \text{Su}^2 / n * ((N - n) / N) \\
 &= 150^2 * 1 / (150/100)^2 * 1.576 / 3 * ((100 - 3) / 100) \\
 &= 5095
 \end{aligned}$$

$$\begin{aligned}
 \text{SE} &= 5095^{0.5} \\
 &= 71.4
 \end{aligned}$$

DOUBLE SAMPLING POINT SAMPLING

With a double sampling point sample, an easy-to-measure value, x , (number of in-trees or, better, number of logs on in-trees) is obtained at each of n' points, and at n randomly selected points the usual measurements necessary for volume estimates are made (y). The ratio estimator works well as the variation in y tends to increase with x and go through zero. Double sampling reduces the field time necessary to obtain a specified sampling error, and, generally, only 25-35% of the total point sample require measurement.. A very simple example, with x = number of in-trees and y = cords per acre, is used to illustrate calculations.

	x'	y	x	x^2	xy	y^2
	2	4	2	4	8	16
	3					
	6	10	6	36	60	100
Σ	11	14	8	40	68	116
Mean	3.67	7	4			

$$n' = 3$$

$$n = 2$$

r is the ratio of means:

$$r = \text{Meany}/\text{Meanx}$$

$$= 7/4$$

$$= 1.75$$

We can now estimate the mean y for the population (P_{opy}):

$$P_{opy} = r * \text{Meanx}'$$

$$= 1.75 * 3.67$$

$$= 6.42$$

$$S^2_y = (\Sigma y^2 - (\Sigma y)^2/n)/(n-1)$$

$$= (116 - 14^2/2)/(2-1)$$

$$= 18$$

$$S^2_R = (\Sigma y^2 - 2*r*\Sigma xy + r^2*\Sigma x^2)/(n-1)$$

$$= (116 - 2*1.75*68 + 1.75^2*40)/(2-1)$$

$$= 0.5$$

$$SE = (S^2_y/n' + S^2_R/n*((n'-n)/n'))^{0.5}$$

$$= (18/3 + 0.5/2*((3-2)/3))^{0.5}$$

$$= 2.5$$

TWO-STAGE CLUSTER SAMPLING

A random sample of primaries (e.g., stands) of size n_p is selected from the total number of primaries (N_p). Sampling is done in selected primaries using n_s secondary sampling units (probably differing for different primaries) of the total number of secondary units in the primaries (N_s). Here is a very simple example ($N_p = 3$, $n_p = 2$):

Primary	No. acres	Sec. (N_s)	10th-ac vol. (X)	meanX	Tot. prim. vol. (T)	n_s
A	30	300	5,6,11	$22/3=7.3$	$7.3*300=2190$	3
B	70	700	2,4	$6/2=3$	$3*700= 2100$	2
C	50	500				
Σ	150	1500	28	10.3	4290	5

$$\text{PrimaryMean} = \Sigma T/n_p = 4290/2 = 2145$$

$$\text{PopTotal} = N_p * \text{PrimaryMean} = 3 * 2145 = 6435$$

$$S_s^2 = (\Sigma X^2 - (\Sigma X)^2/n_s)/(n_s-1)$$

$$S_A^2 = ((5^2+6^2+11^2)-22^2/3)/(3-1) = 10.3$$

$$S_B^2 = ((2^2+4^2)-6^2/2)/(2-1) = 2$$

$$\begin{aligned} \text{Var}_s &= \Sigma S^2/n_s * N_s^2 * (N_s - n_s)/N_s \\ &= (10.3/3 * 300^2 * (300-3)/300) + (2/2 * 700^2 * (700-2)/700) \\ &= 794510 \end{aligned}$$

$$S_p^2 = (\Sigma T^2 - (\Sigma T)^2/n_p)/(n_p-1)$$

$$= (2190^2 + 2100^2 - 4290^2/2)/(2-1)$$

$$= 4050$$

$$\text{Var}_p = (N_p - n_p)/N_p * S_p^2$$

$$= (3-2)/3 * 4050 = 1350$$

$$\text{Var}_T = (N_p^2/n_p) * \text{Var}_p + (N_p/n_p) * \text{Var}_s$$

$$= (3^2/2) * 1350 + (3/2) * 794510$$

$$= 1197840 \text{ (SE for total volume} = 1094)$$

TWO-STAGE RATIO SAMPLING

A random sample of primaries (e.g., stands) of size n_p is selected from the total number of primaries (N_p). Sampling is done in selected primaries using n_s secondary sampling units (probably differing for different primaries) of the total number of secondary units in the primary (N_s). Here is a very simple example ($N_p=3, n_p=2$):

Primary	No. acres	Second. (N_s)	10th-acre vol. (V_s)	V_p	n_s
A	30	300	5,6,11	22	3
B	70	700	2,4	6	2
C	50	500			
Σ	150	1500			5

$$T_p = \text{estimated total volume in a primary}$$

$$= (V_p / n_s) * N_s: T_A = (22/3) * 300 = 2200: T_B = (6/2) * 700 = 2100$$

$$r_s \text{ is the ratio of volume per tenth acre for a primary:}$$

$$r_s = T_p/N_s: r_A = 2200/300 = 7.3: r_B = 2100/700 = 3$$

$$r \text{ is the overall ratio estimator of volume per tenth acre using selected primaries:}$$

$$r = \Sigma T_p / \Sigma N_s = (2200+2100)/(300+700) = 4.3$$

$$\text{estimated total volume of forest} = r * \Sigma N_s = 4.3 * 1500 = 6450$$

$$\text{Var}_p = ((\Sigma N_s^2 * r_s^2) - 2*r*(\Sigma N_s^2*r_s) + r^2 * \Sigma N_s^2) / (n_p - 1)$$

$$= ((300^2 * 7.3^2 + 700^2 * 3^2) - 2*4.3*(300^2 * 7.3 + 700^2 * 3) + 4.3^2 * (300^2 + 700^2)) / (2 - 1)$$

$$= 1638100$$

$$S^2 = (\Sigma V_s^2) - (\Sigma V_s)^2 / n_s / (n_s - 1)$$

$$S_A^2 = ((5^2 + 6^2 + 11^2) - 22^2 / 3) / (3 - 1) = 10.3:$$

$$S_B^2 = ((2^2 + 4^2) - 6^2 / 2) / (2 - 1) = 2$$

$$\text{Var}_s = \Sigma N_s^2 * (N_s - n_s) / N_s * S^2 / n_s$$

$$= 300^2 * (300 - 3) / 300 * 10.3 / 3 + 700^2 * (700 - 2) / 700 * 2 / 2 = 794510$$

$$\text{SE} = (N_p^2 / (\Sigma N_s * n_p) * (\text{Var}_p + \text{Var}_s))^{0.5}$$

$$= (3^2 / (1500^2 * 2) * (1638100 + 794510))^{0.5}$$

$$= 2.2 \text{ (for total volume} = 2.2 * 1500 = 3300)$$

TWO-STAGE LIST SAMPLING

A random sample of primaries (e.g., stands) of size n_p is selected from the total number of primaries (N_p) with a probability proportional to size. Sampling is proportional to size and with replacement, so the same stand can be selected more than once and sampling must be repeated using differ random or systematic locations. Sampling is done in selected primaries using n_s secondary sampling units (probably differing for different primaries) of the total number if secondary units in the primaries (N_s). Here is a very simple example ($N_p = 3$, $n_p = 2$; random numbers used within cumulative sizes to select primaries):

Primary	No. acres	Sec. (N_s)	Accumulated	10th-ac vol. (X)	meanX	n_s
A	30	300	1- 30	5,6,11	$22/3=7.3$	3
B	70	700	31-100	2,4	$6/2=3$	2
C	50	500	101 -150			
Σ	150	1500		28	10.3	5

$$\begin{aligned} \text{PopMean} &= \sum 1/n_p * \sum \text{meanX} \\ &= 1/2 * 10.3 \\ &= 5.15 \end{aligned}$$

$$\begin{aligned} \text{PopTotal} &= \sum N_s * \text{PopMean} \\ &= 1500 * 5.15 \\ &= 7725 \end{aligned}$$

$$\begin{aligned} \text{VarMean} &= ((\sum \text{meanX}^2 - (\sum \text{meanX})^2 / n_p) / (n_p - 1)) / n_p \\ &= ((7.3^2 + 3^2 - 10.3^2 / 2) / (2 - 1)) / 2 \\ &= 4.62 \end{aligned}$$

$$\text{SE} = 2.16 \quad (\text{SE for total} = 2.26 * 1500 = 3390)$$

STAND TABLE PROJECTION

Points to remember:

- Obtain increment boring at dbh for all trees at or approaching merchantable size on small fixed-area plots (even if point sampling is used for the main cruise). Measure bark thickness and inches of wood grown (I_i) during the interval for which you are predicting growth (which we'll assume is 10 years).
- Mortality estimates may be available from historical data, but can often be ignored for short time intervals.
- A local volume table often can be made using the data you collect on the cruise.
- As trees increase in girth, diameter increments tend to decrease but basal area increment will tend to be more constant.

For our simple example of bored-tree data, with D = dbh outside bark now, D_{10} = dbh 10 years ago, d = dbh inside bark now, B = basal area now, B_{10} = basal area 10 years ago:

D	B	d	I_i	I_o	D_{10}	B_{10}	B_i
10.0	0.54	8.2	2.1	2.48	7.52	0.31	0.23
11.2	0.68	9.8	1.8	2.13	9.07	0.45	0.23
11.9	0.77	10.0	1.3	1.54	10.36	0.59	0.18
Σ 33.1		28.0					

note:

$$k = \Sigma D / \Sigma d = 33.1 / 28.0 = 1.182 \quad (\text{outside/inside bark ratio})$$

$$I_o = k * I_i \quad (10\text{-year increment outside bark})$$

$$D_{10} = D - I_o$$

$$B_i = B - B_{10} \quad (\text{basal area increment})$$

Using a linear regression of the form $B_i = a + bB$, $B_i = 0.3450 - 0.1985 * B$.

Using the stand and stock table for the tract, with D = dbh class, N = number of trees, V_p = present volume, d_i = dbh increment, and no expected mortality:

D	B	N	V_p	B_i	d_i	N_s	N_U	<u>N in 10 yrs.</u>
10	0.54	21	6	0.24	1.959	0.4	20.6	0.4
12	0.79	23	11	0.19	1.405	6.8	16.2	27.4
14	1.07	16	9	0.13	0.833	9.3	6.7	25.5
16								6.7

note:

$$d_i = ((B + B_i) / 0.005454)^{0.5} - D$$

N_s = number of trees staying in same dbh class = $d_i / \text{dbh class} = d_i / 2$ as %

N_U = number of trees moving one dbh class = 100 - above answer

Can estimate volume in 10 years using local volume table

For 10-inch class (9.0 to 10.9), simply assume 1 tree in each class and grow them 1.959 inches to predict dbh in 10 years.

For 1-inch class, a d_i of 1.10 indicates all trees move up 1 class and 10 % up 2 classes; a d_i of 0.80 means 80% move 1 class and 20% stay in the same class.

LOCAL VOLUME TABLE CONSTRUCTION

To illustrate the local volume table method, assume you measure the diameter at 1-foot stump heights for trees removed in a trespass, as follows:

Stump diam. (in.)
14
23
17
20

In an adjacent, apparently similar stand, you measure stump diameters and obtain volumes, using the volume tables or equations appropriate in that area and for that species, with the following results:

D = Stump diam. (in.)	V = Volume (bf)
10	50
16	200
24	600

Using CurveExpert and the quadratic fit of the form $y = a + bx + cx^2$, which generally works well for this type of data, we find:

$$V = -42.857 - 16.071*D + 1.7857*D^2$$

With this equation, volume is easily calculated for any stump diameter.

LOCAL VOLUME TABLE FROM A STAND AND STOCK TABLE

If you do not have the original field data, where you could use measured trees to make a local volume table using linear regression of the form $Vol = a + b \cdot D^2$, a local volume table can be made from a stand and stock table with a properly weighted linear regression (D =dbh class, N =number of trees, volume, V_T = volume per tree, w = weight value, N if based on fixed-plot cruise, $N \cdot D^2$ if based on point sample cruise):

D	N	V	V_T	w	w*D²	w*V_T	w*D⁴	w*D²*V_T
10	4	4.0	1.0	4	400	4.0	40000	400.0
12	2	3.0	1.5	2	288	3.0	41472	432.0
14	1	2.2	2.2	1	196	2.2	38416	431.2
Σ	7	9.2	4.7	7	884	8.2	119888	1263.2

$$\begin{aligned} a &= \frac{\sum w \cdot V_T}{\sum w} \\ &= 8.2/7 \\ &= 1.171 \end{aligned}$$

$$\begin{aligned} x &= \frac{\sum w \cdot D^2}{\sum w} \\ &= 884/7 \\ &= 126.286 \end{aligned}$$

$$\begin{aligned} e &= \sum w \cdot D^2 \cdot V_T - (\sum w \cdot D^2 \cdot \sum w \cdot V_T / \sum w) \\ &= 1263.2 - (884 \cdot 8.2 / 7) \\ &= 227.657 \end{aligned}$$

$$\begin{aligned} f &= \sum w \cdot D^4 - (\sum w \cdot D^2)^2 / \sum w \\ &= 119888 - 884^2 / 7 \\ &= 8251.429 \end{aligned}$$

$$\begin{aligned} b &= e/f \\ &= 227.657/8151.429 \\ &= 0.02759 \end{aligned}$$

$$\begin{aligned} v &= \text{volume predicted by the local volume equation:} \\ v &= a + b \cdot (D^2 - x) \\ &= 1.171 + 0.01759 \cdot (D^2 - 126.286) \end{aligned}$$

Using the local volume equation:

D	v
10	0.7
12	1.5
13	2.4

BIG BAF

A small BAF of 20 and a large BAF of 60 are using at 3 points:

Point	Using BAF=20		Using BAF=60		Vol.	VBAR	VBAR ²
	BA	BA ²	BA	BA			
1	80	6400	5.2329	2.1816	1027	196.258	38517.203
2	100	10000	-	-	503	230.565	53160.219
3	30	900	-	-	-	-	-
Σ	210	17300				426.823	91677.422

$$n = 2$$

$$m = 3$$

$$\begin{aligned} \text{Mean VBAR} &= 426.823/2 \\ &= 213.411 \end{aligned}$$

$$\begin{aligned} \text{Mean BA} &= 210/3 \\ &= 70 \end{aligned}$$

$$\begin{aligned} \text{Mean Vol./ac} &= 213.411*70 \\ &= 14939 \end{aligned}$$

$$\begin{aligned} \text{VBAR SE} &= ((91677.422-426.823^2/2)/(2*(2-1)))^{0.5} \\ &= 17.154 \end{aligned}$$

$$\begin{aligned} \text{VBAR SE\%} &= 17.154/213.411*100 \\ &= 8.04 \end{aligned}$$

$$\begin{aligned} \text{BA SE} &= ((17300-210^2/3)/(3*(3-1)))^{0.5} \\ &= 20.817 \end{aligned}$$

$$\begin{aligned} \text{BA SE\%} &= 20.817/70*100 \\ &= 29.74 \end{aligned}$$

$$\begin{aligned} \text{Cruise SE\%} &= (8.04^2 + 29.74^2)^{0.5} \\ &= 30.81 \end{aligned}$$

LIST SAMPLING SIMPLE EXAMPLE

List sampling is useful when a list for the population is available, which is rather rare. This technique is useful for very large timber holdings when all stands cannot be inventoried and when a list of primaries (stands) and their sizes (or better yet estimates of volumes) are available, as is often the case with our modern GPS/GIS technology. This is better than running a very low-intensity inventory on all stands. If the random number is from 1 to 20, Stand 1 is selected, and an appropriate inventory for total stand volume (V) is done, etc. Ratios (R) of (stand volume)/acres or previous volumes are used. NOTE: A covariance term is ignored in this form of list sampling and also in 3P sampling.

Stand No.	Acres	Cumulative ac*	V	R	R ² = R ²
1	20	1-20	7	0.35	0.1225
2	10	21-30	not selected		
3	30	31-60	3	0.10	0.01
Sums	60			0.45	0.1325
Means				0.225	

$$n = 2$$

$$\begin{aligned}
 S &= \text{standard deviation for R} \\
 &= ((\text{SumR}^2 - \text{SumR}^2/n)/(n-1))^{0.5} \\
 &= ((0.1325 - 0.45^2/2)/(2-1))^{0.5} \\
 &= 0.1768
 \end{aligned}$$

$$\begin{aligned}
 \text{CV\%} &= \text{coefficient of variation \% for R} \\
 &= (S/\text{MeanR}) * 100 \\
 &= (0.1768/0.225) * 100 \\
 &= 78.58
 \end{aligned}$$

$$\begin{aligned}
 \text{Sampling error \%} &= \text{CV\%}/n^{0.5} \\
 &= 78.58/2^{0.5} \\
 &= 56
 \end{aligned}$$

$$\begin{aligned}
 \text{Estimated total volume} &= \text{MeanR} * \text{Acres} \\
 &= 0.225 * 60 \\
 &= 13.5
 \end{aligned}$$

3P SAMPLING

3P sampling is similar to double sampling except Probability is Proportional to Prediction, thus PPP. To use 3P one must

- (1) Predict the total of the values to be estimated (as total volume of a hundred trees for which volumes are desired) or in this simulation the total square inches of images.
This estimated value is called KPI.
- (2) Determine the number off 3P samples needed. As you will see, sample size is a random variable (the number you get may be more or less than you want.
- (3) $KZ = KPI / (\text{no. 3P samples desired})$. After each tree is visited, the estimated volume is compared to a random number which can range from 1 to KZ. The volume of any tree for which the estimated volume equals or exceeds the paired random number is a 3P sample tree and must be measured.

Calculation are much simpler than for double sampling as shown, as shown below where x is the estimated value and y the measured value for a 3P sample:

x	y	$r=y/x$	r^2
2	4	2	4
3			
6	18	3	9
sum	11	5	13
mean		2.5	

The 3P estimated volume = $\text{sum}x * \text{average ratio}$:

$$= 11 * 2.5$$

$$= 27.5$$

$$S = ((\text{sum}r^2 - (\text{sum}r)^2/n) / (n-1))^{.5}$$

$$= ((13 - 5^2/2) / (2-1))^{.5}$$

$$= 0.707$$

$$CV\% = (S/\text{mean}) * 100$$

$$= 28.3$$

$$\text{Sampling error \%} = CV/n^{.5}$$

$$= 28.3/2^{.5}$$

$$= 20.0$$

