

Oak Trees, Small Branches and the HP 9825

by Norman Pillsbury

March 14, 2014

Chapter I: How It All Began

In August 2012, I was contacted by a legal firm in Santa Barbara and retained as an 'expert witness' for a tree cutting case near Paso Robles, California.

A winery was clearing 100 acres of oaks to plant a vineyard. They hired a woodcutting outfit to do the work and agreed to pay a lump sum for the job. The agreement provided that the woodcutter would be allowed remove and sell the trees as firewood thus increasing his income. They asked him to start in the northeast corner and work towards the southwest corner and to fell all trees before removing them.

He felled almost all the trees and then was fired from the job. He sued the vineyard for breach of contract and loss of firewood sales. In the meantime the vineyard hired several others who cleared the wood and the vineyard was planted.

As a California professional registered forester, I was supplied with various maps and photos and began to prepare a sample design that would provide an estimate of the "phantom" wood which was now long gone.

My crew and I weren't allowed on the property before the day of a scheduled field visit. With some difficulty I assembled a crew of five former students for the measurement days. Finally with a firm date, November 15, 2012, we were allowed on the property for two days of field measurements.

Since not all of the trees were cut, my plan was to measure existing stands that were similar in appearance to the cut areas for my estimate. Based on pre-cut photos, I ob-

served two density levels of trees, therefore, I stratified the residual trees into these two density classes, high and medium.

When we arrived to make field measurements, we were told that we would only have one day, not two, to complete the field work. I had to redesign the sampling approach on the spot. With our two three-person crews we made good time. My crew had been trained through my classes and field trips, so we were familiar with each other and that helped immensely.

We established 41, one-tenth acre plots, and measured a little over 500 trees. I analyzed the data and made my first estimate of wood removal of 7,069.6 cords of wood. That was on November 29, 2012.

Chapter II: Deposition

The case continued in slow motion through the winter, and thankfully I wasn't involved, since I was teaching full time at the university. I retired at the end of March 2013.

On April 4, 2013, I was informed that the case was likely to go to court and I was to prepare a report, as soon as possible, based on my findings last fall, and plan for a day-long deposition. In other words, it hadn't been settled out of court and it was unlikely it would.

Connie, my wife, and I had planned a month long trip to Louisiana and a tour of the south to visit a string of relatives starting April 11th. They moved my deposition date to April 8 to avoid conflict.

The deposition process was quite an experience. First, I was sworn in by a certified

court Recorder -- the same as if I were on the witness stand. I was accompanied by one of the two attorneys that were working on the case. I'd never been up against a seasoned attorney before, and I found they can make you look totally inept in just a few minutes.

For example (not verbatim):

Question: Mr. Pillsbury did you use the XYZ wildlife classification to determine the percent of canopy cover on the property.

Answer: No, I didn't.

Q: You do know about this system don't you?

A: No, I'm not familiar with that one.

Q: So you're not familiar with it at all?

A: No.

Q: So you didn't use it?

A: No.

Q: So you didn't even know about it and that's why you didn't use it?

A: Yes, that's right.

And it goes on like this for long periods. Of course the XYZ wildlife classification system has nothing to do with the study, but they use obscure, unrelated items like that to make you look unqualified.

During lunch the attorney who hired me (I call him "my" attorney but that's technically incorrect), coached me on how to avoid traps and respond more forcefully. That definitely helped, but by the end of the day my head felt like it was in a vise -- a sensation that lasted all the next day. When a question was posed, there were 4 things going through my head simultaneously: 1. What are they really asking. 2. What will be the follow-up question. 3. Should I answer it best this way, or, 4. that way.

An interesting side note is the banter and jabs that go back and forth between opposing attorneys. Commonly in depositions, a question would arise and the attorneys would go "off record" to work it out before the recorder resumed taking notes.

At one point the opposing attorney was so ticked off she said, "Let's go off record." Then she turned to one of my attorneys and said "You're a jerk!!!" with much emphasis. He didn't say anything. Then she said, "Let's go back on record." As soon as the recorder started up, my attorney said, for the record, "I didn't call you a jerk."

I have to admit it was one of the funniest moments of the case.

Another interesting development occurred during my deposition when the opposing attorney 'let out' some helpful information: new photos were available that showed the property after cutting occurred. Those photos weren't available in November for our field measurement. She also confirmed that the southern boundary on the assessors photos was incorrect, a suspicion of mine for some time. There was time to revise my report, but not now, as we began our vacation. That would happen when we returned.

I still hoped the case would be settled and avoid trial because on the start date we would be somewhere in Florida.

Chapter III: Our Vacation

Ok, fast forward to our vacation in the south. During this time, the attorneys frequently sent email for response, and we had several long phone calls. In short, it wasn't much of a vacation from the case. Finally I realized there was no way to manage my part of the case from afar, and we booked new flights and returned home two weeks early.

We returned the evening of May 30 and I immediately began a series of late night and all-nighters. My first task was to recalculate the volume removed based on the new boundary lines and the new photos, and revise my report. Also I was able to "respond" to many of the opposing attorney's questions/comments in my report. I finished in the wee hours of May 4 (remember the trial starts on May 6).

When opposing counsel read my report they went ballistic. I had successfully cut off many of their arguments. They wrote a scathing six-page statement to the judge demanding that my revised report, which they called a “new” report, be excluded from the official record in its entirety.

I don't know what our attorneys did to keep it in the proceedings, but they were successful. However, as a compromise, the judge allowed the defense to depose me again. On Tuesday, May 7th I went through three more hours of deposition.

Chapter IV: The Trial Begins

The trial began, and on Wednesday afternoon, May 8, 2013, I took the stand, continuing all day Thursday.

No one is automatically an expert witness. First, their entire career is reviewed and then the judge must ‘bestow’ the title “expert witness” on the individual. For me that was like reliving my entire career -- in a court room. Every research study and publication was reviewed and briefly discussed, all 77 of them.

While on the stand I explained the procedure I used to arrive at the volume of wood removed by showing a series of overheads displayed on the large wall monitors. This included all calculations, and my revised estimate of wood removal of 6,378 cords. This estimate was based on adjustments from the use of new photos, the corrected property boundary and deductions for a stump (to be discussed later).

The woodcutter had begun cutting in early summer 2011 and was terminated September 21, 2011. The photos I used were taken on July 26, 2010 (pre-cut) and May 19, 2012 (post-cut). During our field measurements in fall, 2012, I also used pre-cut photos posted by Google Earth on their website.

But as it turns out another set of photos showed up, which was a stroke of good luck for our side.

Three days before my first deposition, I went back to the Google website and “lo and behold” they had updated their photos, now dated September 17, 2011, a mere four days before the woodcutter was terminated.

The defense had claimed the woodcutter was slow and not getting the job done fast enough. Up to this point it was his word against theirs. When I alerted our attorneys about the new photos, it really helped. The photos showed massive cutting all over the 100 acre property, and that the woodcutter was nearly done with the cutting portion of the job. As the trial continued this proved to be a major help to the plaintiff.

Prior to making calculations I had checked about the practices of the woodcutter. Did he leave a stump? Did he use the entire tree including the small branches? I was assured that he used the entire tree, therefore, my calculation of the wood volume removed was based on that information.

Chapter V: The 1984 Equations

A pivotal part of the trial centered on determining which equations should be used to calculate the volume of wood removed.

Thirty three years ago, in 1980, I was awarded a contract from the US Forest Service research station in Portland to develop volume equations for 13 hardwoods in California, many of them oak species. Michael Kirkley, a graduate student, and I travelled the entire state making detailed measurements on 60 trees for each of the 13 species.

From the data, we developed three equations per species, published in 1984. They turned out to be crucial to the estimate of volume removed for this case. They are shown on a diagram on the page 5, and are defined here:

SVOL - Saw-log volume: computed for trees 11" dbh (diameter at breast height) and larger; volume computed from stump height (1') to a 9" top outside bark for straight sections 8' long; excludes roots, bark and foliage.

WVOL - Wood volume: computed from stump height (1') to a 4" top outside bark; excludes roots, bark and foliage.

TVOL - Total volume: includes all stem and branch wood plus stump and bark; excludes roots and foliage.

A critical point is that the WVOL equations do NOT include bark while the TVOL equations DO include bark. Which would be best for a firewood operation? Because woodcutters always leave the bark on the wood, and it's sold that way, the TVOL equation is always the best approximation.

Surprisingly, the expert witness on the opposing side also used my equations which in itself is quite unusual. However, I was amazed to learn that they used the WVOL not the TVOL equation. Doing so would result in a large underestimate of the wood removed in the vineyard tree cutting case.

The USFS research station has been using my equations for 30 years and still does. The difference between the WVOL and TVOL equations is surprisingly large, a factor of about 1.5. That is, using the TVOL equation results in about 1.5 times more wood than using the WVOL equation.

During the trial, I called the USFS research program manager as they use all three equations for their inventory work. Karen, a USFS researcher and long-time acquaintance of mine, recommended TVOL. I also called the former program administrator, Chuck, and he said the same, TVOL. So, will the judge go with TVOL or WVOL, that is the question. Time will tell.

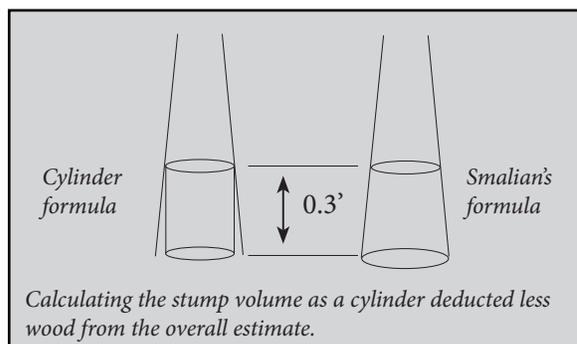
Even though I had checked to find out how much of the tree the woodcutter actually

used, as noted above and the answer came back that he used the entire tree, I found later that that wasn't quite correct.

Just before the trial began, I learned the woodcutter always left a small stump, about 2-3 inches in height when the tree was cut. Thus, I made a correction to the volume removed by deducting a 0.3 foot stump from each tree. In my revised report I wrote that I calculated the volume of this 0.3 foot stump using the shape of a cylinder.

During the trial I was asked why I didn't use Smalian's formula (more like a truncated cone shape) instead of the formula for a cylinder (see sketch below). Note that Smalian's formula would deduct more wood, which was the defense's goal.

I explained that it was common to treat the stump as a cylinder and since that's how the



1984 equations were built, then these calculations must be done the same. The judge asked me how much difference it would make in the final estimate. I said I didn't think it'd account for more than three or four cords from the 100 acres of oaks.

Later in the trial, the stump formula issue came up again, and I addressed it one more time.

I produced the above diagram and showed the difference between the two formulas, and then explained that I had calculated the difference for the 500+ trees we measured

How The Trees Were Measured in 1984.

The volume of a tree was subdivided into three utilization definitions (see sketch below):

Sawlog volume - that wood which was determined to be merchantable by size and board length; did not include bark or the stump.

Wood volume - segments of wood 4" in diameter or larger that could be used for products such as furniture stocks or similar; did not include bark or the stump.

Total volume - the entire volume of tree including stump and bark; the closest to firewood volume of the three options.

To determine these three definitions, every tree segment was measured in the field. Next, segment volume was calculated and summed according to the utilization definitions above, and lastly using statistics, equations were developed for inventory purposes.

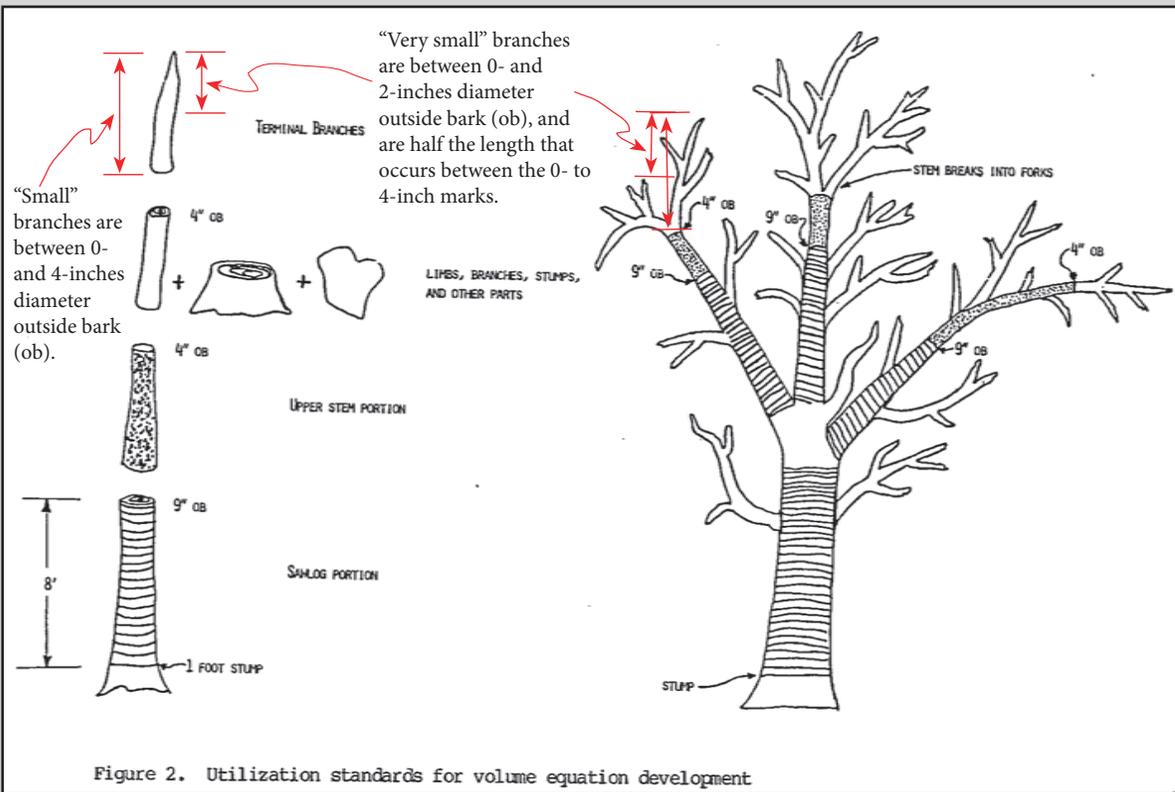
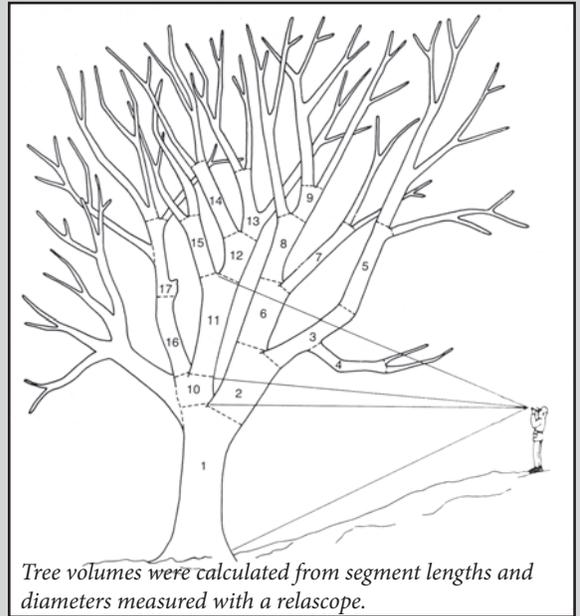


Figure 2. Utilization standards for volume equation development

and extrapolated to the 15,500 trees on the 100 acres. The difference between the two equations equaled 0.67 cords for the entire property. Essentially it's a meaningless number, like zero, compared to the total volume removed.

Thus, it was another smoke screen by the defense, but without actual numbers, it can be made to sound like a big deal.

Chapter VI: The Volume of Small Branches - A Conundrum!

During the trial, the woodcutter testified that he didn't "use" the entire tree above the 0.3 foot stump, but rather used branches down to a 2 inch diameter. Thus my calculations were a slight overestimate of the volume removed. The volume of these very small branches, from 0-2 inches, should be deducted from my wood removal estimate since that portion wasn't used or sold.

See notes and sketch on the previous page to visualize what the 0 to 4-inch and 0 to 2-inch diameter small branches look like.

At the end of a lunch break my attorney asked me to estimate the volume of wood in the 0 to 2-inch diameter branches. This was a bit of a conundrum for me as such an impromptu estimate could be considerably off the mark. I did my best and on the back of a napkin calculated that it was about 65 cords.

Immediately after lunch I was back on the stand and our attorney asked for my estimate. As a scientist I didn't feel good about making any statement without a chance to do some measurements. How many terminal branches does the average oak tree have? What is the average length? Is it the same for the two species? Without that knowledge, it would be impossible to get a good estimate.

Yet, I had made an educated estimate, so I did answer the question with 65 cords. Maybe that was sufficient for the court, and maybe at

the end of the day it really wouldn't make any difference, but I have, uncomfortably, thought about that number many times since. This story isn't over, and more about the "real" answer will be discussed later.

Chapter VII: Science or Spin?

There are so many facets to a trial like this and having never been involved, I found myself sometimes disgusted by statements tossed out as "truth," sometimes amazed at the process, and at some level in awe that any judge could actually understand it all.

As a scientist and researcher for over 40 years, the courtroom process was foreign to me. In my research, we always sought to find the best possible answer, often going to great lengths to get it. Further, the information we produced had to be relevant. Not, for example, explaining calculations that have no bearing on the final answer. Finally, we always tested our hypotheses along the way as a reality check on our work.

In contrast, information brought forward in the courtroom is often designed for maximum persuasion rather than clarity or usefulness. In my process of working through the numbers, whenever I found a better wood volume "answer," I made adjustments to reflect new information that became available. This occurred three times during the proceedings, and my final estimate was 5,700 cords of wood. Each time I updated it benefitted the defense, but who it benefitted was irrelevant in my pursuit of the best answer.

On the defense side, there were many examples brought forward for the purpose of making irrelevant points "look" like major issues when in fact they didn't or couldn't change the result.

I found the courtroom a different world than I have experienced and at times it was mind-boggling.

The trial ended on Thursday, May 23, 2013. I had been on the stand all day, and at the end I asked the judge if I could say one more thing. He is a kindly person and said yes.

I'd been cleaning my project boxes out of storage at Cal Poly and found extra copies of the research publication on the 1984 volume equations. I wrote names and a note on them for several people including: Kim the court recorder, the Judge (“Good luck with the numbers”), Sophie the defense lead counsel (“TVOL all the way!”), Plaintiff attorneys Jim and Mike (“Thanks for the ride”) and the woodcutter (“Keep on cutting”). It was a way of showing that while I take what I do seriously I try not to take myself too seriously. It was a hit and a light moment in the trial.

The final verdict is expected in August, 2013.

Chapter XIII: Unexpected Find

This trial had an unintended side effect. Earlier I mentioned being bothered by not having a good answer for the volume of wood in the very small branches. While I was sorting through the stacks of research and course work boxes in the department warehouse, I looked to see if I had any of the data sheets my graduate student and I collected while measuring the trees used to create the volume equations (SVOL, WVOL, TVOL). I could even visualize the binder they'd been in, but after three hours of searching, they weren't to be found.

But, surprisingly, I did find the data tapes where the data was stored. They were even labelled so I knew exactly which tapes were for coast live oak and valley oak, the species in question.

This set my heart to thumping. I had the 1984 data right there in my hand. If it could be retrieved, I could answer that question -- completely and accurately.

Of course the trial was over, but my quest for the final answer had just begun.



90 research tapes from the HP 9825B computer were found in storage.

Original thermal tapes and data cartridges.



Chapter IX: The HP 9825

Back in 1976, I had co-authored an NSF matching equipment grant for \$20,000 and through it funds for field measuring tools and an HP 9825B desktop computer were included. It used an extensive programming language called HPL (High Performance Language).

The proposal went to the dean's office for approval, but the dean was out of town. An acting dean, one of the department heads,

signed it probably not understanding it was a matching grant and the college would have to come up with \$10,000 if it was awarded. Back then, \$10,000 was our department's operating and expense budget for two years.

Then it went to the campus research office, and since it was signed by the "dean" they also signed it, as did the vice president, and it was mailed.

When the dean returned and saw what happened, he tried to stop it, but it was "in the mail." Then we got a call, not actually blaming us for anything, but close. The vice president said that they were going to call NSF and cancel the proposal, but were afraid that would make the university look bad, and they doubted we'd win the grant anyhow.

But we did! And I got an HP 9825B computer to do my research. I still don't know who paid the matching \$10,000.

That computer was significant because it made the difference between my being an ordinary faculty member and being one that could conduct high level research, support graduate students and produce publications. It opened the door to a whole world of professional opportunities otherwise not possible.

The HP 9825 had a full set of statistical programs, and because they weren't protected, I modified the code to speed the process and use large data sets efficiently. I also learned to write programs and graduate student Mike Kirkley and I wrote a 511 line multiple regression program that would be the envy of statisticians today.

Armed with that machine, which also came with a 4-color ink pen plotter, I applied for a number of grants and they were awarded -- and completed, with rave reviews.

Success builds on success, and more and more grants were awarded. One of them was to produce volume equations for 13 hard-

wood species in California, mostly oaks. The sponsor was the Pacific Northwest Experiment Station in Portland, OR. These were the 1984 equations that became famous (or infamous) during the trial.

The data used to create those equations were on the tapes I was holding.

However, a day long search with our department technician resulted in no trace of the computer. Without an HP 9825B computer connected to a printer capable of printing at least 80 characters per line, we had no chance of printing the data, if, in fact, it could even be retrieved.

I went into high gear to find a working HP 9825. No one on the campus list even responded. An Internet search found an HP museum and a forum of HP calculator users. I posted a query to see if anyone could help. I also wrote to my brother, Russ, a computer/electronics guru in his own right.

On the forum a man from Reno, David, said he'd try to print my tapes. We emailed for several days but he didn't have an external printer and we decided to find other options.

I even considered buying an HP 9825 as they occasionally come on the market. A company in Texas had two of them. How much? \$2,000 each. Wow! They sent pictures and they looked like they'd been through a fire, and a flood! No thanks.



Missing keys and badly cared for -- only \$2000 each.

David from Reno knew a man in southern California that had rebuilt his 9825. The same day my brother who had done some research, found the same person. That was good enough for me, I sent an inquiry.

Yes, Larry Atherton in Anaheim did have an HP 9825B and he would completely rebuild it for \$995. I told him if it would print to an 80 character printer, I'd buy the computer and the printer. It was a deal.

Suddenly it hit me. It's hard to explain, but I'd spent thousands of hours working on that computer with five or six graduate students as well as several senior project students. It was the King in its day for computing. And, it was fast. In fact, on the HP forum someone just did a speed test of all HP calculators through today, and the HP 9825B still ranks fifth (counts by ones to 60,000 in 60 seconds).

That computer had propelled my research career at a time when few at Cal Poly were doing research. For that reason it immediately put me at the head of the university, setting the research bar that others are only now beginning to reach.

You must understand that in those days, the 1970s, computing was done by a central main frame system. After dropping off a job we'd pick up the results the next day. If it wasn't right, another day would go by, and then another. It takes many trials to get a program working exactly as intended. As a result nobody did serious research on the main frame because it was nearly impossible. Having my own computer meant I could complete 10 edits in 10 minutes instead of 10 days.

How many all nighters did I spend working on the 9825? Hard to say, but one night one of my graduate students, Mike De Lasaux and I modified one of my statistical programs and ran over 20,000 regressions searching for coefficients. That's a record that probably still stands among foresters.

Now that I am retired, I took a moment to reflect on those days. Suddenly realizing that I was actually going to own that machine again was an emotional moment. It had meant so much for so many years.

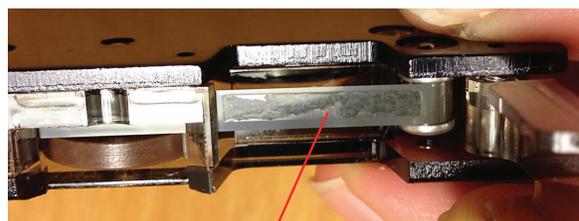
Hey, even if the tapes couldn't be read, I'd still have that wonderful old machine and the memories.

Chapter X - Bad Tapes

The first weak link encountered was the computer's tape drive. The rubber wheel became gummy with age and wouldn't advance the tape, and there are no spare parts for a 35 year old computer. In fact, they don't even make those cartridge tapes anymore.

But Larry had found a fix. He rebuilt the entire tape drive, well, actually he replaced it with one he built that reads both the original tapes and a slightly different sized tape a quarter of an inch wide, called QIC tapes.

I had found seven blank shrink wrapped tapes and sent them to be examined. Five of them failed outright, and two worked, but he didn't think they could be trusted. The defective tapes failed due to the oxide layer detaching from the plastic backing, rendering the tape unreadable. This happens at the



Oxide layer detached from the plastic backing



Tapes with discoloration.

top location where the internal rubber drive belt pushes against the tape. Over the years in that position, the tape oxide sticks to the adjacent layer of tape. Years later when the tape is advanced, it pulls the oxide off of the Mylar layer.

That was a setback. I examined the oak data tapes and they all exhibited the same symptoms he'd described; all had discoloration and most looked unusable.

Those tapes had been stored in a non-air conditioned building for at least 20 years, suffering through the summer heat. It's no wonder they had problems, but could they come alive one more time? My HP 9825B would be shipped in a week. In the meantime, I was left to wait.

Chapter XI: Fascinating Process, But Losing Hope

As Larry continued to work on my computer, the anticipation of its arrival mounted. Then it came.

First, I just touched the keyboard and let my fingers remember the different function keys and design. It was like finding a long, lost friend.

Then I wrote a simple program to count by one's, and it hit 75,047 in 60 seconds. That's faster than reported on the HP forum!

The printer worked great, but I couldn't get



Receiving my HP 9825.

the computer to read the tapes; it kept getting lost. The new QIC tapes as well as the older HP tapes have one small hole drilled through the tape. As the tape proceeds 12-24" closer to the beginning, there are two small side-by-side holes, followed by another set of two small holes. These tell the machine the beginning of the tape is coming during a rewind and to stop.



This hole in the tape tells the machine when to stop re-winding.

In conversation with Larry, we decided to return the unit so he could make sure there wasn't a malfunction.

Connie and I were taking two of our grandkids to Legoland and Larry's place is on the way. On our return trip we stopped, spending an hour going over the various issues. It turned out the machine was fine, but there is a special sequence for "parking" the tape so that the computer doesn't get lost in never land (or Legoland!). Otherwise, the tape winds too far and it can't find its way back. It could even wind off the end.

We spent time running/testing my old tapes, especially the ones that weren't crucial to the trial. Doing so helped us identify the next weak link -- the drive belt -- a little fragile sliver of rubbery material that no longer kept the proper tape tension, or it broke outright. Ten tapes in a row had this problem.

From: <latherton@motionsoftware.com>
 Subj: RE: HP 9825B
 Date: June 6, 2013 5:16:16 PM PDT
 To: Norm Pillsbury,movienight14@gmail.com

Norm,

I would like to give you a progress report on your 9825B.

I found a very clean core in my inventory yesterday, so I started with that one. In fact, the bezel on this one is like new, so I don't have to refinish it; that way, it will keep the 9825B marking (when I refinish these, I have to paint over the HP marking).

I have already performed the tape drive modification (and repair; I socketed and replaced all the ICs on the tape controller board...one of them was bad and the tape would not operate). The tape drive now works great.

Today I completed the refurbishing of the power supply board (that took several hours and uses custom parts that I developed). I can't evaluate the system until it gets clean power. Was intermittent, now seems rock solid.

The new keyboard comes with a new front bezel (it's part of the HP keyboard upgrade kit). The front of the computer now looks new, but the top rear cover and bottom chassis need refinishing. I think I'm going to mix up a color that exactly matches the front bezel. It's a light beige/light gray combo color that looks nice. I usually refinish in a more brown cast beige, but in this case, I think matching the front bezel is the way to go.

I still have the internal printer to rebuild, further system checkouts to perform, etc. But overall, it working fine.

So, if I can continue at my present pace, I should get this done early next week rather than the end of the week.

I took a few photos of the components and work I did over the past two days on my iPhone. I'll attach them to this email.

Thanks again!

Larry Atherton
La-Tech-Renewal

Machining Bezel For QIC Tapes



System Working With Tape Drive But With Original Power Supply

Tape Controller Interface Board Repaired



Your Stock Power Supply vs Modified Supply



Found Very Clean 9825B Bezel. Doesn't Need Refinishing

System With Rebuilt Power Supply



The fix was to dismantle a brand new tape, remove the belt, and replace the broken belt in the old tapes. Of course, the new tape is now destroyed, so this is a costly fix, about \$50 per tape. I left the most important tapes with Larry to make the switch.

But I could see this was becoming an even longer long-shot than I originally imagined. Ten tapes in a row had failed. Would a “new” belt solve the problem? It seemed less and less likely, but I decided to give it a shot.

By the way, Larry has the most incredible workshop - an entire double garage in size - completely filled with every electronic component, device and spare part known to the industry, so it seemed. This guy is Mr. Computer when it comes to these machines.

Chapter XII: Getting Closer

At home, I found one old tape that worked well. It didn't have the data I was hoping to get via Larry's repair job, but it did have two important program files. The first was the multiple linear regression program that Kirkley and I wrote in the early 80's, mentioned above. That program was used for over a decade to analyze research data. We built in many features and options that are impossible to find today.

The second was the “Master Program” I had used to access the raw field data and make all the calculations for the 1984 volume equations. Even though I didn't have the raw data, the program provided important clues to how I calculated the results.

Remember, I'm trying to calculate the volume between the 0-inch and 2-inch points on the terminal branches. This 0 to 2-inch volume would be computed from half the diameter ($4''/2''$) and half the length ($L/2$) of what I called Small Branches in the program.

It was only 132 lines of code but what a job deciphering my “logic” of 35 years ago. And

From: <latherton@motionsoftware.com>
 Subject: RE: Tape recovery
 Date: June 28, 2013 11:29:07 AM PDT
 To: <movienight14@gmail.com>

Norm,

I have been working on your tapes for quite some time. Getting these tapes back to a usable condition is not easy.

Here's what I've done so far (working, primarily, on just one tape):

- 1) Re-belting is not a big issue. I have pretty much remembered the technique I used before.
- 2) As you probably recall, running the tape with the new belt soon results in too much drag on the tape and it will stall or error from the drive roller slipping against the capstan.
- 3) This tightening is not due to the need for lubrication (although lubing the reel pins, etc., does help).
- 4) Turns out after a good deal of testing that the tape itself has changed and now has a much higher coefficient of friction against the two pins at either end of the cassette (these are the pins that cause the tape to turn and move straight across the front of the cassette).
- 5) I machined new idle rollers of various smaller diameters to help reduce belt tension. This does help, but the tape will still eventually “stick” on the pins.
- 6) I tried applying a thin silicone lube on the backside of the tape surface across the entire length of the tape. This also helps, and with doing all of the above, I was able to get one tape to list all of its approx 50 files. The silicone doesn't seem to affect the readability of the tape (at least yet).
- 7) You can only read these tapes a couple of times before the oxide contaminates the drive head. So you have to clean the head quite often.
- 8) I'm still perfecting this technique. But I think I'm ready to move on to the other tapes to see if I get the same results.

I'll keep you posted.

Larry

it certainly could have been much better documented! See program, on right.

Eventually I was able to account for all the variables, over 60 of them, and isolate the point where the small branch volumes were calculated. The program created, and saved, the final summary tables shown in Michael Kirkley's masters thesis.

The summary table data for each species came from one array dimensioned as A[61,25], or 61 rows (one for each tree) and 25 columns of data -- we call them variables -- such as tree number, dbh, height, volume, etc. Michael Kirkley's thesis didn't have all 25 columns printed, only the 12 pertinent ones.

Of the 12 variables listed, all were known to me except one titled "BVOL" or Branch Volume. I had no idea if this was the same as small branch volume or if it referred to volume of all branches, or something else.

However, this program showed exactly where the small branch volume was recorded, and it was in column #11 (of the 25 possible columns). And by a stroke of luck, sometime back in the 1980s, I had handwritten column numbers on one of the printouts in the appendix of Kirkley's thesis. That allowed me to link the two as the BVOL column had the note "11" written over it.

Now I knew that the BVOL data was indeed the small branch volume, which was the volume between the 0- to 4-inch points on the terminal or small branches.

I was getting closer but before making an estimate of the volume between the 0- and 2-inch points, there were two critical steps remaining.

Step 1. Calculating The Volume of Small Branches (0-2").

First I needed to know which equation I'd used in 1984 to calculate the volume of small branches.

*IDF A_i = File No
B_i = File Type
C = File Size
D = Branch Size
C[i] = Species code (1-12)
2 = Tree No (1-bit)
3
4
5
6
7
8
9
10 = width of small branches
11 = No. of*

```

0: *MASTER PROGRAM_PMW2(BACKUP),TRK1,FILES:
1: trk 0
2: ent "FILE NUMBER?",X
3: prt X
4: fdf X,1,d B,B,B
5: dim M(13,50),dim A((B-402)/55,7),dim B(4,4),dim C(14)
6: idf X,M,B,A,C,B,C,C
7: for D=1 to C(12)
8: gsb "LENGTH"
9: gsb "BAOB"
10: gsb "BAIB"
11: "TOTAL-OB":
12: B*AC
13: T*CT
14: "WOOD-IB":
15: if D=1 gsb "SH"
16: if D=1100R
17: if D(1)+0>R
18: S*RS
19: "MERCH":
20: if A(D,1) gsgto "OD"
21: if D=1 gsg "SH"
22: if D=1100W
23: if D(1)+0>W
24: W*WU
25: gto "OD"
26: WRT: fnt 0,10,F,2
27: wnt 10,A,B,C,D,E,F,G,H,I,J
28: fnt 1,2,wnt 10,1
29: wnt 10,K,L,M,N,O,P,Q,R,S,T
30: wnt 10,1
31: fnt 2,3,F,2
32: wnt 10,2,U,V,W
33: fnt 3,5,wnt 10,3
34: "OD" next D
35: "SM,RR":
36: .0007854*(C(11)+C(10))L
27: T*LP
38: gto "REC"
39: fnt 4,2,F,2
40: wnt 10,4,L,P
41: "LENGTH":
42: if A(D,7) gsg A(D,7) Airet
43: abs(A(D,4)-A(D,2))A
44: if C(1)+3 and C(2)+3 gsgto "AA"
45: if C(1)+3 and C(2)+4 gsgto "AA"
46: if C(1)+4 and C(2)+4 gsgto "AA"
47: if C(1)+8 and C(2)+1 gsgto "AA"
48: if D=2(A-3)A < 0.5 wnt 10,5
49: "AA": if A(D,5) gsgto "ANGLE"
50: ret
51: "ANGLE": A/(sin(A(D,6)))A
52: ret
53: "BAOB":
54: (A(D,3)+A(D,3)+.00007854*A(D,5)+A(D,5)+.00007854)/210
55: ret
56: "BAIB":
57: if C(1)+2 gsgto "TO"
58: if C(1)+2 gsgto "TO"
59: gsb "SC"
60: A(D,3)+M(1,E) < 0.5 of all seg's
61: A(D,5)+M(1,F)
62: (E^2+.00007854*(2+.00007854)/210)
63: ret
64: "SH":
65: if A(1,7)+.31 gsgto "1" stamp HT to D 3m, also 1000W
66: if A(1,7)+.31A-.310 gsgto "2", then stamp HT to D 3m, also 1000W
67: 0.6510 L w BAIB 5 V for stamp
68: ret
69: "TO":
70: "HEIGHT":
71: if D=1 gsgto "IFT" < 1.5 if gsgto D=1
72: if D=iret
73: if A(D,7) gsgto "LAT BR"
74: abs(A(D,2)-B(1,1))H gsgto "BAIB-TO"
75: abs(A(D,4)-B(1,1))H gsgto "II"
76: "BAIB-TO":
77: if H(.84) gsgto "IFT"
78: if H(.84) and H(2.06) gsgto "4,SFT"
79: if H(2.06) and H(3.36) gsgto "5FT"
80: if H(3.36) and H(6.4) gsgto "17FT"
81: if H(6.4) gsgto "K"
82: "11" if (5-.84) gsgto "-IFT"
83: if (1-.84) and (1-2.06) gsgto "-4,SFT"
84: if (1-2.06) and (1-3.36) gsgto "-5FT"
85: if (1-3.36) and (1-6.4) gsgto "-17FT"
86: if (1-6.4) gsgto "K"
87: "IFT": A(D,3)+.95882-4.35711 gsgto "BA"
88: "4,SFT": A(D,3)+.95722-3.90980 gsgto "BA"
89: "5FT": A(D,3)+.95683-2.95685 gsgto "BA"
90: "17FT": A(D,3)+.95881-.95293 gsgto "BA"
91: "-IFT": A(D,3)+.95882-4.35711 gsgto "BA"
92: "-4,SFT": A(D,3)+.95722-3.90980 gsgto "BA"
93: "-5FT": A(D,3)+.95683-2.95685 gsgto "BA"
94: "-17FT": A(D,3)+.95881-.95293 gsgto "BA"
95: "K": A(D,3)+.9531ret 2m HT above gsgto 1.5 2.4 m, reduce
96: "K": A(D,3)+.9531 gsgto "BA" 2m to 5.8 to get DIB.
97: "LAT BR":
98: A(D,3)+.84+1.173 DIB lamp end of 1000W seg
99: A(D,3)+.84+1.173 DIB lamp end " " " "
100: "BA":
101: if D=1 gsgto "XX"
102: if D=1 J 2+.00007854*(C(11)+C(10))L
103: "XX": (J^2+.00007854*(2+.00007854)/210)
104: ret
105: "SC":
106: if C(1)+1-.21235 M(.94782) Niret (5.8)
107: if C(1)+2-.60133 M(.95767) Niret (6.4)
108: if C(1)+3-.44083 M(.94483) Niret (6.4)
109: if C(1)+4-.48584 M(.95147) Niret (6.4)
110: if C(1)+5-.20343 M(.98182) Niret (6.4)
111: if C(1)+6-.19239 M(.93475) Niret (6.4)
112: if C(1)+7-.19957 M(.92472) Niret (6.4)
113: if C(1)+8-.12237 M(.92953) Niret (2.4)
114: if C(1)+9-.32431 M(.96579) Niret (2.4)
115: if C(1)+10-.83425 M(.98155) Niret (2.4)
116: if C(1)+11-.78834 M(.95956) Niret (2.4)
117: if C(1)+12-.97254 M(.93545) Niret (2.4)
118: if C(1)+12 ret
119: "REC":
120: trk 1
121: dim D(61,25)
122: idf 2,0+1
123: for D=1 to 5
124: C(1)=C(2),C
125: next C
126: T(D),B
127: L(D),X,1,1
128: P(D),X,1,2 +VOL
129: S(D),X,1,3
130: V(D),X,1,4
131: ref 2,0(+*)
132: end
133: 18943

```

Handwritten notes on the right side of the program listing:

- 2 Lower cord*
- 3 Seg large cord dia*
- 4 Upper cord*
- 5 Seg small cord dia*
- A[D,6] = Angle of Seg (°)*
- I = length of horiz seg*
- A = seg length*
- B = BAIB / ADG*
- C = Vol of B (TVOL)*
- D = Seg No. (1-14)*
- E = DIB seg large seg end*
- F = DIB seg small " "*
- G = X BAIB from D*
- H = HT to lower cord*
- I = HT to upper cord*
- J = TD DIB lamp end*
- K = TD DIB lamp end*
- L = BAIB + I length in No. in BR*
- M = factor DIB Rgr.*
- N = DIB cord.*
- D = Vol of B (TVOL)*
- E = HT of seg (2.00m stamp)*
- R = stamp VOL (13)*
- S = E VOL (13)*
- T = E VOL (13)*
- U = VOL (13)*
- V = E VOL (13)*
- W = VOL (13)*

Other handwritten notes:

- TO: DIB rest cord for DIB*
- Is to seg lamp end DIB*
- K = TD seg lamp end DIB*
- explains BA*
- small (cord) seg BA*
- DIB vs DIB Reg. coeff*
- 1.5 2.4 m, reduce*
- 2m to 5.8 to get DIB*
- 2m HT above gsgto 1.5 2.4 m, reduce*
- 2m to 5.8 to get DIB*
- DIB vs DIB Reg. coeff*
- 1.5 2.4 m, reduce*
- 2m to 5.8 to get DIB*

Equations at the bottom right:

- $BA = 0.0007854(D^2)$
- $D = 10, D^2 = 100$
- $BA = 0.0007854 \times 100$
- $VOL_{br} = BA + XL$
- $VOL_{all br} = BA + XL + N \times B$
- $D = 11.8, D^2 = 0.007954 + 2 \times X$

The equation to make these calculations is a little tricky because there are actually two variants of the equation found in the literature.

The likely equation would be Smalian's equation which is similar to using the branch tip as a cone, and the equation is:

$$\text{Volume} = \frac{(\text{BA}_L + \text{BA}_S)}{2} \times L \quad (1)$$

where BA is basal area (or cross-sectional area) at the Large (L) and Small (S) end, summed, divided by two, then multiplied by the length (L) of the small branch.

The other equation divides by three instead of two, and for a project this size, it would make a considerable difference. So, which denominator did I use back then, 2 or 3? More on that shortly.

Also, in the 1984 study, the small branch lengths (L) for each tree were measured in the field so there would be a number of different lengths recorded. Without that information, branch volume couldn't be computed and the quest was over.

In the meantime Larry was doing his magic again. He built a special tape cartridge and replaced both of the metal stationary "pins" with rolling nylon pins. He found that as the tape came off the reels and slid over and around the stationary metal pins oxide was flaking off and some was sticking to the pins. As the tape continued to move, the residue on the pins was degrading the rest of the tape.

His "invention" was a real life-saver. Tapes he'd marked "non-recoverable" he was now able to read. Even he was amazed. But it meant that he had to open each cartridge, remove the two reels and tape, and mount them into his specially built cartridge case with nylon rolling pins and a small pad to keep the proper tension before trying to access the data. It also meant that only he could attempt recovery as all other cartridges (in the world) were like mine, with metal pins.

From: <latherton@motionsoftware.com>
Subject: RE: Tape recovery
Date: June 29, 2013 10:18:43 PM PDT
To: <movienight14@gmail.com>

Norm,

I now have more than 20 hours of work on these tapes. I don't think I can get more out of them. I have tried "heroic" methods to get them to read, but the real problem is not the drive belts. The REAL problem is the tape stock.

Most of the cassettes you have are early HP designs and suffer from deteriorating tape (some are later models and have better tape stock in them and, while still deteriorated, are somewhat better). This tape loses its "slipperiness" and sticks to the guide posts in the cassette. When the tape reaches this level of deterioration, there is nothing that really fixes the problem. Depending on the degree of stickiness, they may work somewhat, but after a few runs through the tape drive, they soon become unrecoverable (there may be a way to get the data off these tapes if you remove the tape from the cassette and use a special playback setup that doesn't steer the tapes around small guide pins...in other words a specially built tape drive).

Of course, I have not been able to read any of the data files (they must be read under program control), but I have generated various listings of cassette file contents, depending on the condition of the cassettes. The fact that I can get a file listing, does not guarantee that the files are readable, just that the file locations can be found by the system. I did read one of your program files (a data entry program), and I made a copy of it for you on a QIC tape. I also have a printed copy.

All of the following tapes have been re-belted, lubed to some degree, most have smaller idler wheels installed to minimize tape tension to help prevent sticking, and may have other mods required to get the tapes as readable as possible.

All the tapes (to some degree) will contaminate the head in your tape drive. In order to work with these tapes, I used an external drive so I had ready access to the head which required constant cleaning from oxide flaking off the tapes. Some tapes are really bad and others are not too bad when it comes to oxide flaking. So, I recommend that you write a program that moves the tapes as little as possible in the drive to get the data off of them. Test your program with good QIC or other good cassettes before you begin using these tapes, since the more use they get, the LESS LIKELY you are to recover the data

So that's it. I wish I felt better about this, but it's about all I can do with these old cassettes!

Larry

In the middle of this, we both worried about how many times we could run these old tapes before the tape was totally unusable.

With the "Master Program" I identified the code used to record the original data and the size of the array dimensions. With that Larry should be able to retrieve the data.

It was mostly successful. Once the arrays were loaded he stored them on a floppy drive connected to his HP 9825. This saved him from making 120 cartridge swaps; risky business with tapes ready to disintegrate.

Strangely enough, over 100 files on one tape could not be retrieved even though we knew exactly how the data was stored. For you computer programmers, each file included 2 simple variables, one array, and 4 more simple variables -- stored in that order. An error occurred every time the program tried to load the data.

Enter Larry the magician again. He spent several hours researching the problem and found the computer was also capable of loading another type of simple variable, called the r-variables (r1, r2, etc). There is no limit (except memory) to the number you can populate. Further, the r-variables could read simple variables as well as arrays of data.

He tried loading the first file using r-variables and it loaded without a whimper! From there, a program was written to store them similar to the original configuration, but this time he stored the data array first and then the six simple variables. He found this sequence could be read back without error. The saved files were transferred from the floppy to QIC tapes my 9825 could read.

When I think about what Larry did to read those tapes, I shake my head in wonder.

Via an overnight by UPS the tapes arrived and finally I had the two data points needed: (1) the number of small branches per tree, and, (2) their length. As I suspected, a num-

From: <latherton@motionsoftware.com>
Subject: RE: CCRCD Tapes
Date: July 9, 2013 11:42:28 PM PDT
To: <movienight14@gmail.com>

Norm,

The key was putting the tape stock in my specially modified cassette that uses nylon rollers instead of pins to direct tape movement. Without that, there would be NO WAY to read tape B and H and C. The tape is too deteriorated and sticks like crazy; the pin rollers are the only way to get the tape to move without jamming up.

Larry

PS - In short, I developed a special cassette that replaced two large guide pins in the HP cassettes, originally responsible for guiding tape past the recording head and maintaining correct tape tension, with nylon rollers. This prevented the deteriorating tape from sticking to the pins. Adequate tape tension was restored through the use of a pressure pad added to the cassette at the recording head location. With both of these modifications incorporated in a special cassette, we were able to read the old tapes.

From: <latherton@motionsoftware.com>
Subject: RE: File structure for 3 segment tree
Date: July 17, 2013 11:25:40 AM PDT
To: <movienight14@gmail.com>

Norm,

First of all, it occurred to me, as it did to you, that using the r-variables, it would be pretty straightforward to reconstruct the simple and array variables. So I would like to try that so that I can finish the data recovery from CCRCD #2, TRK #1. I'll work on that this afternoon. The first thing I'll confirm is that I can load a variety of files from that tape into r-variable (so far, I've only loaded file zero).

I have kept all the data on floppies. So, don't worry about that. And thank goodness I decided to use floppies to store the data, because those tapes are becoming unreadable and they are a major pain to work with.

By the way, the info you sent me on the data structure DOES look very much like the data I see when I loaded it into r-variables. So, that's good news. I'll study your notes some more this evening.

Larry

ber of different small branch lengths were measured, all the way from 6 to 16 feet. This information was printed, and entered into an Excel program. Next I calculated the volume, using equation (1) above, testing for both a denominator of 2 and 3. It turns out the denominator used in 1984 was 2, the same as shown in equation (1) above.

To complete this step, I calculated the percentage of branch volume between the 0- and 2-inch diameter points relative to the 0- to 4-inch volume for the lengths recorded. It's fairly straightforward math, and the answer is 0.1250 or 12.5%. Thus each 0 to 4-inch volume was multiplied by 0.1250 to obtain the volume from 0 to the 2-inch mark. This is the volume not used by the woodcutter.

Percentage of volume between 0 to 2-inches.

$$V = \left(\frac{BA_L + BA_S}{2} \right) L$$

$$V_{0.4"} = \left(\frac{0.005454D_L^2 + 0.005454D_S^2}{2} \right) L = 0.04363L$$

$$V_{0.2"} = \left(\frac{0.005454D_L^2 + 0.005454D_S^2}{2} \right) \frac{L}{2} = 0.005454L$$

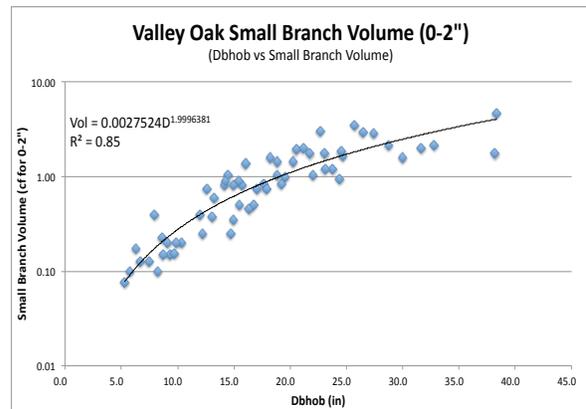
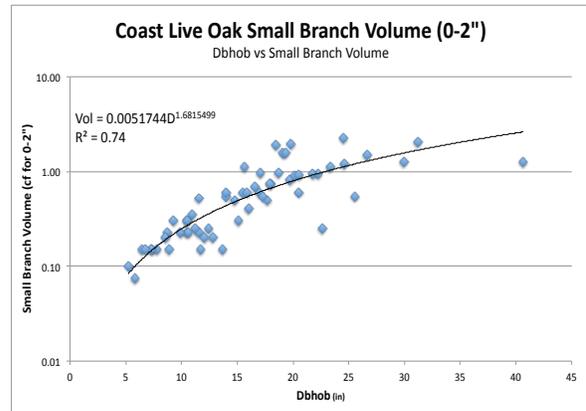
$$\text{Ratio} = \frac{0.04363L}{0.005454L} = 0.1250$$

BA_L is basal area at large end; BA_S is for small end.
 0.005454 is conversion from diameter in inches to area in square feet.
 L is length (ft), but cancels out in the equation.

Step 2. Correlating Small Branch Volume to Dbh.

Secondly, I needed to apply this to the legal case at hand. My two crews and I had measured diameters (dbh) on just over 500 trees located on 41 one-tenth acre plots on the 100 acre area. Dbh was used to calculate each tree's volume. Because dbh was the only tree variable measured in the field, that meant I must correlate small branch volume (0- to 2-inch) to dbh from the original 1984 data set.

The original data for coast live oak and valley oak included 60 trees for each species. Therefore, I regressed tree dbh's against their 0 to 2-inch branch volumes. The two correlations had no major anomalies and provided easy to use equations with an r-squared value for coast live oak of 0.75, and 0.85 for valley oak.



From: <latherton@motionsoftware.com>
 Date: July 17, 2013 12:33:00 PM PDT
 To: <movienight14@gmail.com>

Norm,
 By the way, I tried loading file 6 (a pretty good size file) in r-variables and it worked great. It was an array of about 45 elements. The two variables up front, 45 segments, then four variables at the rear was the same. Looks like reconstructing the data in the "standard" format should be pretty easy (...as he says blithely with confidence ;)

Catch you later.
 Larry

These equations were applied to the 500+ trees measured at the vineyard on a plot-by-plot basis. This resulted in the expected volume that would not have been sold as firewood (0 to 2-inch material).

Plot volumes were extrapolated to per acre volumes, and the data were kept separate for the two density classes identified on the property (medium and high density stands). Last, the per acre volumes were weighted by the number of acres in their respective density class, and summed for the 100 acre property.

Chapter XIII: Much Ado About Nothing?

This might seem like “much ado about nothing,” but recall that I’d been asked to estimate this volume in a few minutes at the end of lunch before testifying to the volume of wood in the 0 to 2-inch tips of tree branches. As a scientist and researcher, that is a last resort if a better method can’t be found. However, I did it and it left me very uneasy. So, this quest is actually about finding the real answer.

My search resulted in finding very old data tapes for a machine that the University no longer had, and finding a way to read that data to make a solid estimate.

With the help of my brother and the HP Forum on the Internet I was able to locate Larry who actually rebuilds these old HP 9825s and who was instrumental in retrieving the data.

During the “journey” I remembered I once had something of great value - the HP 9825. The thousands of hours I spent on that computer and the significant advantage it gave me in research and, really, in my career all came flooding back. I’d found something I’d lost and never thought would be replaced. So the journey led me to buying one of those wonderful machines, and the importance of this search broadened from just finding the best “answer,” to also finding a great memory.

So, even if I never found the “answer,” I’d still be content owing my own HP 9825. And if I did find the answer, and if it was close to my testified estimate of 65 cords for the 100-acre property, I would be relieved. Mightily relieved. If it wasn’t close, then I would send a revised volume number to the attorneys I worked for.

As I readied for the final Excel calculation -- Excel, as that’s where all the field data for the case was stored -- the above thoughts were racing through my mind.

I pasted the final equations into the spreadsheet and stared at the cell where the result would be displayed.

Answer: 67.1 cords.

Just like that, the search was over.

Chapter XV: Prologue

For so long it seemed that determining a reliable estimate would elude me. But, in the end, with perseverance and a bit of luck, I figured it out. The solution required two rare individuals. One who could reconstruct the research methodology and calculations from 35 years ago and one who is best described as a computer magician.

And for the answer, I even calculated the 90% confidence limits, and it is ± 10 cords. We foresters would say that we are 90% sure the true number of cords falls between about 57 and 77 cords with the best estimate at 67.1.

So that’s that. Maybe we should round the number to 65 or 70 cords, but somehow I like 67.1.

I thought you’d never ask how “amazed” I was that the final answer was so close to my testified estimate. Answer: Totally amazed.

But my wife, Connie, wasn’t. She said, “They wouldn’t have hired you if you couldn’t make a good estimate!”

Maybe she’s right.

Chapter XVI: The Verdict

The case was to be decided by the end of August, but August came and went, as did September, and still, we heard nothing.

While I waited I found myself wondering if all the work done for this case was really helpful. I remember the Judge saying this was one of the more unusual cases he'd ever tried and not one he'd ever forget. I agree. This is a case I'll never forget.

Then, on Oct 7, 2013, came a phone call from my attorney saying that they'd won the case and a \$444,112 settlement! It was a time for high-fives over the phone. A major relief.

For my part of the case, the judge had several choices. He could have used the defense's volume estimate, or he could have used mine, or he could have averaged them in some way. As a minimum we all expected some discussion about the two estimates as my estimate was considerably higher (5700 cords vs. 1600 cords of wood).

Surprisingly, there was no mention of the other expert witness or any of their work. None. Zero. Nada. The judge had accepted my calculations 100%. The attorney's I worked for said they'd never seen that happen before.

Also, there was no discussion about small branch volume as, apparently, he accepted my "back of the napkin" estimate without question.

And now I know he made a good decision when he did that.

*The HP 9825 in use
at my home.*

Chapter XVII: Final Footnote

While looking for a place to post this story, I found Steve Leibson, author of the *hp9825.com* website. Among many accomplishments of his amazing career, he was one of the creators/developers/inventors of the HP 9825 in the 1970s in Loveland, CO. That this story would end by finding one of the HP 9825 inventors is icing on the cake!

In an email received from Steve Leibson, he says:

March 12, 2014

Finally, thanks for the smile. The HP 9825 experience was my first as a graduated BSEE and I was incredibly fortunate to have helped create such a useful and ground-breaking machine. It was the high-water mark of my design career and it was the first job I had as an engineer. There are so many components to the 9825's development that make absolutely no sense today. You could not afford to develop a special microprocessor for such a low-volume product today (1000s a month at its peak). Back then, you could create a semiconductor fab literally from optical components bought at the local camera store. That's why it was possible. You could not afford to develop a unique printing technology for such a low-volume machine, but we did. You could not afford to develop a tape technology (drive and cartridge) for such a low-volume product, but we did. And we made excellent profits even with all of that invention. It's a very, very different world today.

Regards,
Steve

