Expanding the Legacy of Research at the Fritz Wonder Plot, Big River, California: A Report to Save-the-Redwoods League

Matthew Gerhart

Recommended Citation:
Gerhart, Matthew. 2006. Expanding the legacy of research at the Fritz Wonder Plot, Big River, California: A report to Save-the-Redwoods League. Mendocino Land Trust. Mendocino, CA.

This report was produced with support from Save-the-Redwoods League. The views and findings contained within are those of the researchers and not necessarily those of Save-the-Redwoods League.

Expanding the Legacy of Research at the Fritz Wonder Plot, Big River, California

2005 Project Report
August 2006

Matthew Gerhart
Big River Program Manager
Mendocino Land Trust

With the Partnering Participation of:
The California Department of Parks and Recreation &
University of California Cooperative Extension

And Financial and Project support from:
Save-the-Redwoods League

2005 Measurement Team:
Greg Giusti, RPF, Matt Gerhart, M.A., Dan Porter, RPF, Roger Sternberg, RPF, & Michael Wells, PhD., with assistance by Louise Young and Laura Prival

"To stand in this 105-year-old forest is to make one wonder over the power of nature – the rain, the sun, the soil – to heal a wound. This young forest lacks the majesty of the climax forest of redwoods which it has replaced and which, in time, it will duplicate and, quite possibly excel in grandeur. But the young forest exemplifies the spirit of youth, the urge to grow bigger & stronger.

In its youth this stand carried on a battle quite different from its present battle. And from it we possibly can learn something about man's battles from childhood to and beyond maturity."

—Emanuel Fritz, May 6, 1963, after examining a photo taken in 1953 of the Wonder Plot

Introduction

In 2002, with the help of Save-the-Redwoods League as well as over 20 conservation organizations, a dozen state and federal agencies, 17 private foundations, 70 businesses and over 1,400 private donors, the Mendocino Land Trust (MLT) acquired 7,334 acres of redwood forest timberlands in the lower Big River watershed and transferred the property to the California Department of Parks and Recreation (DPR).

With this acquisition and transfer, an Agreement of Terms and Conditions was signed that permanently dedicated the property to estuarine and wildlife protection, as well as recreation consistent with that protection. It further set a new goal for the forest, specifically, "to support late seral forest characteristics and associated natural functions."

Up to this time, Big River had experienced a 150-year history of intensive timber management, with one unique exception. In 1923, Professor Emanuel Fritz of U.C. Berkeley successfully set aside a grove of "the best and oldest second growth of the entire redwood region" at Big River, for the purposes of ongoing studies of redwood forest growth. From 1923 through 1983, Dr. Fritz conducted decadal surveys of redwood survivorship and growth on the one-acre plot, establishing one of the most complete records of older second growth redwood to date.

The plot was named the "Wonder Plot" for its outstanding growth over those decades, with volume figures Fritz called "astronomic, even for California Redwood." A follow-up measurement was performed in 1995 by a group of researchers from Humboldt State University. Today, the second-growth redwoods at the Fritz Wonder Plot are approximately 147 years old, with a number of residual old growth trees intermixed.

Project Objectives

The purpose of the 2005 Fritz Wonder Plot project was to continue the monitoring work of Professor Fritz in order to extend the growth record into the later stages of redwood stand development, as well as to foster additional investigations into redwood ecology at Big River.

This report lays out the results of the year's work. Specifically, tasks for the project included:

1) Compiling and standardizing all existing data on the Fritz Wonder Plot,
2) Re-measuring the plot to expand on existing growth data by a decade,
3) Convening redwood researchers at Big River to discuss proposals for future research directions and management strategies for the plot, and
4) Reporting data, findings, and recommendations for further study to project partners.

The Legacy of the "Wonder Plot"

The Big River Watershed is located in the central section of California's Coastal Redwood forest belt, and is part of the extensive tier of forestlands extending north from Marin and Sonoma into Mendocino, Humboldt and Del Norte Counties. The watershed extends over 181 square miles, draining from the heavily corrugated uplands of the coast range to one of the longest tidal estuaries in northern California. Land cover in the watershed is dominated by redwood forest but grades into Douglas fir forest and oak woodlands to the east.

The Fritz Wonder Plot is located in the Big River Watershed about 100 miles northwest of San Francisco (source: Google Maps).

There are reports that Big River's name came not from its size as a waterway, but from the size of the trees originally lining its banks.[1] It is no surprise, then, that river logging came to the watershed soon after the Gold Rush of the 1850s. The remarkable old growth of Big River's lower terraces and hillsides was quickly cleared and transported by water to the new town of Mendocino, where it was milled to produce the lumber needed to grow boom-era San Francisco.

At this time, probably in 1858, a riverside bench approximately 8 miles upstream of the river's mouth was cleared of its old growth and opened up to the sunlight. Subject to

[1] Mendocino Land Trust, *Big River Acquisition Pamphlet*, 2002.

regular inundation from floods, the bench provided fertile soil for vigorous redwood re-sprouting. Within years, thousands of small redwoods were likely growing among the few remaining and scattered old growth too small or too gnarled to provide timber.[2]

Sixty-three years later, the stands had matured into a thicket of redwood and alder. It was at this point, in 1921, that Berkeley Forestry Professors Emanuel Fritz and Woodbridge Metcalf happened upon the ground that would later become known as "Fritz's Wonder Plot."

Woodbridge Metcalf in the Wonder Plot, June 1921 (source: Fritz-Metcalf photographic archive, U.C. Berkeley).

At the time, the region's timber companies were largely focused on clearing the remaining selections of old growth redwood timber from their extensive holdings. It was common practice for companies to divest from their heavily-cut former timber lands, often for conversion to pastoral and residential uses. Second growth redwood was generally not considered a viable lumber product.

Professor Fritz, who had been trained in the German forestry techniques of sustained-yield production, was a fervent believer that second-growth redwood could in fact become a viable product. He tirelessly advocated for North Coast timberland owners to hold onto their cut-over lands and invest in more sustainable forms of timber management. While he and Professor Metcalf set up the boundaries of the one-acre plot upon seeing it in 1921, it was not until two years later, when he returned to Big River to pursue a cutting experiment on the timber yield of second growth, that he decided to map and measure the plot.

Fritz reports: "Little did I think then that I would ever see the plot again, much less remeasure it myself in 1933, 1943, and 1955…I have been on the plot nearly every year since 1923 and hope to make what will likely be my last measurement in 1963."[3] In fact, he saw it and measured it many times after that. He completed decadal measurements until the early 1980s and saw the plot and its adjacent acreage permanently protected by Georgia Pacific for the purposes of research on redwood growth and yield.

After his death, Fritz's major publication on the plot, "Twenty Year's Growth on a Redwood Sample Plot," was followed up by Humboldt State University researchers Jerry

[2] Emanuel Fritz, "*May 6, 1963, after examining a photo taken in 1953 of the Wonder Plot.*" Handwritten note, Collection of Emanuel Fritz, courtesy of Barbara Fritz, 1963.
[3] Emanuel Fritz, *History of the "Wonder Plot" on Big River, Mendocino County, California.* Unpublished typewritten document, 4 pages, Collection of Emanuel Fritz, courtesy of Barbara Fritz, undated (~1960).

Allen and John Stuart working with foresters Jere Melo and James Lindquist.[4] They summarized the findings of their 1995 measurement in "Seventy-Two Years' Growth on a Redwood Sample Plot: The Fritz Plot Revisited."[5]

By the 1960s, research at the plot had produced a host of new information. Fritz relates its contributions thus: "The Wonder Plot to date has already yielded valuable data on natural mortality; natural pruning; diameter; height and volume growth; loss due to wind throw (or other cause); the change, downward, of crown class; ground vegetation, soil deposition by floods, and the tree's adjustment thereto."[6]

By this time, it had also become abundantly clear that second-growth redwood was not only viable as a product, but in fact one of the most vigorous and productive timber species known. Many credit the efforts of Professor Fritz, and in some part the Wonder Plot itself, for the eventual decisions of timber companies in Northern California to remain in continued production of large contiguous holdings in the region. While such management has itself led to numerous and lasting impacts to natural ecosystems in the region, it is also recognized by many today as presenting one of the best remaining opportunities for landscape-level ecological conservation of the redwood forest.

This opportunity is reflected in the newest role of the Wonder Plot, as part of an extensive 7,334-acre park dedicated to natural resource protection. Furthermore, in 1998 a new natural disturbance—in the form of a winter wind throw event—opened up the canopy and facilitated redwood regeneration in the plot for the first time in over a century.

Therefore today, continued study at the plot promises to help resource managers understand not only how productive redwood can be, but how processes of stand development and regeneration in older second-growth stands reclaim the habitat values that have been lost elsewhere in Northern California's forests. While not Fritz's original goal, he captures this enduring value well:

> The Wonder Plot proved to be very productive of information on how second-growth redwood behaves when in forest formation. I wish we had laid out 100 such plots in the 1920s, scattered over the redwood belt on different kinds of soils, slopes, elevations, aspects, etc. The data they would have yielded would now be invaluable…Such plots are necessary for periodic study and observation of what goes on and why.[7]

As brought to light by the research directions workshop held at the plot in the summer of 2005, much opportunity for expanded research exists at Big River, now focused more on the regeneration of late-seral forest than its sustained harvest.

---

[4] Emanuel Fritz, *"Twenty Year's Growth on a Redwood Sample Plot."* Journal of Forestry, Vol. 43 (1945): 30-36.

[5] Gerald Allen, James Lindquist, Jerry Melo, and John Stuart. *"Seventy-Two Years' Growth on a Redwood Sample Plot: The Fritz Wonder Plot Revisited."* Proceedings of the conference on coast redwood forest ecology and management. June 18-20, 1996. Arcata, CA: Humboldt State University , 1996.

[6] Fritz, *History of the "Wonder Plot,"* undated (~1960), p. 3.

[7] Fritz, *History of the "Wonder Plot,"* undated (~1960), p. 3.

The 2005 Research Directions Workshop

In July of 2005, MLT, DPR, and Save-the-Redwoods League convened a day-long meeting at the plot for participants with research interests in the redwood forest at Big River. Preparatory materials included an agenda and background document laying out the history of the plot, key questions and potential research areas for the plot. The workshop asked:

- *What information resources will be most necessary in order to understand the forest ecosystem and its functional dynamics at Big River?*
- *What elements will support the development of later-seral stage forest characteristics and associated natural functions that support fisheries and wildlife?*
- *What opportunities for research into redwood forest dynamics and regeneration might be most valuable for State Parks to pursue at Big River in general?*
- *What studies could augment the growth record at the Wonder Plot to provide a more comprehensive understanding of the stand's ecology, contributing to research on dynamics in older redwood forest?*
- *In what ways can the Wonder Plot be treated as an example for extrapolation to other situations and in what ways must it be regarded as an exception or unique?*
- *What are management challenges that DPR should expect in taking on management of the forest at Big River? What strategies will best deal with these?*

In addition, participants considered the following set of potential research directions:

- Canopy complexity, structure, fauna and flora: how are canopy complexity and species diversity recruited and maintained?
- Fire history at Big River and its importance in the maintenance and restoration of the redwood forest,
- Floodplain dynamics at the Wonder Plot,
- Links between processes of forest regeneration and wildlife and fisheries dynamics,
- Possibilities for investigating the spatial structure of redwood clones,
- Understanding forest floor (sub-canopy, litter surface, etc.) dynamics at the Wonder Plot,
- Edge effects in regenerating forest and within older forest patches at Big River. How will they alter over time?
- Edge effects due to adjacent timber harvest on adjacent lands,
- Restoring age structure distribution in regenerating redwoods stands,
- Management tools likely to support late-seral development on the property, and
- Potential impacts of visitor use and management prescriptions for the Wonder Plot and older forest stands at Big River.

Workshop participants gathered at the plot in July 2005 (photo: Matt Gerhart).

The fourteen participants included representatives of the Save-the-Redwoods League's Redwood Research Committee, Jackson Demonstration State Forest (JDSF), College of the Redwoods, and U.C. Cooperative Extension in addition to staff from MLT and DPR. Participants toured the plot and heard about Fritz's research, as well as the measurement planned for the fall.

The research directions discussion centered on possibilities for expanding research at Big River and areas of additional interest at the Wonder Plot. Key points discussed included:

Regarding the Big River Property

- Participants agreed there was strong opportunity for further research into redwood dynamics at Big River, in ways that could simultaneously advance both scientific and management goals.
- There is most likely significantly less need for direct stand manipulation at Big River than at DPR's Mill Creek property in Humboldt County, due to an older and more complex stand composition and structure. Manipulation needs due to stand suppression or skewed species compositions could be assessed through inventory plots, or through paired studies with JDSF.
- Priority should be placed on assessing the existing condition of the forest, from which management-relevant research directions can then be determined.
- Rather than relying simply on previous stand/timber cruise information, re-assessment of the forest will likely be necessary, and should be targeted to specific goals.
- Creating a system of comparative plots at Big River, of which the Wonder Plot could be one, across stand histories and environmental conditions (soil, aspect, altitude, etc.) would be the most effective way of assessing the current state of the forest and monitoring its recovery. This larger effort, however, can start with an initial subset, and then tier outwards.
- The Big River Property presents a unique research opportunity in that it is a regenerating forest that will never be harvested in the future; DPR's research and management can take advantage of that. Again, paired studies with JDSF could be profitable.
- Refinement of what the "support of later-seral stage characteristics" referred to in the Agreement of Terms and Conditions means, in the context of the process-based ecological restoration favored by DPR, is needed.
- The potential for utilizing different areas of the park for different purposes (such as public access, research, and reserves) is significant and should be explored in the general planning process.

Regarding the Plot

- An intensive baseline survey of the current condition of the plot would be warranted as a first step in expanding research there. Such a survey should be expanded beyond the boundaries of the plot (perhaps up to a ¼ mile) to capture any gradients operative at the plot itself. Ideas included: examining the structure and distribution of sub-canopy vegetation, getting a detailed topographic baseline.
- Due to the uniqueness of the plot, it was not considered the best area for assessing representative characteristics of redwoods. It was, rather, a grove in transition, and "a great place to just watch and see what happens."
- Most agreed that open access to the plot as an active research site was undesirable, but that guided/docent-led interpretation would be key to providing a live experience and building support for the park.
- Specific areas suggested for additional assessment included:
    - Lichen abundance and diversity,
    - Investigating soil microfauna and flora,
    - Bird abundance and species composition (already partly underway),
    - Investigating clonal structure in the stand,
    - Looking at branch re-iteration at the plot,
    - Continuing study of stand release and stand structural dynamics,
    - Investigating bat species, amphibians,
    - Pursuing studies of downed wood and decomposition processes,
    - Litter and sediment accretion,
    - Nitrogen fluxes (and limitations), and
    - Carbon sequestration potential.

The 2005 Measurement

In late 2004 MLT received approval from State Parks and grant funding from Save-the-Redwoods League to pursue the remeasurement of the Wonder Plot during the summer and fall of 2005. In preparation, MLT contacted researchers who had worked on the plot in 1995, and found that Jerry Allen of Humboldt State was retired and John Stuart was not available to continue the study. Additional contacts with forest mensurationist Jim Lindquist and local forester Jere Melo, who were also part of the 1995 measurement, confirmed their excitement and interest in the project.

There was some concern expressed by previous researchers—who had studied the plot primarily to construct a record of uninterrupted redwood production—that the blowdown of 1998 made the plot uninteresting from a research standpoint. At the time, no one had confirmed the extent of the effects of the blowdown on the plot, but there were reports that Campbell Hawthorne had salvage-logged the downed and damaged trees from the area shortly afterward, and it was clear that from a forestry standpoint there would be a significant loss of volume and the stand's even-aged characteristic would be altered.

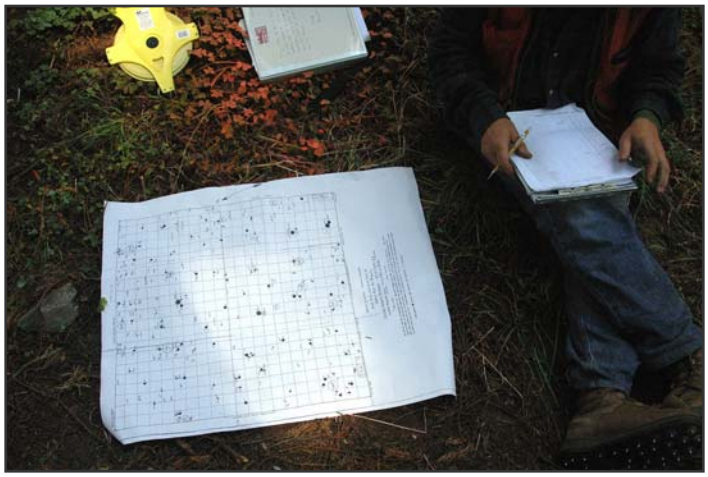
For the redwood research team assembled for this project, however, this condition was seen as an opportunity rather than a constraint. Partners Save-the-Redwoods League, California Department of Parks and Recreation, and U.C. Cooperative Extension agreed that other questions of ecological change, stand release, and the continued development of old growth characteristics were of great interest and worthy of continued research at the plot. Measurement was scheduled with lead work by Greg Giusti, Forest Advisor for Mendocino County U.C. Cooperative Extension.

Methods

The first step of the measurement involved re-establishing the plot boundaries using copies of the original map created by Fritz in 1923. Greg Giusti and his assistant worked at the plot to find the original corner posts (where extant) and set visible t-posts at each of the corners.

Initial tree measurements were conducted on August 26 and 27, 2005. A first step was locating and surveying the trees still living on the plot, which was done in conjunction with measurements of Diameter at Breast Height (DBH) and tree-tag height. DBH was measured using standard forestry DBH tapes at tag height. Trees missing tags were noted and re-tagged at 4.5 feet above ground; tree 28 had been previously mis-tagged as 27 and was re-tagged. Tree tag heights were also recorded using a meter-stick placed at the level of firm duff encountered at the base of the tree below the tag.

Where double-trees prevented direct measurement of DBH at tag height, DBH was estimated using a Biltmore stick, and in one instance (tree 16) through a caliper-style measurement using gridded stringing.



Measurements in the Plot were based off the map Emanuel Fritz originally created in 1923 (photo: Matt Gerhart).

Heights were measured for 60 trees using a combination of laser hypsometer (kindly lent by Professor Steven Sillett of Humboldt State University) and clinometer, due to some uncertainty in the field as to the accuracy of hypsometer measurements. Greg Giusti and Dan Porter measured distances to the tree using the hypsometer and angles using a clinometer. Angles were measured down from level to the base of the tree and up from level to the top of the tree. Measurements were not taken to a certain diameter top, but as best as possible to full tree height.

Subsequent comparison of the hypsometer and clinometer found slight differences in measurements between instruments (See Appendix A). However, these variations lie

within the more general accuracy of the field measurements, and tree heights were more often limited by difficulty in sighting the tops of trees than by the technique used.

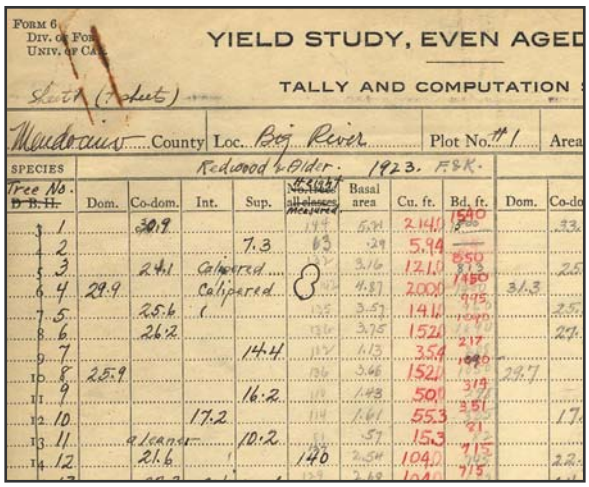
Additional measurement and mapping of new stems in the plot took place on November 15, 2005. New stems were mapped in the field using distances taped from existing trees, and, where needed, bearings to known points. All stems greater than 3 inches DBH and with greater than 1/3 live crown were included in the remapping. Trees were marked with new tags set at 4.5 feet high, using a new 300 numbering series.

Georeferencing was also undertaken for the plot at several points. Matt Gerhart created fixes with a commercial-grade Garmin eTrex GPS on Feb 5, 2005 and January 29, 2006. An accuracy of approximately 10 meters was recorded. A fix was also attempted with a Trimble GeoXT receiver (capable of sub-meter resolution), however, adequate satellite reception was not obtained in the plot.

Finally, a subsequent field check of certain heights whose accuracy was in question (due to being inconsistent with 1995 heights) was conducted on June 23rd and 25th. 11 anomalous tree heights were found to be inconsistent with the original measurement; as a result, remeasured heights were selected for the final dataset.

Re-constructing the Historical Data Set

For the first time, the entire previous record of individual tree measurements for the Wonder Plot was reconstructed using the variety of historical sources investigated. Appendix B gives details of the structure of the dataset. Wherever possible, original field sheets were used for recording data; these were checked against all other available records of individual tree measurements for each decade.[8] A computerized printout provided by Jim Lindquist provided a valuable summary of tree measurements from 1923-1963, including the X/Y measurements of each tree taken from Fritz's 1923 map.


FORM 6
DIV. OF FOR
UNIV. OF CAL.

YIELD STUDY, EVEN AGED

TALLY AND COMPUTATION

Mendocino County Loc. Big River Plot No. 1 Area

SPECIES Redwood & Older. 1923. F&K.

Tree No. D. B. H.	Dom.	Co-dom.	Int.	Sup.	No. trees all classes measured	Basal area	Cu. ft.	Bd. ft.	Dom.	Co-dom
1		30.9					2.141	1540		33.
2				7.3			5.94			
3		24.1	Calipered				12.1	850		25
4	29.9		Calipered				20.0	1450	31.3	
5		25.6					14.1			25
6		26.2					15.2	217		27.
7				14.4			3.54			
8	25.9						15.2		29.7	
9				16.2			5.0	319		
10			17.2				5.53	351		17.
11		4 leaners		10.2			1.53	71		
12		21.6			140		10.4	703		22.

Archival data from all available historical sources were used in reconstructing the data set (source: Archive of Emanuel Fritz, Courtesy of Barbara Fritz).

Due to the process of reconstructing the data from a variety of sometimes inconsistent historical sources, there are likely differences between the current compilation and the figures used at various times by previous researchers. As a result, in addition to making reference to previous figures cited for the plot, new summary statistics have been run for the plot using the 2005 data compilation.

[8] Many thanks to intern Iris Koski and volunteer Priscilla Comen for their work re-constructing the data set.

To analyze heights and calculate tree volumes, natural logarithmic regression curves were constructed for each decade's measurements using the set of actual height measurements for that decade. These were analyzed for statistical relevance and used to extrapolate heights for missing tree measurements for the purposes of volume calculations.

Estimated stand volume was calculated using the most relevant local volume equations and is presented in board feet using the International ¼ rule used by Emanuel Fritz.[9] Cubic foot volume has also been selected as an additional metric reflecting total tree volume, and is presented alongside board foot volume in Table 2. Technical comparisons with previously reported volumes and alternative volume equations are presented in Appendix C.

Results

A total of 71 of the original trees from 1923, as well as 17 new stems, were located on the plot for 2005. One newly marked tree, #314, was subsequently determined through mapping to be just outside the plot boundaries. This represents a significant drop from the 112 trees present on the plot in 1995, many of which were lost in the windthrow of 1998.

Chart 1 shows the reconstructed trajectory of the Fritz Wonder Plot including the new data from 2005. Overall, the plot has shown consistent growth in average DBH, slowly decreasing growth in tree height, and continuous reduction in tree numbers. Tree numbers and stand volume are punctuated by significant drops in the 2005 measurements, corresponding to the trees and volume lost in the blowdown of 1998. In particular, the loss of an additional old growth tree, tree number 98, contributed to volume loss.

Average height topped out in 2005 at 198.5 feet, with average DBH also increasing to 39.9 inches. Total stand basal area dropped from 945 square feet to 692 square feet, equivalent to the plot's status in the late 1930s. Stand volume, however, remains roughly equivalent to the 1963 measurement.

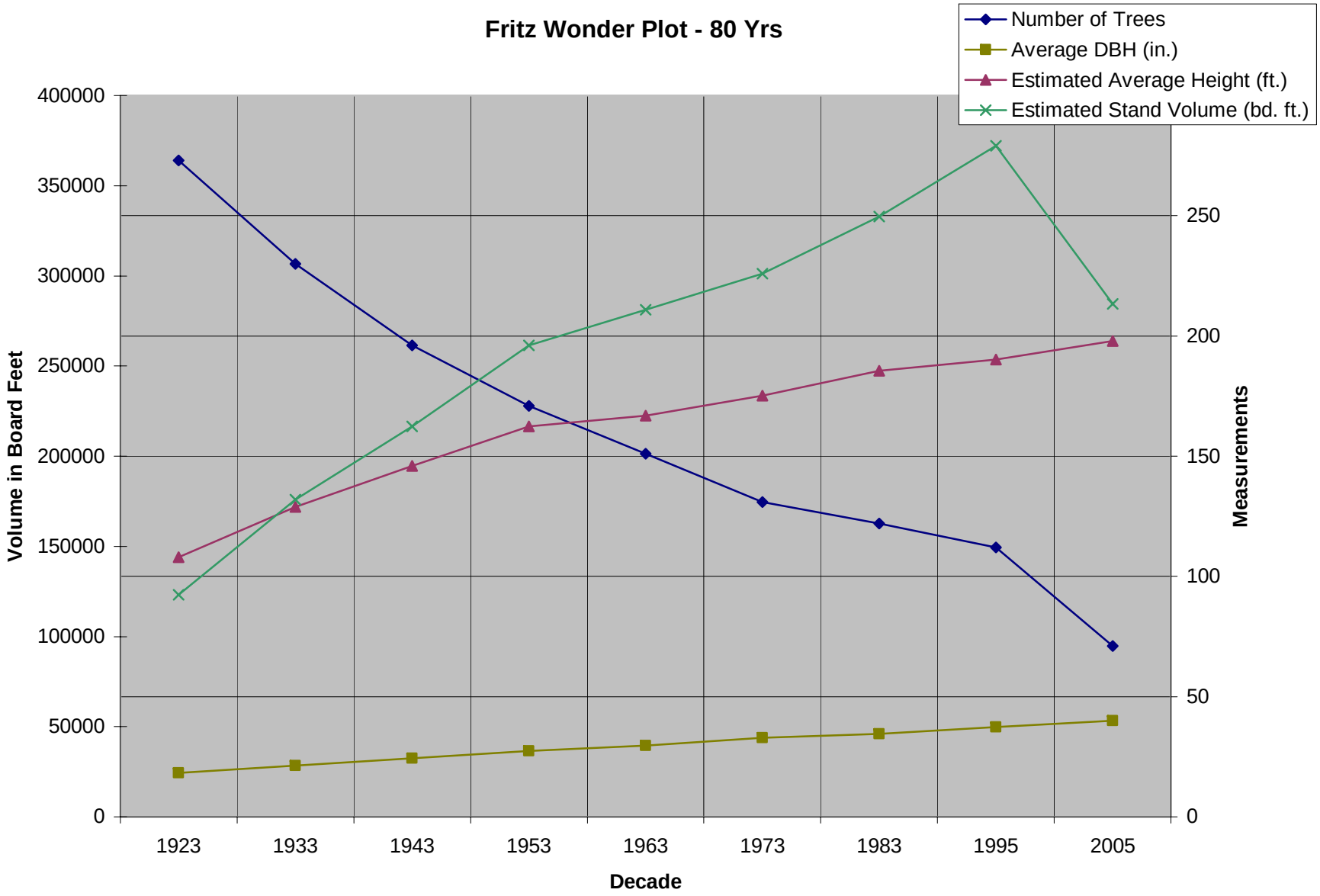
While quadratic mean diameter continued to grow to over 40 inch DBH (in some modern conservation analyses, a threshold used to proxy old-growth), stand density index (SDI) dropped to a new low, reflecting the new potential in the stand for release and regeneration. It is interesting to note that SDI at the plot has begun to drop off due to natural factors after nearly reaching the maximum of 1000 reported for redwood by Reineke (1933).[10]

---

[9] The formula used here is for International ¼ rule board foot volume to a 8 inch top using total tree height (*Volume (bd. ft.) = 7.0914D - 1.9681H + 0.08436DH - 0.57675D^2 + 0.01158D^{2}H*, where H=height and D=Diameter at Breast Height). From Lindquist, James L. and Marshall N. Palley, "*Empirical Yield Tables for Young-Growth Redwood*," California Agricultural Experiment Station Bulletin 796, 1963; also: personal communication, Marc Jameson, Manager, Jackson Demonstration State Forest.

[10] Reineke, L.H. *Perfecting a stand-density index for even aged forests*. Journal of Agricultural Research, Vol. 46 (1933): 627-638, as cited in Allen et al., 1995.

Chart 1: Results from the 2005 Measurement and Data Compilation.



Tables 1-3 below present figures from the 2005 Fritz Wonder Plot data compilation, following the format from Allen et al., 1995.

Table 1. Number of trees by species and years.

Year	Stand age (years)	Second-growth Redwood living	Second-growth redwood died since 1923	Alder living	Residual redwood living	Total Living Trees (2005 data comp.)
1923	65	259	---	9	5	273
1933	75	221	38	4	5	230
1943	85	190	69	1	5	196
1953	95	166	93	0	5	171
1963	105	147	112	0	4	151
1973	115	127	132	0	4	131
1983	125	118	141	0	4	122
1995	137	108	151	0	4	112
2005	147	68	191	0	3	71

Table 2. Total stand and second-growth redwood volume and basal area development.

Year	Stand age (years)	Total Stand Basal Area, Sq. Ft. (2005 data compilation)	Total Stand Volume, Board Feet (2005 Data Compilation)	Total Stand Volume, Cubic Feet (2005 Data Compilation)	Second-growth Redwood Basal Area (2005 Data Compilation)	Volume MAI Total Stand (Bd. Ft.)	BA MAI Second-growth redwood (Sq. Ft.)
1923	65	597	123,300	21,500	536	1,900	8.2
1933	75	669	175,800	29,600	599	2,340	8.0
1943	85	739	216,500	35,800	654	2,550	7.7
1953	95	800	261,400	42,600	701	2,750	7.4
1963	105	809	281,100	45,300	735	2,680	7.0
1973	115	846	301,200	48,100	767	2,620	6.7
1983	125	870	333,000	53,100	786	2,660	6.3
1995	137	945	372,000	58,800	847	2,720	6.2
2005	147	692	284,600	44,800	610	1,940	4.1

Table 3. Stand density index for the second-growth redwood component.

Year	Stand age (years)	Number of trees	Quadratic mean diameter (inches)	Stand density index
1923	65	259	19.5	760
1933	75	221	22.3	800
1943	85	190	25.1	830
1953	95	166	27.8	860
1963	105	147	30.3	870
1973	115	127	33.3	880
1983	125	118	34.9	880
1995	137	108	37.9	920
2005	147	68	40.6	640

New Trees

The new trees on the plot are a third growth generation, most likely the result of the opening of the understory due to the loss of trees in 1998. There is no record of previous sprouts in the plot earlier in the data set, however it is certain that if any existed prior to this set, none survived to maturity. The 17 trees measured meeting the criteria of 3" DBH and 1/3 live crown, listed in Table 4, ranged from 3.2 to 5.7 inches DBH (average 4.1 inches) and ranged in height from 12 to 28 feet (average 19.9 feet). All are redwood sprouts or seedlings, with many showing clear indication of having sprouted from the base of existing trees or from stumps.

Table 4. New Trees in the Fritz Wonder Plot.

TREE ID	DBH	HEIGHT	X	Y
300	3.75	26	172	40.8
301	3.6	17	171	46.6
302	4.5	16	8.9	70.3
303	3.3	12	21.9	102
304	4	25	21.6	106.6
305	5.5	22	55.8	99.5
306	5.7	28	57	93.2
307	3.4	14	134.6	108.2
308	4.75	26	155.8	174.6
309	3.5	19	155.4	175.6
310	3.8	23	157.4	180
311	3.2	26	120.4	189.6
312	3.4	15	84.6	191.6
313	4	13	72.7	172.7
314	4.7	16	25.3	211.8
315	3.75	18	13.2	207.2
316	4.75	25	41.6	150
Average	**4.1**	**19.9**		

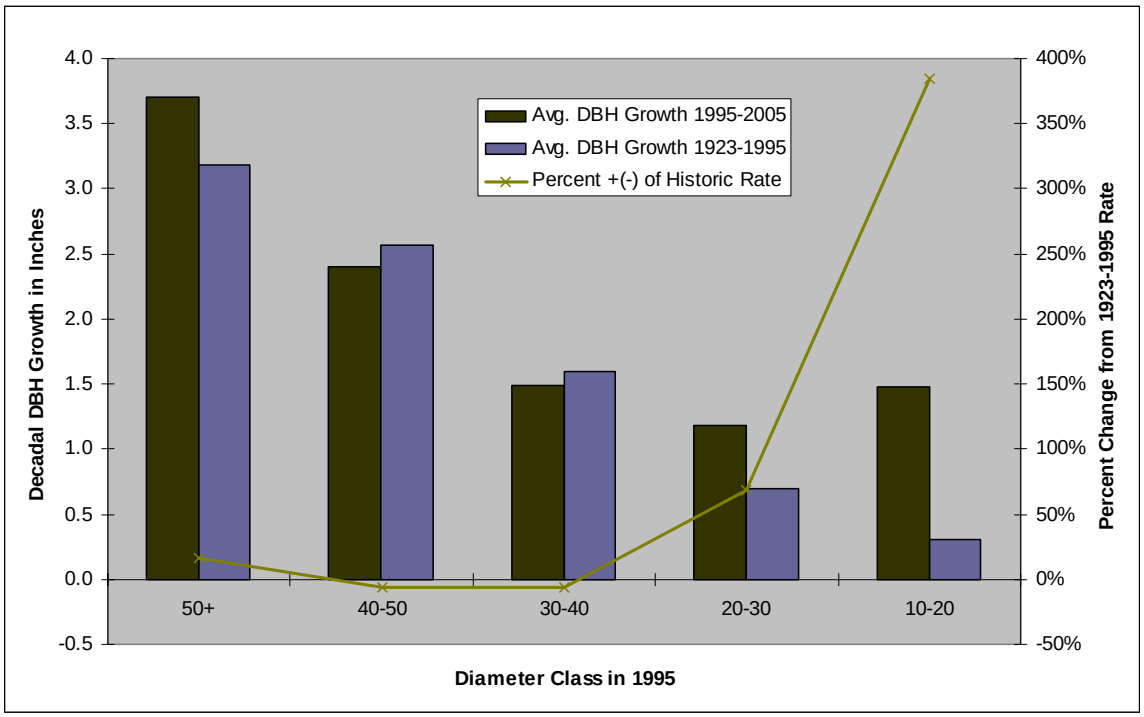
Stand Release

A major question for the future is what the stand's response to the canopy gaps created in the 1998 windthrow event will be. This will take several additional decadal measurements to establish, but as noted above there is already evidence of new regeneration in the stand, the release of the stand as a whole, and of individual suppressed trees.

Average decadal DBH growth for trees present in 2005 for the period of 1923 to 1995 was 1.7 inches of DBH added per decade. Average DBH growth for the period of 1995 to 2005, however, increased 150% to 2.6 inches per decade. This is indicative of a greater growth rate for the stand as a whole during the last decade, but does not reveal how that increased growth was distributed within the plot.

A look at Chart 2, however, suggests that diameter growth increases were uneven across the plot, and came largely from a rapid release of suppressed small diameter trees (10-30 inches), with a more modest release in the largest diameter class (50+ inches).

Chart 2: Decadal DBH growth in inches by 1995 diameter class, with percent increase in growth for 1995-2005 compared with the historic rate from 1923-1995.[11]



This reflects the remarkable plasticity of redwood trees even after decades of suppression. A look at two individual trees, # 131 and 132, is revealing: both are 147 years old today, yet have exhibited dramatically different life paths. In 1923 tree 131, a dominant tree, was measured at 25.6 inches, while intermediate crown class tree 132 was measured at 12.8 inches. By 1995, 131 had grown to 53.9 inches DBH and a height of 240 feet, while tree 132 remained suppressed at 12.4 inches and a height of around 90 feet – effectively zero growth over seventy years.

However, since 1998, the canopy around tree #132 has opened up extensively (see stand maps), and by 2005 it had already added 2.4 inches in DBH for a total diameter of 14.8 inches.

Tag Heights and Sedimentation Rates in the Plot

As early as the 1940s, Emanuel Fritz had already begun to notice that the tree tags he had originally set at 4.5 feet above the ground were steadily lowering due to sedimentation in

[11] From an analysis of second-growth trees present in both 1995 and 2005, excepting double trees historically prone to inconsistent measurement (n=56).

the plot from seasonal flooding. Clear indications of flood marks of over 5-6 feet high are common both today in the plot and in historical photographs.

The results of the 2005 tag height measurements provide interesting information on sedimentation rates along Big River's floodplain flats. 65 tag heights were collected in the plot, ranging from a height of 50 inches down to 18 inches. Average tag height was 32.2 inches, compared to the original 1923 tag heights of 54 inches.

Extrapolation results in the following long-term accretion rates:

Average 2005 Tag Ht.	Original Tag Ht.	
32.2	54	
Average Accretion	21.8	in
Time	82	yr
Average Accretion/Decade	2.65	in
Average Accretion/Year	0.265	in
Average Accretion/Year	6.74	mm

It should be noted that these include both sediment deposited due to flooding and long-term accretion of vegetative material on the forest floor. It is unknown whether missing tags may have been replaced at 4.5 feet at intermediate dates; therefore this estimate should be viewed as potentially lower than the actual accretion rate.

Mapping

After the field mapping measurements, all new trees were given X/Y coordinates to match up with the mapping of the plot Emanuel Fritz had done in 1923. X/Y coordinates for all previous trees were taken from Jim Lindquist's records. These were used to plot the growth and survivorship of trees throughout the 80-year record in digital form. A separate map was created for each decade, for use in creating comparative graphics. New numbered maps were created for 2005 as well as 1923.

The maps provide clear illustration of the development and growth of the plot, and are included in Appendix D and in digital form on the project CD.

The Historical Archive

At the time of the transfer of the Big River Property to State Parks in 2002, an archive of a number of Fritz Wonder Plot materials was made from documents stored at the Campbell-Hawthorne archives. As part of the 2005 project, additional efforts were made to secure copies of all remaining Fritz Plot documentation and archival photography. These documents have been drawn together into a new compilation and bibliography.[12]

[12] Many thanks to intern Iris Koski, Holly Newberger and volunteer Priscilla Comen for their work compiling the Fritz bibliography and binders.

Major source materials were identified at:

1) *The Campbell-Hawthorne Archives*. Campbell-Hawthorne maintains a file folder of Fritz Wonder Plot materials at its offices in Fort Bragg. Many of these were documents sent to Jere Melo by Barbara Fritz at the time of Emanuel Fritz's death. Campbell Timberland Management contact information: (707) 961-3302.
2) *The Noyo Hill House*. This non-profit historic archive currently keeps the records and material for the Guest House Museum in Fort Bragg. Numerous copies of Fritz-related materials were found and copied from the *Noyo Chief*, Union Lumber Company's newsletter publication. Noyo Hill House: 28953 Hwy. 20, Fort Bragg, CA 95437; (707) 964-6485; nhh@mcn.org.
3) *The Bancroft Library at U.C. Berkeley*. The Bancroft currently holds the entirety of Emanuel Fritz's professional papers in its collection. The collection is stored offsite and is catalogued through a finding aid available at the reference desk. All boxes with information relevant to the Wonder Plot were requested and relevant materials collected; much of the material specific to the Wonder Plot could not be located. Fritz's personal photographic archives have been moved from his papers into a separate collection; this collection of several thousand photographs has not been catalogued to date and was not available for examination. Bancroft Library: http://bancroft.berkeley.edu; Reference desk: (510) 642-6481.
4) *The Fritz-Metcalf Photographic Collection.* This is a special collection of the Bancroft held by the U.C. Biosciences Library (formerly the Forestry library). It includes approximately 6,400 photographs taken and catalogued by Emanuel Fritz and Woodbridge Metcalf as part of a long-term project documenting California's forest and vegetation types. The collection relates primarily to forestry, conservation, and the lumber industry in California and the United States. Subjects include logging operations, logging equipment, reforestation, forest research, fire protection, lumber mills, and the activities of the University of California's School of Forestry.


1645. Sample plot in Redwood second growth, on a bench above Big River, two miles below Boyle's Camp. 60 yrs. old, consisting mainly of root and stump sprouts with some old growth left. Measured up over 100,000 B.F. per acre, which included about 30,000 B.F. of old growth. Laid out and measured by Metcalf and Fritz, June 1921. H.P.
See also 1646 & 1647.

Photograph from the Fritz-Metcalf Collection.

This collection was discovered by virtue of several numbered photographs found in the course of research that appeared to catalogue the Wonder Plot's condition; these were subsequently traced to the Fritz-Metcalf collection. The collection is no longer catalogued by the same system of numbers (a cross-referencing project is underway), so a subject index was used to examine photographs that might be relevant to Mendocino, Big River, or the Wonder Plot. All photographs were scanned at high resolution and are available in digital format on the project CD. Bioscience Library contact

information: http://www.lib.berkeley.edu/BIOS/; Reference desk: (510) 642-0456.

5) *Archives of Emanuel Fritz, held by Barbara Fritz*. Professor Fritz's daughter, Barbara Fritz, currently lives at the Fritz family house in Berkeley and discovered a number of original copies of Wonder Plot documentation. These were copied, scanned, and returned, and are being recommended for addition to the Bancroft collection. To access these archives, please contact the Land Trust at (707) 962-0470.

6) *The collection of Jim Lindquist*. Jim Lindquist is a forest mensurationist who worked with Emanuel Fritz and the Wonder Plot data, at one point putting it into computerized form. The digital data was no longer available, but Mr. Lindquist was able to contribute copies of several sets of data printouts, including a summary of tree-by-tree measurements from 1923 to 1963. These included as well X/Y location information based off of Emanuel Fritz's original 1923 stand map. To access these archives, please contact the Land Trust at (707) 962-0470.

Every effort was made to identify all potential historical resources on the plot. Additional contacts were made to previous researchers, including Jerry Allen and John Stuart, who did research on the plot in 1995. Neither had additional data to contribute to the archive. Lee Wensel, who worked on earlier measurements of plot as well, was contacted but also did not identify any new archival resources on the plot.

A bibliography of compiled historical resources is included here as Appendix E.

Oral Histories

As part of the research, two oral histories were recorded with people central the Wonder Plot's history. The first was with Jere Melo, a Fort Bragg forester who worked with Fritz at the Wonder Plot over many years, and was part of the 1983 & 1995 measurement and the 1983 dedication ceremony honoring Dr. Fritz. The second was with Barbara Fritz, Emanuel Fritz's daughter, who lives at the family's house in Berkeley and continues to care for many of his archives. Each was kind to spend time recalling his or her experiences with Dr. Fritz at the Wonder Plot.

Forester Jere Melo was taken to the plot and interviewed in September 2005 (Photo: Matt Gerhart).

Topics in the interviews include:

Jere Melo:

- *Fritz's and Metcalf's establishment of the plot,*
- *History of timberland disposition in Mendocino after WWII,*
- *Logging history of the area,*
- *Fritz's campaign for sustained second growth management,*
- *Dedication ceremony in 1983,*

- *Stories of Fritz and his love of the forest,*
- *The blowdown at the plot in 1998,*
- *Measurements at the plot, seed trees, and*
- *Fritz's entrée into forestry.*

Barbara Fritz:

- *Fritz family friends, connections with State Parks and Save-the-Redwoods League,*
- *The importance of the Wonder Plot,*
- *Fritz's education as a forester,*
- *The role of Germany forestry, its transfer to California,*
- *Fritz and the Bohemian Club,*
- *Fritz's commitment to his work and love for redwoods,*
- *Fritz and improved harvest techniques, writing the Forest Practices Act,*
- *Dedication ceremony in 1983, and*
- *Fritz's wit and character.*

Documents and Resources on the Wonder Plot

Tree #131 in May of 1940 (Source: Fritz-Metcalf Photographic Collection, U.C. Berkeley).

The following project resources were created as part of the Fritz Wonder Plot project:

- *CD with 2005 dataset, project report*
- *Reconstructed plot maps from 1923 to 2005*
- *Binder with compiled historical materials on the Fritz Plot and summary of bibliographic resources.*
- *CD with scanned photographic and archival materials*
- *Proceedings of the Research Directions Workshop*
- *Oral history transcripts, Melo and Fritz*