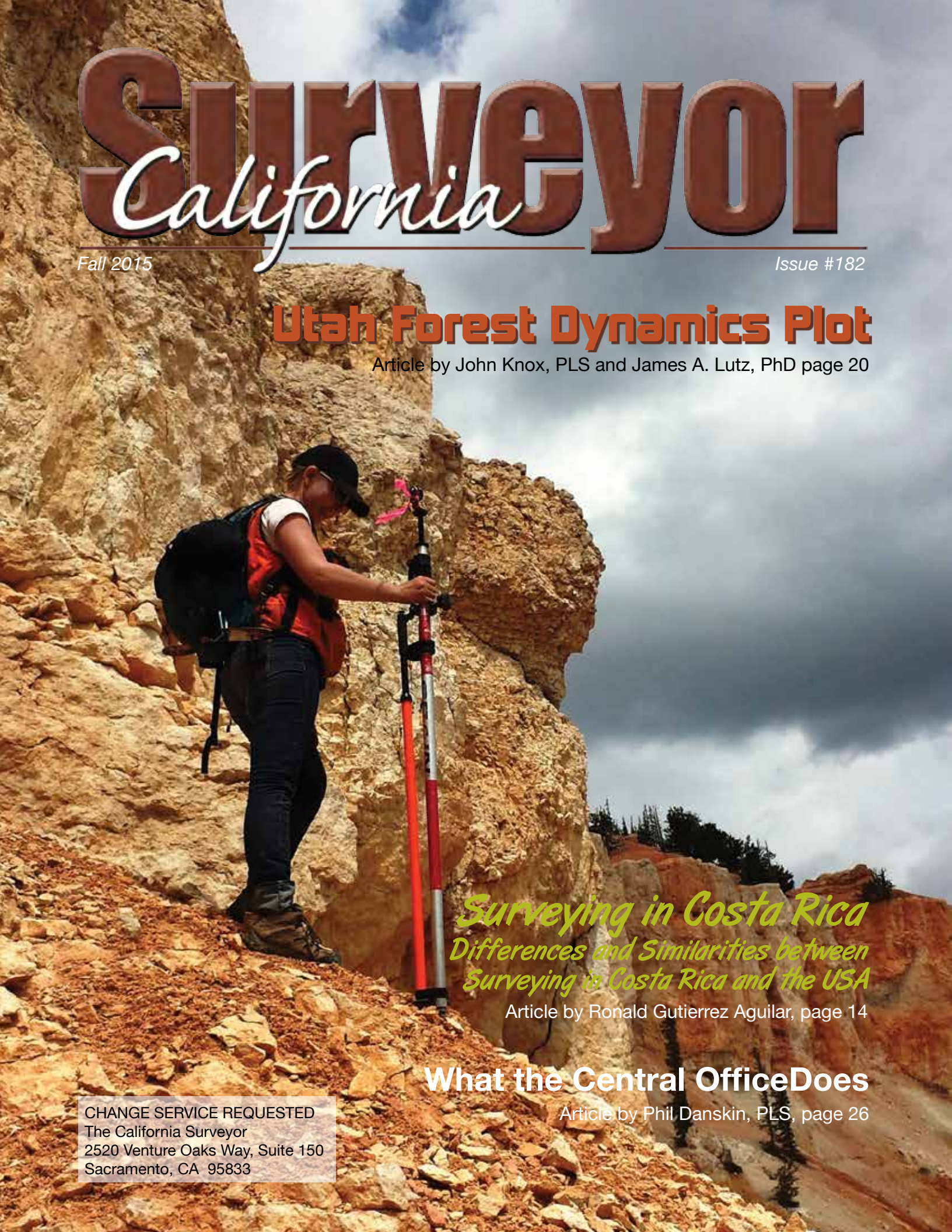

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The California Surveyor
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Sacramento, CA 95833

Brian Moe (Photo by Erika Blomdahl)

By: John Knox, PLS with James A. Lutz, Ph.D.

John Knox, PLS *recently retired after 34 years of practice as a land surveyor. He now has the greatest job and the greatest boss ever.*

James A. Lutz, Ph.D. *is Assistant Professor of Forest Ecology at Utah State University. He studies the forests of the western United States.*

The authors wish to thank the management and staff of Cedar Breaks National Monument for assisting with this research.

Utah Forest Dynamics Plot

Five years back, I remember sitting on a log within the Yosemite Forest Dynamics Plot (YFDP) (see California Surveyor issues #159 and #163) thinking that "surveying just couldn't get any better than this". When Jim Lutz called last year and requested assistance with the survey of another beautiful big-tree plot, this one within Cedar Breaks National Monument in southwestern Utah, I jumped at the opportunity. "The campground even has showers", he promised, reminding me of the primitive camping conditions of the YFDP. As if any encouragement was really necessary.

The Utah Forest Dynamics Plot (UFDP) was established in 2014 as a third research plot in a network of old-growth forests in the western United States. Within each plot, over 30,000 trees and shrubs are tagged, identified, and mapped. Every tree or shrub that reaches a diameter of 1 cm at breast height (1.37 m from where the plant exits the ground) is part of the study. The tags make the research a 'permanent plot' study, where the individual trees are revisited every year to assess their condition (mainly whether any existing trees died, and how, or if new trees have grown enough to join the data set). The UFDP is located at about the highest elevation where closed-canopy forests occur in the United States – about 3,000 m. The forest trees include: bristlecone pine (the longest-lived individual tree on earth), limber pine, subalpine fir, white fir, Engelmann spruce, Colorado blue spruce, aspen, Douglas-fir, as well as a few individuals of ponderosa pine, two-needle pinyon, and juniper. Because trees in old-growth forests live a long time (more than 500 years in the case of the UFDP – and maybe even 1,000 years), to understand how forests change it's necessary to follow them for decades.

The three western plots (UFDP, YFDP, and the Wind River Forest Dynamics Plot in southern Washington state; WFDP) are in turn nested within a global network of 62 plots coordinated by the Smithsonian Institution Center for Tropical Forest Science (www.forestgeo.si.edu). The ultimate goal of this network of large plots is to understand how the world's forests work. An important part of the research is learning how trees and shrubs interact with each other, and mapping their original rooting location accurately is critical to this objective. Once a 20 m grid is established, individual trees are referenced to the

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grid with a combination of tapes and handheld lasers. (Laser Technology Impulse 200 LR). This is basically a station/offset method using a slope-corrected tape as a baseline. For a small, relatively cylindrical tree, our objective is to locate the tree to ±0.10 m of northing and easting. For larger, less symmetric trees, an accuracy of ±0.25 m is more realistic. In either case, our primary objective is to map close inter-tree distances accurately (i.e., relative distances between trees), with longer inter-tree accuracies being less important. However, some of our research uses LiDAR data to assess canopy structure, and to match the LiDAR data with the tree locations requires a high degree of accuracy across the entire plot.

The task of the surveyors was to establish a 20 meter rectangular grid, from which the trees and shrubs will be located and tagged. UTM coordinates were provided for proposed grid corners, with an allowable positional variance of +/- 0.10 meters. Traverses would zig-zag through the plot via a series of interconnected loops, with grid corners staked out along the way. Basic closures would be monitored to ensure against blunders, but the final positions of traverse points and grid corners were to be established by least squares adjustment. In theory, and on paper, this sounded like a piece of cake, but experience gained within the YFDP told me that this would be no easy task. First off, the physical challenges. Each day began with a 45 minute downhill hike, carrying food, water, survey gear, and rebar, lots of rebar, with aluminum caps. But downhill was fine, even when the only trail veered off to elsewhere. After ten hours of scrambling through the forest, the days would end with a 60 minute uphill slog, a serious grind, and most days with soggy mud-caked boots. Add to that the elevation - 3000+ meters - and the old timers (John Knox, PLS and Patrick Busby, PLS) were regularly spotted with hands on knees, fighting for air. Night time temps regularly dipped into the low 30s, and nearly every day brought rain and hail, with the occasional horizontal snow. Plus that "grid to ground" thing … dealing with a combined scale factor of 0.9994 meant that raw field data would have to be scaled before traverse closures could be reviewed or stakeout of corners performed. And of course, the trees, always a tree or two on line, and strict instructions against the wielding of steel ("My kingdom for a brush hook!" was muttered a time or two).

2014

The surveying began in spring of 2014, when Lutz and Tucker Furniss, a master's student at Utah State University, weathered inclement conditions (read: snow!) to install monuments and perform static GPS observations on four primary control stations. The data was sent off to OPUS, but sadly, due to 50+ mile distances to the nearest CORS stations and the unavoidable problems presented by tree canopy, only two of the four positions could be resolved to our satisfaction. Ultimately a better control solution would be needed, but in the meantime the two resolved positions provided a respectable inter-visible baseline from which to begin traversing. In late June I met with Lutz and Furniss by the campfire at the YFDP for a strategy session, and to familiarize us all with a new data collector and software package. Due to scheduling conflicts, I couldn't be present to kick off the traversing, so I called in a favor from fellow PLS and close friend Patrick Busby. As Busby had been part of the team that surveyed in the grid corners at the YFDP a few years back, I knew I could sucker him into driving to Utah and donating his vast wealth of knowledge and wisdom for a week or so. He teamed up with Furniss, who had been a member of our survey crew at the YFDP, and Kendall Becker, a Ph.D. student at Utah State, to begin the traversing. Periodically, when the unfamiliar software proved sufficiently perplexing, we held teleconferences to get the field crew back on their feet. The survey and tree tagging operations continued throughout the

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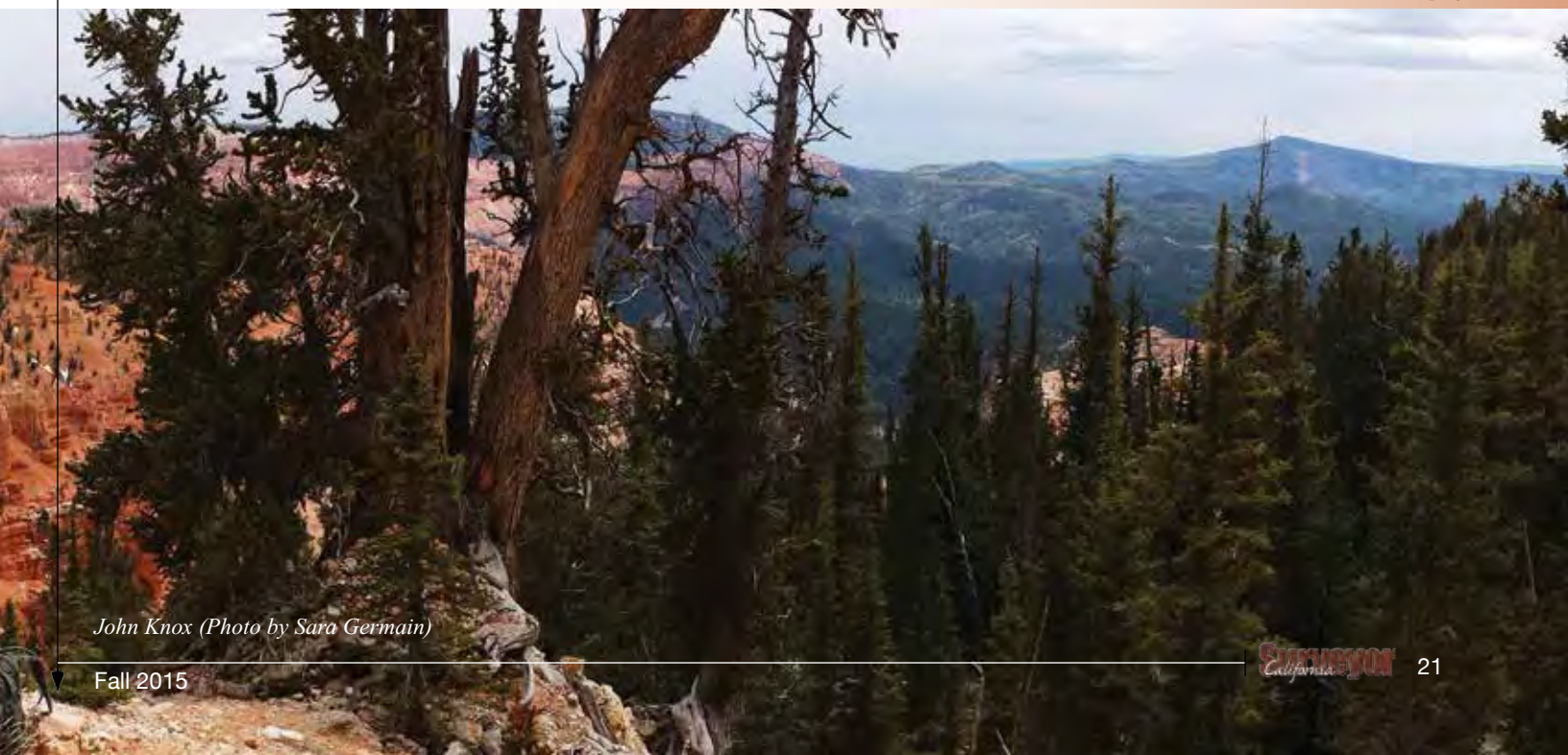

John Knox (Photo by Sara Germain)

Utah Forest Dynamics Plot

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John Knox (Photo by Erika Blomdahl)

UFDP location plot is inside the rectangle. (Photo by John Knox)

summer, during which time the GPS network was extended to two additional primary control stations. In September, I stopped by the plot for the purpose of training two new surveyors, Erika Blomdahl, Chief Field Operative for the Western Forest Initiative, and Brian Moe, a summer hire working on the project. Blomdahl skillfully assumed the role of crew chief, and together they continued traversing and stakeout until the snows came and ice crystals graced their pillowcases each morning. Note: winter camping as part of an adventure may be fun, but as a home away from home while working in the forest, not fun.

Data Processing

Data for 2014 was compiled and adjusted using a Star*net least squares adjustment. The GPS baselines that could be resolved were processed in Trimble Business Center (TBC) and exported to Star*net input file (DAT) format. Total station raw data files were also converted to DAT format. The final 3D adjustment was performed by combining all processed GPS baselines and total station data, fixing only the CORS stations. Adjustment results were outstanding, considering the obstructed sky and long length of GPS baselines, and the unavoidable short legs and poor geometry of traverse data. After realistic weighting strategies were applied, error factors for measured angles and distances were a shade under 1.0 and for zenith angles was 2.0. GPS deltas weighed in predictably at 4.1. Coordinate standard deviations for primary control stations were under 0.01 meters, while those of secondary traverse points mostly fell under 0.02 meters. With exceptions for the few grid corner positions that happened to fall on trees or fallen logs, all set corners fell within the desired 0.10 meter variance.

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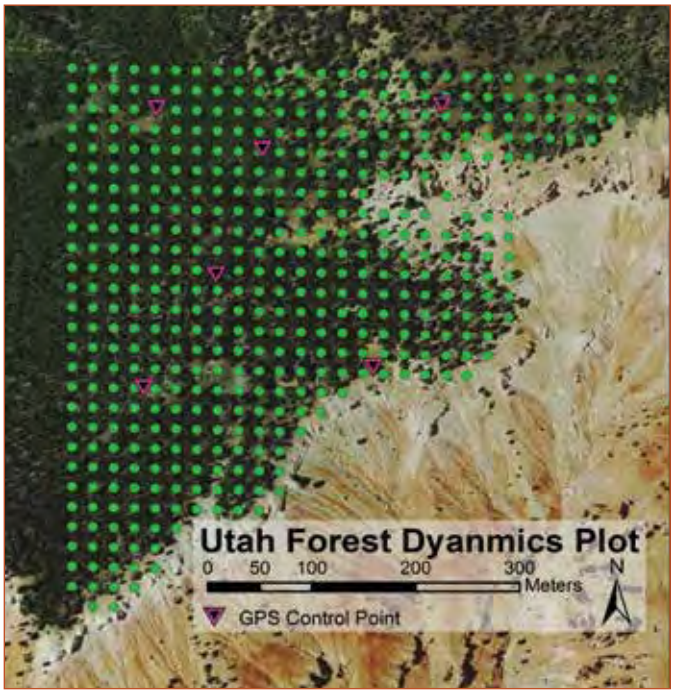

Grid points and GPS control prepared by Tucker Furniss.

Utah Forest Dynamics Plot

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2015

After (most of) the snow had melted, the crew regrouped in June 2015 for a final wave of surveying. Lutz provided the personnel needed to fill out two three-person survey crews. Knox and Busby were joined again by Furniss, Blomdahl, and Becker, and newcomer Sara Germain, an undergraduate student at Utah State, was occasionally able to break away from her botanical duties to assist with the surveying. Our goal was to set grid corners within an area that had recently been added to the plot. The Busby crew began by running a long circuitous traverse around the perimeter, adjacent to the drop off. The Knox crew cut across the center of the area, through the dense forest, and tied into Busby's traverse in three locations. Some loops closed as tight as 0.015 meters before adjustment. Grid corners were set as the traverses progressed, at an average of 15 points per crew per day. Slow going by urban survey standards, but collectively we were quite satisfied with the progress. Considerable time was spent mentoring the four crew members, as they will be called upon to complete the survey later in 2015. All learned quickly and participated enthusiastically, taking turns running the total stations and the layout rods, setting sights, and pounding rebar. The ultimate size and shape of the plot will be determined by the progress of the tree taggers - additional cells will be surveyed as needed just ahead of tagging crews, right up until snowfall once again calls the game.

At the conclusion of this season's efforts, all survey data from 2015 will be adjusted in Star*net, holding positions from the 2014 adjustment as fixed.

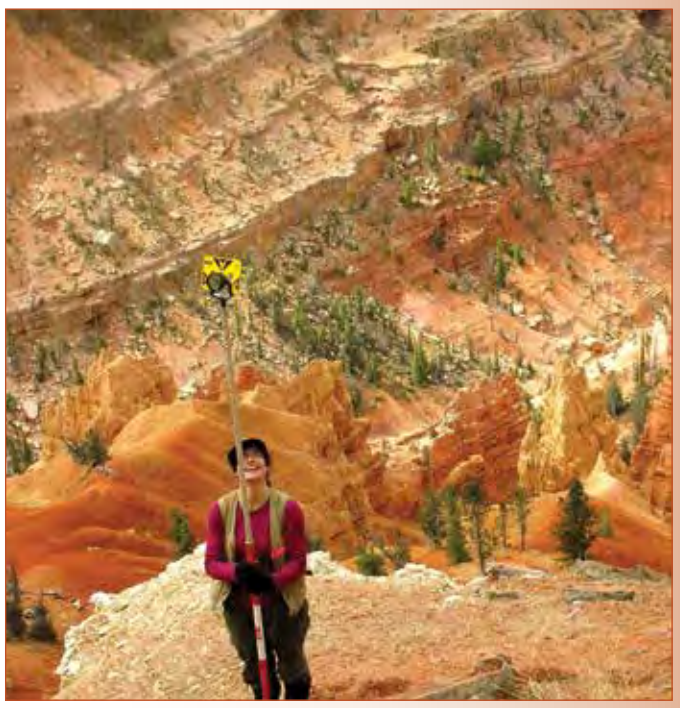
The following field equipment was used for this project:

- **Leica GS15 GNSS receivers (2)**
- **Topcon Hiper SR GNSS receivers (2)**
- **Topcon OS105 total station (with Magnet running on-board)**
- **Topcon GTS312 total station with Topcon FC2600 Field Controller (also running Magnet)**

All in all, it was another fantastic experience - great friendships and lifelong memories were forged. Despite the challenges brought about by inclement weather and steep terrain and by the complexity of the task, we (nearly) never stopped smiling. Not during the wild thunderstorms and close lightning strikes. Not during frequent pelting delivered by hailstones. Not after crawling out of damp tents to see the entire campsite covered with a sheet of ice. Not on that long uphill march at the end of each day. And only sometimes, while getting our near-daily rain soaking and slopping our way through the muddy forest, or while eating dinner while huddled under a tarp in muddy work clothes and full rain gear. Perhaps Dr. Lutz will surprise us by establishing yet another big-tree plot, but topping the UFDP experience ... doubtful.

For more information about the UFDP, YFDP, and WFDP on the web, visit ufdp.org, yfdp.org, and wfdp.org or follow the work on Facebook: "Utah Forest Dynamics Plot", "Yosemite Forest Dynamics Plot", and "Wind River Forest Dynamics Plot". ❖

Erika Blomdahl (Photo by Patrick Busby)



Kendall Becker (Photo by Patrick Busby)

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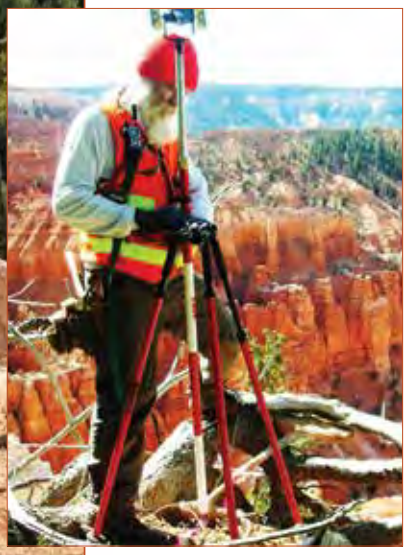
Jim Lutz and Sara Germain
(Photo by Erika Blomdahl)



Patrick Busby

Sara Germain, Kendall Becker, John Knox,
Tucker Furniss, Erika Blomdahl