Sierra Nevada Adaptive Management Project Spatial Team Lidar Workshops Notes
Oakhurst, CA June 3rd and Foresthill June 4th, 2009, 9:00 to 12:30 pm

In Attendance:
Both locations:
Celia Garcia Feced – UC Berkeley
Shasta Ferranto - UCST
Marek Jakubowski - UCST
Maggi Kelly - UCST
Alessandro Montaghi - UC Berkeley

Oakhurst:
Matt Brooks - USGS
Bill Dodge –Calvin Crest Outdoor Ed School
Karen Folger – National Park Service Sequoia/Kings Canyon
Jim Garner – USFS PSW
Jeannie Habben –Central Sierra WS Council
Anne Lombardo - UCST
Theresa Lowe - USFS
J. Matchett - USGS
Adele Marks – local resident
Reid Marks – local resident
Jere Miller – CalFire
Peggy Moore - USGS
Sara Morrison – CDF&G
Brenda Negley – Local resident
Maxwell Norton- UCCE Mariposa
Kristine O'Neal – Table Mountain Rancheria
Steve Ostoja - USGS
Anae Otto - USFS Sierra NF
Jared Paul – USFS
Kathryn Purcell – USFS PSW
Susan Roberts - USGS
Judith Redtomahawk – Table Mountain Rancheria
Mary Sanchez – Table Mountain Rancheria
Mark Smith –USFS Sierra NF
Heather Taylor - USFS
Craig Thompson – USFS PSW
Trudy Tucker - USFS
Kevin Williams – USFS Sierra NF

Foresthill:
Chris Ball - CDFG
Ryan Bellanca - Placer County RCD
Vince Berigan - UCST
Tim Biddinger – USFS Tahoe NF
Janet Brewster – California Tahoe Conservancy
Sue Britting – Sierra Forest Legacy
Mike Brenner - NRCS
Mike Chapel – USFS Region 5
Marie Davis – Placer County Water Agency
Rich Gresham – Placer RCD
Tyler Harkness – Foresthill Fire
Ann Huber - UCST
Zach Hymanson –Tahoe Science Consortium
Kim Ingram - UCST
Marilyn Jasper - Sierra Club
Susie Kocher - UCST
Jonathon Long – USFS PSW Tiffany Meyer
Larry Peabody – USFS Tahoe NF
Richard Rypinski - public
Tony Rodarte – USFS Tahoe NF
Shane Romsos – Tahoe Regional Plan. Agency
Gary Roller – UCST
Nicole Shaw - Tahoe Regional Plan. Agency
Doug Temple - UCST
Sheila Whitmore - UCST
Otis Wollan - American River Watershed Institute

I. Introduction: After introductions by the groups, Maggi Kelly gave an overview of the Sierra Nevada Adaptive Management Project (SNAMP) and how SNAMP is relying on Maggi and her spatial data team to integrate with the other science teams that are part of the project. The goal of the workshop was to inform stakeholders about SNAMP spatial team research using lidar. The Spatial Team was developed to assist in the GIS and remote sensing information that all the SNAMP science teams require. They conduct applied research in the application of spatial technology to forest science and management including lidar data acquisition and analysis and field verification.

II. Lidar Overview: Maggi gave an overview of the fundamentals of Light Detection and Range (Lidar) technology. Some advantages of lidar is that large and very accurate data sets can be collected quickly and economically, in many conditions including at night, when cloudy, and during all seasons. Disadvantages are that it cannot sense through rain, thick clouds, haze, wind (dust), or smoke and it is limited in thick forest or dense vegetation. It requires large data files and small project areas not economical. It can be collected from airplanes or the ground. Products include a

- Digital Elevation Model (DEM) - elevation points over a contiguous area
- Digital Terrain Model (DTM) - elevation information about the bare earth surface without the influence of vegetation or man-made features
- Digital Surface Model (DSM) - elevation information about all features in the landscape, including vegetation, buildings and other structures
- Canopy Height Model (CHM) - height information about vegetation features with elevation removed

Lidar data can be used to characterize vegetation by analyzing the canopy height model and the height profile through the full range of lidar returns. Only a few application areas have been rigorously evaluated, and many other applications are feasible. Developments in Lidar remote sensing are occurring so rapidly that it is difficult to predict which applications will be dominant in five years. Currently ecological applications of Lidar remote sensing include ground topography, 3D structure and function of vegetation canopies, and forest stand structure attributes.

Question: What is the difference between a DEM and a DTM?
Answer: These are the same thing basically.

Question: What are the scan angle limits?
Answer: 20 – 25 degree limits

Question: How does the density of vegetation affect the number of returns? Is there a problem with underestimation of returns, with second and third returns with obstructions?
Answer: Yes, the denser the canopy, the harder it is to get through, but you do get multiple hits.

Question: What is the accuracy at the edges of the Lidar data collection swath? Is it less accurate than at the interior?
Answer: Yes, but this corresponds to only a few centimeters of error.

Question: What is the difference between ground- and airborne- lidar?
Answer: Ground and airborne lidar use similar technology. Airborne lidar systems are mounted on an aircraft and include with the Lidar emitter and receiver, a GPS, an inertial measurement unit, and a computer. Ground-based systems are mounted on a tripod, and instead of scanning along a flight path, they scan in a "doughnut" around the stationary tripod. Airborne lidar can capture moderately detailed data covering 100s of km2. Ground lidar captures extremely detailed information about a few trees, or a forest stand. The tripod and system can be moved through the forest, but this process can be slow.

Question: Could you stitch together ground and aerial lidar?
Answer: This can be done, but with some difficulty. It is important to note that in general, ground-based lidar does not cover the same amount of area as aerial lidar.

Question: What type of lidar instrument is the SNAMP project using? What is the vertical resolution?
Answer: We are using a "discrete return" lidar instrument, that gives us four returns per pulse. The time it takes a pulse to travel to a target and back is converted to a “range” or height measurement. SNAMP data was 7 centimeters. It is typically 5-10 centimeters.

Question: How do you measure posting density?
Answer: This is calculated as part of the final product. It is not collected from each flight line.

Question: How far can a Lidar pulse penetrate a dense forest canopy? When you have only four returns, how do you know it’s reached the litter on the forest floor?
Answer: In dense canopy you cannot be sure your last return is a “ground” return. However, there are two factors that help us derive a model of the ground in dense canopy forests from airborne lidar data. First, because each tree (and each patch of ground) is “sensed” by the lidar multiple times, and from multiple angles, often there will be a path through the forest to the forest floor. Second, we often use ground data from areas with less dense canopy and interpolate the ground through areas of dense canopy.

Question: What kind of light do lidar instruments use? Has there been any study on the electromagnetic study at the hitpoint. i.e., the impact on tree health or human health?
Answer: Most terrestrial lidar applications (those mapping buildings, topography and vegetation) use laser light, in the near infrared portion of the electromagnetic spectrum. The laser’s maximum power is limited so that they are safe to the human eye. Impacts to plants and animals are considered to be negligible.

At the break, the spatial team demonstrated the Lidar data on laptops around the room.

III. How Lidar is being used in SNAMP: Dr. Maggi Kelley gave an overview of how each SNAMP science team will use Lidar data as inputs for their models. Though collecting lidar data can seem expensive, it will be critical to the success of each team, and integrating the teams together, and so the success of the entire project.

Lidar data has already been collected on the two SNAMP study sites through a contract with the National Center for Airborne Laser Mapping (NCALM). Lidar was flown for the Sugar Pine project (117 square kilometers) in September 2007 from an altitude of about 700 meters yielding 6 data points per square meter. Data was collected at Last Chance Area (107 square kilometers) in September 2008 leading to 9 data points per square meter. Both used a "discrete return" instrument, that yields 4 returns per pulse.

Field data collected at the Sugar Pine area used the forest inventory plots established by the SNAMP forest team. Spatial team members surveyed 1,950 trees in these circular plots that are 0.05 hectares in size, and 500 meters apart. They located each tree and center with a laser range finder from at least 2 vantage points. They will be using these data to produce data on elevation (DEM), canopy cover & closure, tree height, canopy bulk density, canopy fuel, canopy base height, and leaf area index. This data will be used by SNAMP science teams including the water team, forest team and wildlife teams to run models.

Question: Can soil type be gotten from lidar? How will the water team collect this?
Answer: No, soil type cannot be gotten from lidar. The water team will be collecting soil samples for their work.

Question: Can Lidar be used to identify different tree species?
Answer: Not yet, but there is great potential when you combine lidar, aerial photos, and intensity to identify species. The detailed elevation returns from a lidar instrument can give us information about the shape of a tree, or the structure, but will not alone give us definitive information on species. When lidar data is combined with multi-spectral or hyper-spectral imagery, species discrimination is possible.

Question: Can lidar data be used to measure parameters of individual trees, like diameter at breast height (DBH)?
Answer: Lidar measures some variables directly, like tree height, and others are inferred. DBH is not measured directly, but a relationship between tree height and tree DBH can be used to "model" DBH across the landscape from Lidar data.

Question: Doesn't the diameter to height relationship of a tree depend on the tree species?
Answer: Yes, that's why the spatial team needs information about tree species from the field verification. Marek Jakubowski, a graduate student on the team, is working on this as part of his dissertation.

Question: Will lidar pick up big snags?
Answer: This is a difficult task, and there are very few papers that claim to be able to operationally identify snags with multiple-return lidar data. It depends on whether the snag gets a lidar hit. With 9 hits per square meter, it's definitely possible but is more likely with ground-

based lidar. Field data of snags will be needed to test whether they are being picked up. The spatial and owl team can work together to do this field verification.

Question: Does the computer actually detect the crowns and within the crown look for points? What is the accuracy then for measuring crowns?
Answer: No, the algorithm doesn't find crowns. The search engine finds local maxima which are usually crowns. This technology is not perfect for that. It will miss some and overestimate some.

Question: Will you be ground-truthing the data?
Answer: Yes, we have already collected data in the Sugar Pine site. The forest team is also sharing data they have taken, which includes measured heights of trees.

Question: Will you develop the algorithms in the future to analyze this data?
Answer: Yes, that is why ground-truthing is being done now.

Question: Will you be looking at shrubs at all?
Answer: Possibly. The team has not started the analysis yet, but it's definitely on the table. They really want to analyze this data for everything that it can yield.

Question: Is it possible to quantify ground fuels using lidar?
Answer: Airborne lidar has been used to map forest canopy fuels, but not to measure ground fuels. These kinds of measurements will likely require ground based lidar.

Question: Is it the data analysis or the collection of lidar data that is expensive? What is the budget needed to do a lidar purchase?
Answer: It's really both that are expensive. The cost of lidar includes acquisition, field data collection, and processing, which includes software and hardware as well as personnel. These can add up. Most comparisons of lidar versus field alone concentrate on the technical advantages of lidar. One exception is Renslow et al. (2000) who claim that for a typical even-aged, managed forest of 500,000 acres where in each year, 2% of 10,000 acres (200 acres) are sampled to determine what management steps are needed, cost savings with lidar would be $15,400 annually. I think this is overly optimistic, as it only includes 2 weeks for analysis. Our SNAMP analysis (albeit over a much larger area) takes considerably longer.

IV. Other Imagery: Dr. Maggi Kelly described how the uses and coverages of lidar are expanding rapidly and said that a national scale program is really needed. There is a USGS committee meeting to try to increase the availability and use of lidar data. She also reviewed the other types of data currently available besides lidar (see PowerPoint presentation at http://snamp.cnr.berkeley.edu/events/. This includes:

- National Agricultural Imagery Program (NAIP) which is one meter resolution imagery acquired during the agricultural growing season
- Landsat data (now Landsat 7) with data at 30 to 60 meter resolution
- Aerial photography, including mosaics and frames, and digital orthoquads
- One meter Digital Orthoimagery Quarter Quadrangles (DOQQ) NAIP (1m)

Much of this is free and can be downloaded through the USGS Seamless Data Server at http://seamless.usgs.gov/index.php. An affordable alternative to Lidar data is NEXTMap. It includes high resolution digital geometries and imagery data, digital elevation models with 5 to 25 meter resolution, 1 meter and orthorectified radar images.

Maggie also reviewed the data sharing being done by SNAMP. The project has set up a data sharing website at http://snamp.ucmerced.edu. SNAMP is making spatial and non spatial data public whenever possible unless there are compelling reasons not to. Some exceptions are when:

- the disclosure of the location of people or rare species might put them at risk;
- the data is not complete;
- there are publications in progress that might be at risk from early data distribution;
- the data has proprietary restrictions originating outside of the project.

V. Next steps: At the end of the workshop, announcements about upcoming events were made:

- July 11th - Spotted Owl team research methods field trip near Foresthill
- July 15th - Pacific Fisher team integration team meeting near Davis
- Last week in August - Water team field trip in Oakhurst
- September 1st - Water team field trip near Foresthill
- October 20th - SNAMP annual meeting, Sacramento