United States Department of Agriculture
Forest Service

PNW
Pacific Northwest
Research Station

Science FINDINGS

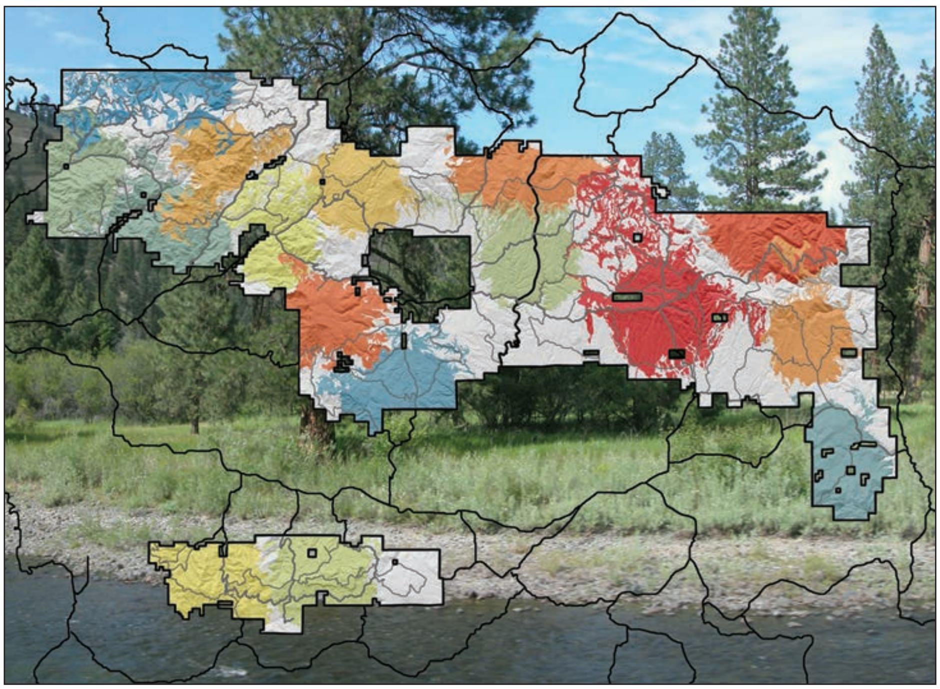
INSIDE

issue one hundred fifty nine / march 2014

"Science affects the way we think together."

Lewis Thomas

Accelerated Restoration: New Landscape Tools to Prioritize Projects and Analyze Tradeoffs



Frank Vanni

The Landscape Treatment Designer can be used to explore landscape treatment designs and perform tradeoff analyses concerning different management objectives.

IN SUMMARY

The catastrophic fires and tragic losses during the 2013 fire season have resulted in many discussions about fire management policies aimed at protecting communities and restoring fire-resilient forests from the growing incidence of severe wildfires.

Forest Service scientist Alan Ager has been exploring how concepts in spatial ecology and operations research can be used to better prioritize fuel management and restoration projects and design landscape fuel treatment strategies. This work has yielded a new model and software program called the Landscape Treatment Designer (LTD) and a case study of its application on a fire-prone, dry-forest landscape within the Deschutes National Forest. In this specific study, Ager used the LTD to test a new prioritization scheme in which treatments were used to build "low-hazard fire containers" that optimize the future use of prescribed and natural fire to maintain long-term fire resiliency in dry forests.

The program has since been used to explore prioritization strategies at a range of scales, from Forest Service ranger districts to multi-state regions. LTD allows planners to quickly test different strategies in terms of management priorities, tolerance of fire risk or loss, implementation time frames, and budget constraints. The analyses can reveal tradeoffs associated with particular management decisions.

"The key is not to prioritize what's on your schedule, but to schedule your priorities."

~Stephen Covey

"Conservation is the foresighted utilization, preservation or renewal of forests, waters, lands and minerals, for the greatest good of the greatest number for the longest time." This is the heralded quote of the U.S. Forest Service's founding father and first chief, Gifford Pinchot. It captures the agency's recognition of the multiple uses and sometimes competing interests in the resources it oversees.

But the quote also suggests an element of hierarchy or prioritization in identifying, and then implementing, management activities that generate ecosystem services for the public. In these times of growing demands for ecosystem services—coupled with such threats as climate change, wildfire, and insect outbreaks—the models and concepts for prioritizing management investments deserve a closer look, says one Forest Service scientist.

"We can't optimize the greatest good for the greatest number, either in theory or practice, so federal land managers make choices and prioritize specific mixes of ecosystem services," says Alan Ager, an operations research analyst at the Western Wildland Environmental Threat Assessment Center (WWETAC).”

Ager describes his job with the Forest Service as working on the interface of landscape planners, fire scientists, and ecologists. He has been using tools in the field of operations research, including statistical modeling and spatial optimization, to better understand the on-the-ground implications of policies and management priorities.

“When the agency calls for new programs, like the current accelerated restoration efforts, I look for new ways to apply operations research to understand ways these programs can be better accomplished,” Ager says. “My hypothesis is that, at a minimum, we could better understand the tradeoffs we are making with existing prioritization of budgets, and perhaps even improve prioritization with respect to managing threats, especially losses from large wildfires.”

KEY FINDINGS

- Prior studies on spatial prioritization of fuel management have focused on optimizing the arrangement of treatments to disrupt fire spread and protect areas from burning. Landscape Treatment Designer can be used to optimize use of prescribed and natural fire to help create and maintain fire resiliency across the landscape.
- Application of the Landscape Treatment Designer model on a 605,000-acre dry-forest landscape in eastern Oregon revealed tradeoffs in terms of the size and location of projects, and an optimal treatment intensity to protect old-growth ponderosa pine from potential wildfire loss.
- The study resulted in a broader framework of spatial fuel management strategies and a discussion of their respective merits from both an ecological and fire management perspective.

TECHNOLOGY CATCHES UP TO THEORY

Much of Ager’s work is rooted in landscape planning and in spatial optimization, the concept that the ordering of things or activities in a specific location along a certain time frame can produce an optimal result. Such thinking first appeared in academic circles in 1939 under the tutelage of a German geographer named Carl Troll. The science continued to evolve when, by the 1980s, it also factored in human impacts on landscape structures and functions.

“Spatial optimization, as a concept, has been around for more than 30 years,” he says. “The concepts have been applied to a wide range of problems, including designing wildlife habitat reserves, locating fuel breaks, and scheduling management activities.”

However, the tools and approaches were too complex for practical application, especially at the scale of a national forest. The models required computing power beyond what was available in the agency. Thus, there was no way to experiment with different configurations of treatments on large landscapes, or to look at how changing management priorities affected the results of different projects.

“We didn’t have the technology to analyze the basic problem at the scale of a national forest. Where should the next project be located, how big should it be, and what are the tradeoffs versus implementing the project elsewhere?” Ager says. “While we do tradeoff analysis among NEPA alternatives as part of project planning, that’s after the project area has been chosen.”

Purpose of PNW Science Findings

To provide scientific information to people who make and influence decisions about managing land.

PNW Science Findings is published monthly by:

Pacific Northwest Research Station
USDA Forest Service
P.O. Box 3890
Portland, Oregon 97208

Send new subscriptions and change of address information to:

pnw_pnwpubs@fs.fed.us

Rhonda Mazza, editor; rmazza@fs.fed.us

Cheryl Jennings, layout; cjennings@fs.fed.us

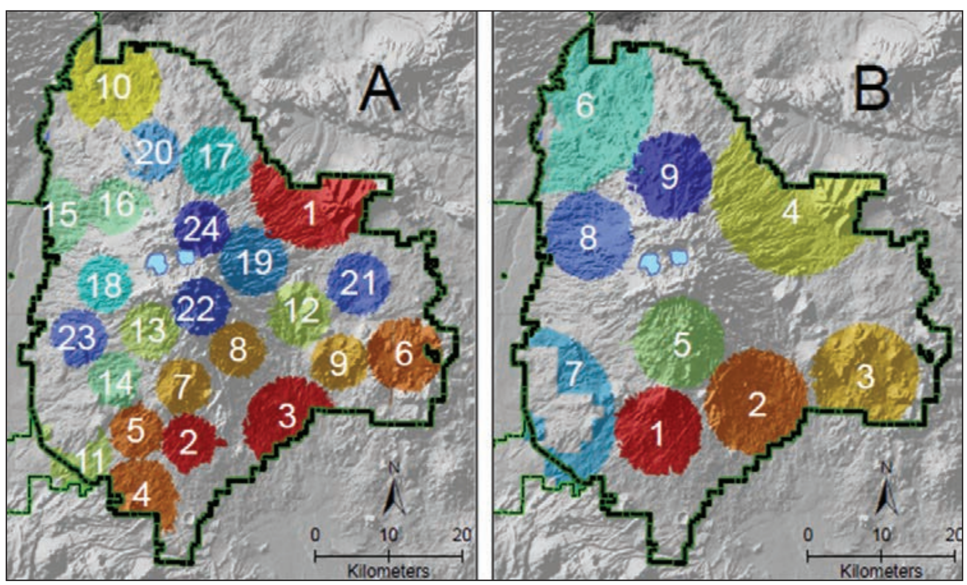
Science Findings is online at: http://www.fs.fed.us/pnw/publications/scifi.shtml

To receive this publication electronically, change your delivery preference here:

http://www.fs.fed.us/pnw/publications/subscription.shmtl

USDA United States Department of Agriculture

Forest Service



The maps above show a possible long-term plan for restoration based on density of treatments within the numbered project areas and amount of available funding. The two scenarios identify the optimal location for project areas designed to protect old-growth ponderosa pine from wildfire. Scenario A prioritized project areas based on funding to treat 7,400 acres within a project area; scenario B prioritized project areas based on funding to treat 17,000 acres within a project area. The simulation shows that priorities change based on the scale of investment per project. The Landscape Treatment Designer enables forest planners to quickly explore alternative strategies with respect to budget and restoration priorities in ways not previously possible.

"It's complex to work on million-acre landscapes and consider the arrangement and location of projects and treatment areas at the same time," Ager says. "The technology wasn't there, yet, to support the science."

With a backlog of areas in need of restoration, combined with limited budgets, Ager suspected that streamlined methods could be developed to prioritize restoration to better achieve long-term goals. Further, he believed the agency should have the ability to quantify how management decisions affected overall ecosystem services when it prioritized investments at the forest, district, and project scales.

"I didn't think that capability existed with the current tools used by the agency," he says.

The work on spatial optimization started about 10 years ago when Ager observed that the science for optimizing fuel treatments was not entirely compatible with dry-forest restoration.

"There were a dozen publications on optimizing fuel management that all used the same premise that we should strategically locate fuel treatments to impede the spread of fire," he says. "However, the stated goal of dry-forest restoration was to reintroduce fire, not exclude it."

Ager sketched out a concept of optimizing treatments to build "low-hazard fire containers" that in the long run maximized the potential for using wild and prescribed fire to maintain fire resiliency in old-growth pine forests. The program later evolved into a larger planning system that could essentially dissect landscapes to understand spatial patterns in management opportunities and constraints, and then optimize the location of project areas based on land management objectives.

A turning point was when Ager teamed up with Stu Brittain, a programmer in Missoula, Montana, who develops high-performance wildfire simulation models for the Forest Service. Brittain re-engineered Ager's original code to take advantage of newer computers with multiple processors. The result was a program that could handle complicated spatial problems on million-acre landscapes that would have been almost impossible to solve even a few years earlier.

"I'm hoping to re-energize the agency's thinking about how we prioritize work and how projects relate to one another in the long run," Ager says. "The whole idea is to understand tradeoffs in the decisionmaking, which is a pretty standard practice in any management system."

ACTIONS, CONSEQUENCES, AND UNDERSTANDING

"One of the questions I think is important to answer is: What are the opportunity costs of all the compromises we make when we design restoration projects in terms of achieving long-term restoration objectives?" Ager says. "You can't optimize everything, so it's important to know the potential production of ecosystem services." Ager describes the existing prioritization methods within public land agencies as ad hoc systems that can't look at optimizing tradeoffs.

"The net result is that we don't understand the opportunity cost associated with specific restoration investment decisions," he says.

Ager designed the Landscape Treatment Designer (LTD) program using standard operations research methods. The program uses a framework of decisionmaking based on goals, constraints, and management thresholds, similar to other optimization systems used in operations research.

Then Ager built a number of features into the program to help understand tradeoffs and analyze how the production of ecosystem services can be spatially optimized under different assumptions.

One feature helps users quantify how a particular management priority or treatment design may affect other ecosystem services by working iteratively through multiple management scenarios. This sensitivity analysis lets users understand how changing the constraints and management thresholds affects the attainment of the stated goals.

"The program doesn't provide a single answer," Ager says. "It shows the tradeoffs and alternative solutions. But with that information, I think you can better understand the context for specific decisions."

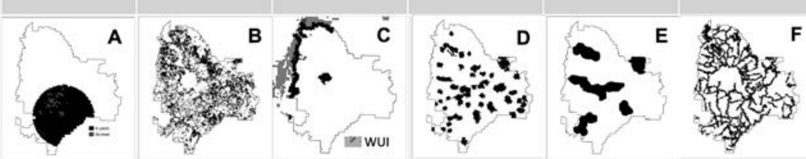
Another way to use the program is to iteratively partition a forest or district into a series of project areas, each one representing the optimum given the previous one having been implemented.

"This is a quick way to see if the landscape is a level playing field or if there is sufficient variation at the project scale to worry about prioritization," Ager says. "In each iteration, the same scenario is used to find the optimal project area, generating the first, second, third, fourth best, and so on until the entire landscape is prioritized."

Goals could be reducing wildfire risk, maintaining habitat diversity, improving watershed condition, or producing wood fiber. By contrast, constraints are absolute requirements that must be met for a particular planning problem.

Examples of constraints include the annual fuels management budget on a forest, funding for specific habitat improvement, or the total workload capacity to perform a project. Administrative constraints could be forest plan standards, forest plan land allocations, and protection of trees of a certain size or diameter.

	Spatial Strategies for Fuel Management					
	Restoration of low severity fire regime in dry forests	**Broad landscape protection**	**Localized protection**	**Protection of dispersed values**	**Restoration on mixed severity fire regimes**	**Strategic containment**
Spatial pattern of values	High density, dispersed	Low density, dispersed	Variable density, clumpy	Clumpy	Any	Low or none
Landscape goal	Low hazard fire containers	Disrupt spread, facilitate containment	Localized defensible fuel breaks	Dispersed defensible fuel breaks	Restoration of dispersed natural fire barriers	Contain large fires at defensible locations
Performance measure	Area burned by prescribed and natural fire	Reduction in landscape burn probability	Local reduction in exposure near values at risk	Reduced exposure to fire	Landscape reduction in hazard and burn probability	Area burned by natural fire
Treatment goal	Reduce fire severity	Reduce fire spread rate	Facilitate suppression	Facilitate suppression	Reduce fire spread rate	Facilitate suppression
Example map	A	B	C	D	E	F



The Landscape Treatment Designer program makes it possible to quickly design different landscape fuel treatment strategies for specific fire management goals.

Finally, management thresholds describe conditions where a prior decision requires an action to be performed if a certain condition is met. For instance, management actions are required for a given parcel of land if a specific fire behavior (such as flames reaching tree tops) is predicted, a stream temperature threshold is exceeded, or road density exceeds some standard.

The program allows for multiple objectives that can be blended with different levels of prioritization or emphasis to build hybrid scenarios that allocate investments to multiple values of interest.

“You can set up problems, for example, to vary the emphasis among multiple objectives such as fiber production, wildfire hazard reduction, wildlife habitat, and aquatics, and then find optimal project areas and treatment units given each particular combination of emphases,” Ager says. “By varying the objectives and constraints, the program reveals the production frontiers.”

Gil Dustin, BLM

Field (left) and laboratory studies have helped managers understand how to arrange fuel treatments to slow the spread of wildfire. However, arranging treatments to help restore fire requires a different landscape strategy.

Ager used this approach in previous work to examine the effectiveness of fuel treatments around the urban interface versus in the surrounding landscape to understand competing management goals for protecting private property versus landscape restoration.

TEST RUN ON A LARGE SCALE

Ager first took the LTD program to Dave Owens, a fuel planner on the Ochoco National Forest in central Oregon.

“Dave explained to me that they wanted a forest-wide prioritization map of project areas to develop a 5-year action plan,” Ager says.

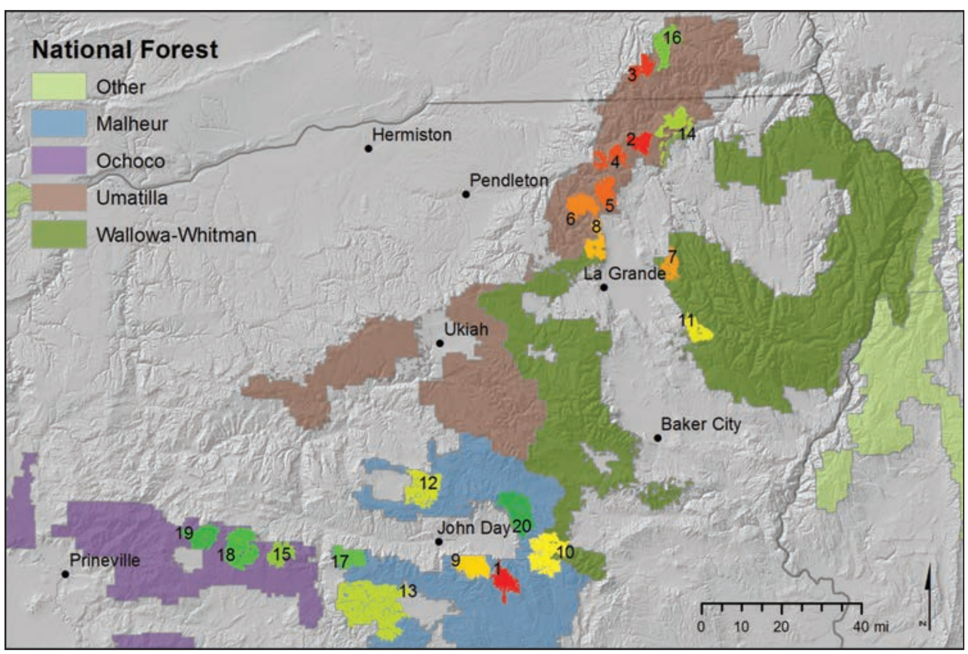
Owens gave Ager a set of restoration objectives and a digital map file of the trees and vegetation on the forest. Ager entered the objectives into the LTD and generated a map of project areas and a priority sequence of about 20 project areas and stands to treat that covered the entire forest.

Owens, using some GIS queries—or selection criteria—had a general idea of where the highest priority project area might be located, but had no way to partition the entire forest and look at the relative merits of different project areas. In the end, the highest priority area matched, the difference being Ager had a complete sequence and could look at how optimal the best project was. Moreover, he could change the priorities and rerun the problem in a few seconds.

In a subsequent study, Ager used the LTD on the Deschutes National Forest in central Oregon, where planners have been implementing dry-forest restoration projects on the Bend-Fort Rock Ranger District to help reintroduce low-intensity managed and prescribed fire. It is the same scenario being played out across much of the western United States within the dry-forest ecosystem.

“I wanted to compare how the district prioritized projects relative to an optimal solution suggested by LTD,” Ager says. “I also was hoping to find some patterns that could be extrapolated to hundreds of other planners doing the same kind of work.”

The problem was clear: On a fixed restoration budget and a backlog of areas to restore, where does a forest or ranger district invest the least amount of money and protect the most ecological value (e.g., old-growth pines) such that when the project is completed, land management planners can walk away and not worry about wildfire impacts on ecological values? The objective was to use fuel treatments to create what Ager calls “low-hazard fire containers” that maximize the protection of old-growth ponderosa pine from wildfire losses and sets the stage for reintroducing fire.



Output from the Landscape Treatment Designer for a portion of the Blue Mountains national forests showing the top 20 project areas optimized to reduce wildfire exposure while simultaneously meeting minimum thinning volume targets. In this simulation, each project area was about 12,000 acres.

Under these goals, the model located optimal project areas for restoration and identified treatment areas within them. The LTD program also provided observations regarding many tradeoffs between fire intensity, treatment intensity, and tree mortality.

Treating at high density (e.g., 80 percent of stands) shrunk the overall project area, leaving old-growth trees outside of the treatment area vulnerable to fire. Meanwhile, treatments at a lower density of stands per treatment area (e.g., 20 percent) created larger project areas, but the old-growth trees within the project were more vulnerable to fire.

An interesting finding was the agreement between the optimal treatment density identified by the model and recent restoration projects on the Deschutes National Forest. To best protect old-growth ponderosa pine, the LTD indicated a treatment density of 35 percent, whereas actual treatment rates on recent projects in the forest averaged 34 percent.

"This kind of result helps describe restoration programs and shows good perception by the planning staff," Ager says. Although originally envisioned as a model to be used in wildfire management, Ager says the LTD's applications and range are growing.

"It's not just a fuels planning tool," he says. "We potentially can use this to optimize fiber production, habitat restoration, and for other resource management problems."

"We're experimenting with optimizing fuel management investments on all 82 western national forests—with declining budgets there is a lot of interest in optimization approaches. How much funding do we have? Where do we invest it? And what do we get back?"

But LTD provides more than a computer program, it's a conceptual framework for thinking about landscape planning and restoration—at multiple scales, Ager says.

"I hope this program and the case studies associated with it will stimulate some thinking about connecting the various scales that we can work into a more coherent framework," he says.

The LTD program, manual, and example data are publicly available and can be used on any desktop computer. Ager notes, though, that the program is complex and forces users to reduce their problems to a small set of key variables.

"It's not a kitchen sink approach to land management planning where you throw all the data in and mix it up and look for something good," he says.

Rather, it's the opposite, and users need to think about their specific problem before attempting simulations.

In terms of data, Ager notes that "federal land management agencies are awash in data; the problem now is figuring out how to bridge between data and decisionmaking, that is, build better decision-support systems"

"Action expresses priorities."

~Mahatma Gandhi

LAND MANAGEMENT IMPLICATIONS

- Meeting the long-term goals of dry-forest restoration will require dramatic increases in prescribed and managed fire that burn under conditions that pose minimal ecological and social risk. Optimization models can facilitate the attainment of these goals by prioritizing management activities and identifying investment tradeoffs.
- The work resulted in a relatively simple and fast optimization model that potentially has wider application to spatial planning problems in the Forest Service and other land management agencies.
- Land management planners and resource specialists can apply the model at a range of scales (e.g., districts, forests, regions) to analyze the tradeoffs among ecosystem services associated with different restoration strategies.

FOR FURTHER READING

For more information about Landscape Treatment Designer, or to download the program, visit: www.arcfuels.org/ltd.

Ager, A.A; Vaillant, N.M; McMahan, A. 2013. Restoration of fire in managed forests: a model to prioritize landscapes and analyze tradeoffs. Ecosphere. 4(2): 29.

Ager, A.A.; Vaillant, N.M.; Owens, D.E.; Brittain, S.; Hamann, J. 2012. Overview and example application of the Landscape Treatment Designer. Gen. Tech. Rep. PNW-GTR-859. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 11 p.

Tom Iraci

Decision support systems can help optimize treatment priorities so that existing fire-resilient stands are incorporated into larger low-hazard fire containers.

WRITER'S PROFILE

Paul Meznarich specializes in environmental communication. He is owner of Otter Creek Communications and can be reached at ottercreekcomm@gmail.com.

Science
FINDINGS

U.S. Department of Agriculture
Pacific Northwest Research Station
1220 SW Third Avenue
P.O. Box 3890
Portland, OR 97208-3890

Official Business
Penalty for Private Use, $300

PRSRT STD
US POSTAGE
PAID
PORTLAND OR
PERMIT N0 G-40

SCIENTIST PROFILE

ALAN AGER, with the Pacific Northwest Research Station, works for the Western Wildland Environmental Threat Assessment Center and is stationed on the Umatilla National Forest. He received his doctoral degree in forest genetics and bachelor's degrees in forest management and forest science at the University of Washington in Seattle. Dr. Ager has worked on a wide array of resource management issues in his 26 years with the U.S. Forest Service.

Ager can be reached at:

USDA Forest Service
Western Wildland Environmental
Threat Assessment Center
3160 NE 3rd St.
Prineville, OR 97754

Phone: (541) 416-6583
Email: aager@fs.fed.us

COLLABORATORS

Nicole Vaillant, Western Wildland Environmental Threat Assessment Center, Prineville, OR

Mark Finney, Rocky Mountain Research Station, Missoula, MT

Stu Brittain, Alturas Solutions, Missoula, MT

Jeff Hammond, Forest Informatics, Corvallis, OR

Michelle Day, Oregon State University, Corvallis, OR

Dave Owens, Deschutes National Forest, Prineville, OR

Bob Clements, Wallowa-Whitman National Forest, La Grande, OR

Drew McMahan, Softec Solutions, Fort Collins, CO

Haiganoush Preisler, Pacific Southwest Research Station, Albany, CA

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, 1400 Independence Avenue, SW, Washington, DC 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.