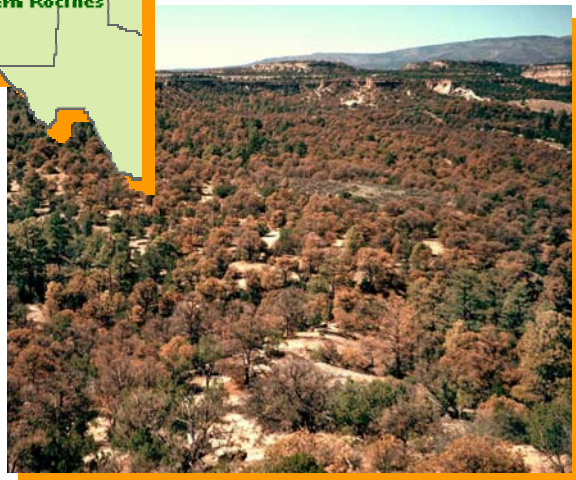
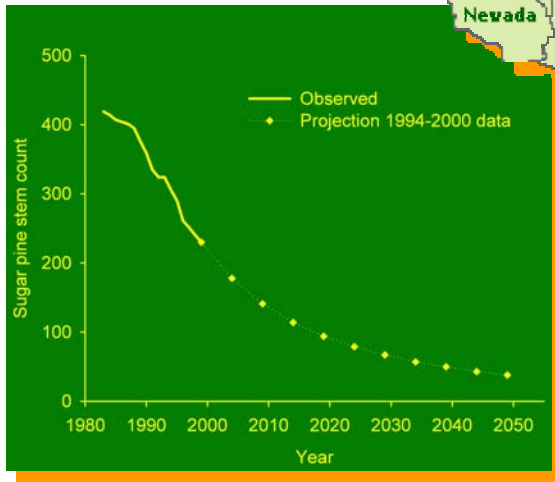
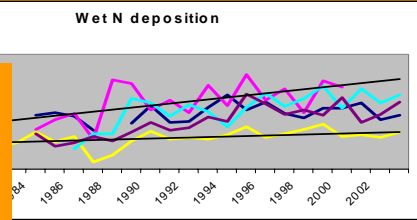
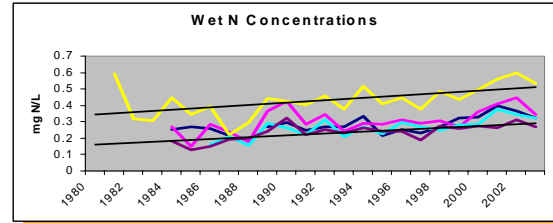
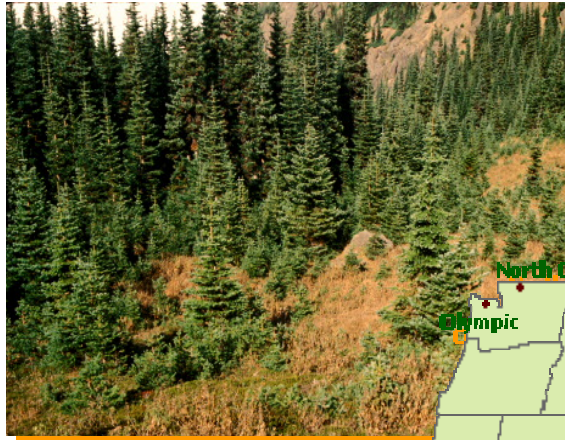




The Western Mountain Initiative

A Network of Mountain Protected Areas for Global Change Research
www.cfr.washington.edu/research.fme/wmi/

Program Report August 2005



About WMI

The objective of the Western Mountain Initiative (WMI) is to understand and predict the responses – emphasizing sensitivities, thresholds, resistance, and resilience – of Western mountain ecosystems to climatic variability and change.

The rate and magnitude of ecosystem responses to changes in the global atmospheric environment are variable and uncertain, ranging from gradual to abrupt, from moderate to profound. The least understood and least predictable responses are those of greatest importance to policy makers and land managers: responses that are both abrupt and profound. Recent examples of such responses include ongoing drought-induced forest mortality on millions of acres in New Mexico, Arizona, and southern California, and the increasingly large area burned by severe wildfires in the western United States during the past two decades. In both cases, ecosystem thresholds were exceeded relatively quickly, leading to large and often unexpected changes that will have long-term consequences for ecosystem structure, function, and production of goods and services.

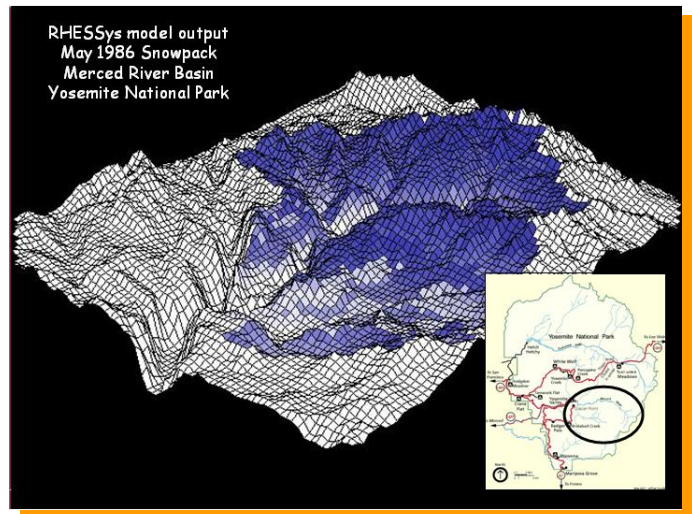
In the face of expected climatic change over the next several decades, are significant changes in ecosystem structure and processes likely to become more common? Are these changes predictable? What are the characteristics of ecosystems likely to respond quickly or gradually, profoundly or minimally? How will ecological and economic productivity be affected at various spatial and temporal scales?

Mountain ecosystems of the western United States are ideally suited to address these questions. First, they lend themselves to ecological inquiry because they have: 1) compressed climatic and biogeographic zones containing many ecosystems within relatively small areas; 2) rich paleoecological resources, which record past environmental changes and consequent ecosystem responses; and 3) common ecological drivers, such as snowpack, which facilitate comparisons across ecosystems. Second, because national parks and wilderness of the montane West have experienced minimal human disturbance, effects of environmental changes on ecosystems can be inferred with fewer confounding influences than on intensively managed lands. Third, Western mountain ecosystems are important to society, providing water, wood products, carbon sequestration, biodiversity, and recreational and spiritual opportunities. Finally, more than a decade of USGS research at seven Western mountain parks provides the foundation for broad syntheses of existing knowledge.



WMI Highlights in Ecosystem Research - August 2005

- ◆ Kickoff meeting in Seattle in February 2004 with all six WMI PIs. WMI hired Kelly O'Brian as coordinator.
- ◆ Work by WMI was prominently featured at the Mountain Climate Sciences Symposium in May 2004 at Lake Tahoe. WMI PIs and numerous collaborators met to discuss plans and expectations for the proposed 5-year course of work, noting emphasis on developing synthetic products.
- ◆ WMI PIs and key colleagues hold first annual site-specific meeting in September 2004, hosted by PI Craig Allen of USGS Jemez Mts. Field Station at Bandelier National Monument, focal point for the Southern Rocky Mountains node. Included one day field trip.
- ◆ Jill Baron hosted a RHESSys modeling training workshop in Fort Collins in fall 2004. RHESSys model calibration work begun at Yosemite NP, eventually will encompass all WMI core sites.
- ◆ Work by WMI was prominently featured at the Fall American Geophysical Union Meeting in December 2004 in San Francisco, including participation in a session sponsored by CIRMOUNT (Consortium for Integrated Climate Research on Western Mountains) on "Climate Challenges to Mountain Water Resources & Ecosystems".
- ◆ Work by WMI was prominently featured at the initial MTCLIM2005 meeting in March 2005 in Pray, MT, sponsored by CIRMOUNT and the Mountain Research Initiative (MRI).
- ◆ WMI PIs and key colleagues held second annual site-specific meeting in August 2005, hosted by PI Dan Fagre of the USGS at Glacier National Park, focal point for the Northern Rocky Mountains node. Included one day field trip.



Southern Rockies (American Southwest)

This region exhibits major effects of climatically induced stress, with extensive mortality in forest ecosystems subjected to prolonged drought. Dieback is most prominent in lower elevation and drier conifer forests, with mortality caused directly by insufficient soil moisture in combination with beetle outbreaks. Fuel accumulations throughout

Southwestern mountains have created the potential for large wildfires, which are also linked to ENSO cycles (fewer fires during wet El Niño, more fires during dry La Niña). Southwestern forests may be exhibiting some of the first signs of the effects of climatic change in arid Western forests. It remains to be seen whether conifer forests with extensive dieback will regenerate or will change to woodlands and shrublands.

Southern Rocky Mountains Science Highlights

- ◆ WMI continued to conduct research on ecosystem responses to recent drought in the Southwest, ranging from tree-growth patterns, runoff and erosion in woodlands, and documentation of extensive forest and woodland mortality. This work led to multiple invited presentations by Craig Allen on "massive forest dieback" at scientific meetings and extensive press coverage in 2004, including *Time* magazine, the *New York Times*, *High Country News*, and an AP wire report picked up by many newspapers.
- ◆ Other WMI work with collaborators continued on reconstructing fire histories from charcoal and tree-ring proxy records in the southern Rockies.
- ◆ WMI provided key support to implement a sediment core drilling project in 2004. The project extracted ~81m of largely laminated sediments from an ancient lake ca. 500,000 years B.P. from the Valles Caldera basin in north-central New Mexico (see figure). A collaborative effort, partners include USGS, Univ. of New Mexico, Los Alamos National Laboratory, NSF-funded DOSECC and LACCOR, and more than a dozen other colleagues from a variety of universities.
- ◆ Craig Allen was a co-author on an article published in the *Proceedings of the National Academy of Sciences* that addresses emerging ideas about spatial nonlinearities and cross-scale ecological interactions, with an associated symposium at the 2005 annual meeting of the Ecological Society of America.

Southern Rocky Mountains Management / Policy Highlight

- ◆ Information from long-term studies of erosion and restoration treatments in local pinyon-juniper woodlands was essential in supporting development of a NPS environmental impact statement on woodland restoration at Bandelier

A section of a sediment core, with varying types of lamination, which have the potential to provide unique paleoclimatic information for the Valles Caldera basin in north-central New Mexico from ca. 500,000 years ago.



National Monument.

Southern Rocky Mountains Integrative Highlights

- ◆ The Southwest node of WMI funded a workshop “Fire History and Climate Synthesis in Western North America”, held April 30 – May 4, 2005 in Flagstaff Arizona. This workshop assembled about 75 leading scientists who work with either/or tree-ring and sedimentary charcoal records of paleofire to discuss their most recent research findings and to develop collaborations, research synthesis products, and plan for future database development and investigations (<http://www4.nau.edu/firehistory/>).

Sierra Nevada

Mixed conifer forests in the Sierra Nevada have also experienced drought stress in recent years, with considerable mortality in some areas. These forests are particularly susceptible to large fires because of the additional effects of fire exclusion on stand density and fuel accumulation. Also, elevated tropospheric ozone reduces vigor and increases litterfall in ponderosa pine and Jeffrey pine. Finally, the exotic white pine blister rust has caused mortality of sugar pine and increased canopy and surface fuels. Paleoecological data suggest that a warmer climate may cause treeline to rise significantly at some locations.

Sierra Nevada Science Highlights

- ◆ In a global analysis motivated by research findings along a climatic gradient in the Sierra Nevada, Nate Stephenson and Phil van Mantgem demonstrated that forest turnover rates (mortality and recruitment) follow global and regional patterns of forest productivity. The results, published in *Ecology Letters*, have implications for understanding and predicting the effects of climatic changes on forest carbon storage and dynamics.
- ◆ Along with a National Park Service colleague, Phil van Mantgem, Nate Stephenson, and Jon Keeley published an article in *Ecological Applications* analyzing the ongoing decline of sugar pine in the Sierra Nevada. This majestic species has been suffering the effects of fire exclusion and an introduced pathogen – stresses that may be exacerbated by expected climatic changes.
- ◆ In December, Nate Stephenson was an invited speaker at the international FLUXNET Open Workshop in Florence, Italy, where he spoke on “Thinking like a plant: connecting biogeography to fluxes of energy and water.”

Sierra Nevada Management / Policy Highlights

- ◆ Nate Stephenson gave several invited presentations to National Park Service (NPS) and other natural areas managers at the national and regional level, focusing on the possible consequences of rapid environmental changes. Are ongoing

environmental changes of such a nature that NPS goals may evolve from restoring and maintaining naturally functioning ecosystems toward enhancing or maintaining ecosystems that are best able to resist and recover from stresses?

Sierra Nevada Integrative Highlight

- ◆ Phil van Mantgem and Nate Stephenson completed assembly of a large forest dynamics database aimed at elucidating climatic controls of forest dynamics in western mountains.

Pacific Northwest

During the past year, WMI PIs in the Pacific Northwest and their collaborators focused on associations between tree growth and climate, fire and climate in the historical and modern record, and potential responses of forest species composition to climatic change. Tree-growth responses to increasing temperatures and associated reductions in snowpack have been variable. At higher elevations, where regeneration is mostly limited by duration of snowpack, seedling establishment and growth rates have increased on all but the driest sites. At lower elevations and on drier sites, drought stress has limited growth rates and is expected to continue to do so as temperatures increase. Current evidence of stress is most noticeable on the east side of the Cascade Range, where semiarid forests dominated by ponderosa pine, especially those with high stem density as a result of fire suppression, have experienced unprecedented beetle outbreaks. Based on historical reconstructions and statistical models of 20th century fires, increased fire severity and area burned are expected across the Northwest in response to prolonged and more severe droughts in the 21st century. Forest landscapes across the region may become increasingly vulnerable to synergistic disturbances such as the combination of fires and insect outbreaks. We are currently beginning a simulation modeling experiment to examine future scenarios for ecosystem productivity, forest species succession, and changes in disturbance regimes on six representative watersheds.

PNW Science Highlights

- ◆ Models of growth-climate relationships for key montane and subalpine species: mountain hemlock, subalpine fir, Douglas-fir, lodgepole pine.
- ◆ Models of species distributions as function of climate for most Northwest conifer species.
- ◆ A regional-scale, replicated study of the response of montane Douglas-fir to climate.
- ◆ Fire-climate relationships from Holocene sedimentary records (charcoal), fire-scarred trees, and the modern record all point to drought and temperature as key controls on fire regimes at broad spatial scales. Based on these diverse records, we project substantial increases in fire severity and extent in the future.

PNW Management / Policy Highlight

- ◆ Large fire years are controlled by climate and only secondarily by fuel configurations, particularly in crown-fire ecosystems. We can therefore expect overall increases in fire disturbance over the next century even with increased attention to fuel management or effective fire suppression.

Northern Rocky Mountains

Similar to the Pacific Northwest, this region also is experiencing rapid establishment of subalpine forests in meadows. Although the location of altitudinal treeline has not changed in response to climate, there is currently a trend of more upright growth of trees from previous krummholz (shrubby) form. Tree regeneration and growth in this location are also strongly affected by the PDO, with growth and regeneration being high during warm phases the PDO (less snow) and low during cool phases (more snow). Crown fire has spread through a large portion of lower-elevation forests during the past decade.

Northern Rocky Mountains Science Highlights

Mean annual temperatures continue to increase, driven predominantly by increases in nighttime and winter minimum temperatures. Snowpack persistence has declined by two weeks during the past 50 years and spring meltout occurs earlier. Several glaciers have recently disappeared and the total number now stands at 27, a remnant of the 150 glaciers that previously existed. A glacier monitoring program has been established to document the expected demise of all glaciers by 2030. Paleoclimatic studies demonstrate that strong multidecadal patterns of winter snow water equivalent and summer drought explain cycles of glacial accumulation and ablation as well as widespread wildfire. Snow avalanche frequency also responds to multidecadal climatic variability but has more complex drivers. Understanding these drivers is critical to estimating the ecological role of snow avalanches and providing key management guidelines for mitigating damage to infrastructure such as railroads and highways in avalanche-prone mountains.

Northern Rocky Mountains Management/Policy Highlight

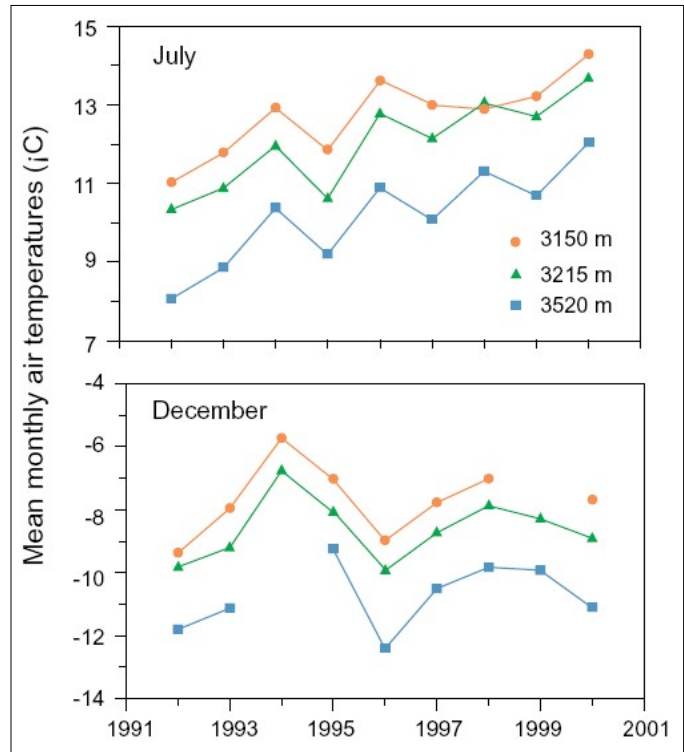
Multidecadal droughts have occurred regularly for the past 500 years and should be expected in the future. The impact of these droughts will be worsened by higher mean temperatures. Ecosystem services, such as water supplies, will be negatively impacted at a time when mountains are playing a greater role in regional water management plans.

Central Rocky Mountains

To date, climatic variability has had minimal effects on forests of this region, although some data suggest that upright growth of krummholz trees may be increasing near altitudinal treeline. As in other forests throughout the West, fire exclusion has increased stand density and fuel loading in lower elevation mixed conifer forests.

Central Rocky Mountains Scientific Highlights

- ♦ Summer mean temperatures are increasing. When coupled with drought, warming has initiated melting of permafrost and glacier ice, as evidenced by greater annual stream discharge than precipitation in recent years.
- ♦ Elevated nitrogen deposition at high altitude is already affecting aquatic systems, and has also altered subalpine forest microbial activity and soil and foliar nutrient ratios. Evidence that inputs of industrial and agriculturally-derived nitrogen to high elevations in the Colorado Front Range began 1950-1960 has come from paleo-interpretation of diatom assemblages in sediment cores. This has been augmented by new findings from pigment analyses of sediments showing concurrent increases in whole lake primary production. Statistical analyses of NO_x emissions since 1990 coupled with measured precipitation chemistry since 1983 suggest nitrogen deposition in 1950-60 was $1.5 \text{ kg N ha}^{-1} \text{ y}^{-1}$. This value can be interpreted as the critical load that triggered the onset of ecological change in high-elevation Rocky Mountain lakes.



Temperature trends from the Loch Vale weather station in Rocky Mountain National Park, from Clow et al. (2003).

- ♦ In nitrogen-limited forest plots soil CO_2 respiration decreases when N fertilizer is added, due to increasing carbon accrual by forest biomass. Nitrogen additions to nitrogen-saturated forests, on the other hand, appear to stimulate microbial breakdown of soil organic carbon; respiration increases, but only when there is adequate soil moisture.

Central Rocky Mountains Management Highlight

- ♦ The accumulated body of evidence from long-term ecological research and monitoring in Loch Vale Watershed, Rocky Mountain National Park has convinced national park managers, the State of Colorado, and the EPA to collaborate to develop a process for possibly reducing nitrogen emissions that have led to measurable change in terrestrial and aquatic high elevation ecosystems.

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- Allen, C. D. 2004. Ecohydrology and landscape change in northern New Mexico. University lecture at New Mexico Tech University, Socorro, NM.
- Allen, C. D. 2004. Ecological and landscape responses to severe drought. Western Governor's Association / USGS / International Boundary Commission meeting: Improving the application of science in Western drought management & planning. Phoenix, AZ.

- Allen, C. D. 2004. Ecological restoration: A case study from the Bandelier Wilderness, New Mexico. Presentation and led discussion for regional wilderness stewardship training course of 40 federal land managers, held by Arthur Carhart National Wilderness Training Center. Burns, OR.
- Allen, C. D. 2004. Massive forest dieback. Mountain Climate Sciences Symposium, Lake Tahoe, CA.
- Allen, C. D. 2004. Persistence, teamwork, serendipity, and ecosystem change: Long-term studies in the mountains of New Mexico. Utah State University, Logan, UT.
- Allen, C. D. 2004. Range-related research at the USGS Jemez Mountains Field Station. Talk and panel discussion to New Mexico Society for Range Management annual meeting. Albuquerque, NM.
- Allen, C. D. 2004. Restoring woodland ecosystems: Practical ideas from recent research on piñon-juniper woodlands. Workshop presented at The Quivira Coalition third annual conference. Albuquerque, NM.
- Allen, C. D. 2004. Sensitivity of southwestern US mountain ecosystems to climate variability: Interactions among forest dieback, fire, and erosion. American Geophysical Union fall meeting. San Francisco, CA.
- Allen, C. D. 2004. A thousand years of ecological change in the Southwest: Views from New Mexico mountains. Utah State University, Logan, UT.
- Allen, C. D. 2004. Vegetation change in the Rio Grande Basin. Keynote presentation to fourth annual meeting of NSF Science and Technology Center SAHRA (Sustainability of semi-Arid Hydrology and Riparian Areas). Albuquerque, NM.
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- Allen, C. D. 2005. Climate, insects, and regional-scale vegetation dieback in the southwestern U.S.: Historical perspectives and global change implications. seminar, University of Arizona, Tucson, AZ.
- Allen, C. D. 2005. Cross-scale nonlinearities and interactions among forest dieback, fire, and erosion in northern New Mexico landscapes. Spatial nonlinearities and cross scale interactions: Cascading effects in the Earth system. Ecological Society of America annual meeting, Montreal, Canada.

- Allen, C. D. 2005. Ecological restoration: A case study from the Bandelier Wilderness, New Mexico. George Wright Society biennial conference on parks, protected areas, and cultural sites, Philadelphia.
- Allen, C. D., and K. L. Beeley. 2005. Climate and patterns of tree growth and death in the Jemez Mountains, New Mexico: 1991 to present. First MTCLIM2005 workshop, Pray, MT.
- Allen, C. D., and K. L. Beeley. 2005. Persistence, serendipity, and ecosystem change: Long-term monitoring at Bandelier National Monument. George Wright Society biennial conference on parks, protected areas, and cultural sites, Philadelphia.
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- Balice, R. G., T. W. Swetnam, W. H. Romme, and C. D. Allen. 2005. The post-fire secondary succession paradigm: Are there predictable alternative trajectories? Organized oral session - Post-fire conversion of forest to non-forest: Do we need new theory? Ecological Society of America annual meeting, Montreal, Canada.
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- Fagre, D. B. 2004. Integrated projections of global change impacts. Workshop on projecting global change impacts in mountain biosphere reserves, European Union GLOCHAMORE project, Gran Sasso National Park, L'Aquila, Italy.

- Fagre, D. B. 2004. Variability and trends in alpine glaciers [abstract]. Pacific Division, American Association for the Advancement of Sciences, Utah State University, Logan, UT.
- Fagre, D. B., K. Holzer, B. Reardon, D. Selkowitz, and L. McKeon. 2004. Snow and climate change research in two mountain catchments, Glacier National Park, Montana. EOS Trans. American Geophysical Union, 85(47), Fall Meet. Suppl., Abstract C31A-0311.
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- Fagre, D. B. 2005. Crown of the continent ecosystem responses to climate change. Mountain geography specialty group, "3536 the crown of the continent ecosystem: New insights from recent research – I", Association of American Geographers 2005 annual meeting, Denver, CO.
- Fagre, D. B. 2005. Glacier National Park natural resource changes as a sign of climatic change. Rotary Club, Kalispell, Montana.
- Fagre, D. B. 2005. Glaciers, snow and avalanches as ecological drivers of change in Glacier National Park, Montana. Connecting the dots between the physical and ecological sciences III: Biodiversity and geodiversity, "People, places, and parks: preservation for future generations", The George Wright Society biennial conference on parks, protected areas, and cultural sites, Philadelphia, PA.
- Fagre, D. B. 2005. Global change in the northern Rocky Mountains: Leaving our Ice Age legacy behind. Climate change in National Parks I: Past initiatives, current science, and implications for the future, "People, places, and parks: Preservation for future generations", The George Wright Society biennial conference on parks, protected areas, and cultural sites, Philadelphia, PA.
- Fagre, D. B. 2005. Global change research at Glacier National Park: What a park visitor should know. Interpretation and education division winter training, Glacier National Park. West Glacier, Montana.

- Fagre, D. B. 2005. Disappearing Montana glaciers: Leaving our Ice Age legacy behind. Keynote presentation. In *Special Session on Glaciers*, Canadian Geophysical Union 2005 Annual Meeting, Banff Centre, Banff, Alberta, Canada.
- Fagre, D. B. 2005. Mountain ecosystems and the services they provide: Estimating responses to climatic change. Gore Range natural science school seminar, Avon, Colorado.
- Fagre, D. B. 2005. Receding glaciers reflect ecosystem changes in Glacier National Park. Glacier Institute, Big Creek, Montana.
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- Hicke, J. A. 2004. Understanding mechanisms driving carbon sources and sinks using satellite remote sensing. Global connections between NREL and the World: Lessons learned, NREL symposium, Fort Collins, CO.
- Hicke, J. A. 2005. Development of a web site for analyzing temperatures in mountain regions over the last 100 years. MTNCLIM 2005, Pray, MT.
- Hicke, J. A. and D. N. Kindig. 2004. ENSO influences on a 17-year record of satellite-derived net primary production in western North American mountains. Mountain Climate Sciences Symposium, Lake Tahoe, CA.
- Hicke, J. A., J. A. Logan, J. Powell, and D. S. Ojima. 2004. Increasing temperatures in mountainous regions of the western United States and effects on insect outbreaks. American Geophysical Society, San Francisco, CA.
- Hicke, J. A., D. S. Ojima, S. Running, and D. Schimel. 2004. Using remote sensing products in carbon cycle studies of the mountainous western US. MODIS Vegetation Workshop II, Missoula, MT.
- Holzer, K. and D. Fagre. 2004. The Glacier National Park GLORIA project: A new US target region for alpine plant monitoring installed in the northern Rocky Mountains, Montana. EOS Trans. American Geophysical Union, 85(47), Fall Meet. Suppl., Abstract U53A-0712.
- Holzer, K. and D. B. Fagre. 2005. Monitoring alpine plants in the crown of the continent ecosystem: The Glacier National Park GLORIA project. Mountain geography specialty group, "3536 The crown of the continent ecosystem: New insights from recent research – I", Association of American Geographers annual meeting, Denver, CO.
- Holzer, K. 2005. Monitoring climate change in Glacier National Park. Natural Resources Conservation Service, Montana Districts Annual meeting, St. Mary, Montana.
- Jacobs, B. F. and C. D. Allen. 2004. Recent dynamics in a southwestern piñon-juniper woodland: Disturbance, disequilibrium, and opportunities for restoration. Ecological Society of America annual meeting, Portland, OR.
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- McKenzie, D. 2004. Climatic change and wildfire: Past, present, and future. JISAO-Climatic Impacts Group, University of Washington, Seattle, WA.
- McKenzie, D. 2004. Fire regimes of the Western Hemisphere from the boreal forest to Tierra del Fuego. International conference in Oaxaca, Mexico.
- McKenzie, D. 2004. Integrated modelling to predict regional haze from prescribed and wildland fire. International Society for Ecological Modelling (ISEM) conference, Quebec.
- McKenzie, D. 2004. Media interviews with several publications around the West, including High Country News, the Albuquerque Journal, and the Missoulan.
- McKenzie, D. 2005. Climate, mountain ecosystems, and disturbance across scales: Challenges for the next century. MTNCLIM annual meeting, Chico Hot Springs, Pray, Montana.
- McKenzie, D. 2005. How will climatic change affect regional haze and visibility in parks and wilderness? George Wright Society conference, Philadelphia, PA.
- McKenzie, D. 2005. Integrated modelling to predict regional haze from wildland fire. International Association for Landscape Ecology annual meeting, Syracuse, NY.
- Millar, C. I. and D. B. Fagre. 2004. Integrating climate and ecosystem-response sciences in temperate western North American mountains: The CIRMOUNT Initiative. EOS Trans. American Geophysical Union, 85(47), Fall Meet. Suppl., Abstract U51A-01.
- Muldavin, E. H., C. D. Allen, and R. G. Balice. 2004. Forest and woodland communities of the Jemez Mountains, New Mexico, USA. IAVS, Hawaii.

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- Pederson, G. T. 2003. Climate change: Local and global perspectives. Gordon Research Conferences. Big Sky Institute Outdoor Science Adventures.
- Pederson, G. T. and K. Kirk. 2004. Volcanic heat to glacial ice: A quick tour through events that shaped the northern Rockies and the Big Sky region. Moonlight Basin Ski Resort.
- Pederson, G. T., D. B. Fagre, S. T. Gray, and L. J. Graumlich. 2004. On thin ice in Glacier National Park: Linking climate history to glacial dynamics using tree-rings. Lake McDonald Lodge, Glacier National Park.
- Pederson, G. T. (presenter), D. B. Fagre, and L.J. Graumlich. 2003. Do trees tell the same story as glaciers? Reconstructing drought in Glacier National Park, Montana since A.D. 1540. [abstract]. American Geophysical Union Fall Meeting, San Francisco, CA.
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- Pederson, G. T. (presenter), D. B. Fagre, S. T. Gray, and L.J. Graumlich. 2005. Fire and Ice: Understanding the legacy of the Little Ice Age for contemporary landscape patterns and processes in Glacier National Park, Montana, USA [abstract] Meeting of the Association of American Geographers program. Denver, CO. www.aag.org/annualmeetings/index.cfm
- Pederson, G. T. (presenter), E. Watson, B. H. Luckman, D. B. Fagre, S. T. Gray, and L. J. Graumlich. 2005. Tree-ring based estimates of glacier mass balance in the Northern Rocky Mountains for the past 300 years. [abstract] MTNCLIM 2005 program. Chico Hot Springs, Pray, MT. www.fs.fed.us/psw/mtnclim/index.html

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- Pederson, G. T. 2005. Fire and ice: Climate change and melting mountains. Moonlight Basin Ski Resort, Big Sky, MT.
- Peterson, D. L., C. Allen, J. Baron, D. Fagre, D. McKenzie, and N. Stephenson. 2004. The Western Mountain Initiative: A network of mountain protected areas for global change research. Mountain Climate Sciences Symposium: Anticipating challenges to western mountain ecosystems and resources. Lake Tahoe, CA.
- Peterson, D. L. and D. B. Fagre. 2003. Climatic variability, ecosystem dynamics, and disturbance in mountain protected areas: Assessing the vulnerability of natural resources [abstract]. USGS Global Change Program Overview Meeting, Phoenix, AZ.
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- Reardon, B. and G. T. Pederson. 2003. Long-term change in Glacier National Park, Montana. Northwestern Wilderness Managers Workshop. Glacier National Park, MT.
- Reardon, B. and D. Fagre. 2005. Climate change and avalanche prediction in Glacier National Park. Science and History Conference, Waterton-Glacier International Peace Park, Lake McDonald Lodge, Glacier National Park, Montana.
- Reardon, B. 2005. Avalanche Hazards and Patterns in John F. Stevens Canyon, 1910-2004. Middle Fork Environmental Impact Statement Team, U.S. Forest Service and National Park Service, West Glacier, Montana.
- Reardon, B. and K. Holzer. 2005. Global climate change research at Glacier National Park. Interpreter Annual Training, Glacier National Park, West Glacier, Montana.

- Reardon, B. A., D. B. Fagre, and T. Steiner. 2004. Natural avalanches and transportation: A case study from Glacier National Park, USA. International Snow Science Workshop, American Avalanche Institute, Jackson Hole, Wyoming.
- Rich, P., D. Breshears, K. Price, N. Cobb, J. Kastens, C. Allen, and R. Balice. 2004. Drought-induced mortality in semiarid woodlands: Assessing regional consequences of climate change. ESRI International User Conference, San Diego, CA.
- Rich, P., D. Breshears, K. Price, N. Cobb, J. Kastens, C. Allen, and R. Balice. 2004. Drought-induced mortality in semiarid woodlands. New Mexico Geographic Information Council (NMGIC) fall meeting. Albuquerque, NM.
- Running, S. W. and J. S. Baron. 2004. Assessing landscape-scale connections between the water cycle and vegetation dynamics: Ecohydrology: Towards an ecologically meaningful water budget. Ecological Society of America annual meeting, Portland, OR.
- Selkowitz, D. and D. B. Fagre. 2003. American Geophysical Union Annual Meeting, San Francisco, CA.
- Selkowitz, D., A. Nolin, and D. Fagre. 2004. Landscape vegetation structure and snow cover relationships at multiple scales in Glacier National Park, Montana, USA. EOS Trans. American Geophysical Union, 85(47), Fall Meet. Suppl., Abstract C31A-0291.
- Selkowitz, D., A. Nolin, and D. B. Fagre. 2005. Measuring and modeling snow cover variability across a range of vegetation zones and climate regimes in Glacier National Park, Montana, USA. Cryosphere Specialty Group, 4537 climate and cryosphere IV: Snow system science, Association of American Geographers annual meeting, Denver, CO.
- Stephenson, N. L. 2004. Fire in national parks: Stories of the past, present, and future. Invited keynote address, National Interagency Fire Center -- NPS Annual Fire Education, Prevention, and Information Specialists' Workshop, Leading Fire Communications into the Future. Sequoia National Park, California.
- Stephenson, N. L. 2004. Thinking like a plant: connecting biogeography to fluxes of energy and water. FLUXNET Open Workshop, Florence, Italy.
<http://www.bbc.co.uk/radio4/science/lifespans.shtml>.
- Stephenson, N. L. 2005. Biotic consequences of climatic change. Joint USGS - FWS Future Challenges Project, Southwestern Regional Workshop. Sacramento, CA.

- Stephenson, N. L. 2005. The era of rapid climatic changes: "Natural" is dead, so now what? Caring for parks, caring for people, acting for the future. Superintendents of the Pacific West Region of the National Park Service annual meeting. Portland, OR.
- Stephenson, N. L. 2005. Fire management and the National Park Service mission in an era of rapid global changes. Annual Fire Ecology Meeting, National Park Service, Pacific West Region. Sequoia National Park, California.
- Stephenson, N. L. 2005. Models of vegetation responses to global changes: How good are our assumptions? Seminar series in environmental systems, University of California, Merced, CA.
- Stephenson, N. L. 2005. The National Park Service mission in an era of rapid global changes: A dinosaur that must evolve or die? Abstracts, the George Wright Society biennial conference on parks, protected areas, and cultural sites, Philadelphia, PA.
- Stephenson, N. L. 2005. Three issues with restoring fire and forests. Forest health, fire, and biodiversity. The George Wright Society biennial conference on parks, protected areas, and cultural sites. Philadelphia, PA.
- Stephenson, N. L., and P. J. van Mantgem. 2004. Dissecting the inverse relationship between tree growth rate and probability of death. Abstracts, Ecological Society of America annual meeting, Portland, OR.
- Stephenson, N. L., P. J. van Mantgem, J. E. Keeley, R. S. Anderson, L. J. Graumlich, M. K. Hughes, D. J. Parsons, T. W. Swetnam, D. L. Urban, and J. W. van Wagtendonk. 2004. Climatic change research in the Sierra Nevada: Building the Western Mountain Initiative. *Abstracts*, Mountain Climate Sciences Symposium, Lake Tahoe, CA.
- Swetnam, T. W., R. G. Balice, W. H. Romme, and C. D. Allen. 2005. Is a new paradigm of post-fire succession warranted? Organized oral session - Post-fire conversion of forest to non-forest: Do we need new theory? Ecological Society of America, annual meeting, Montreal, Canada.
- van Mantgem, P. J., and N. L. Stephenson. 2004. The accuracy of matrix projection models for coniferous trees in the Sierra Nevada, California. *Abstracts*, Ecological Society of America annual meeting, Portland, OR.
- Watson, E. (presenter), B. H. Luckman, G. T. Pederson, and B. Yu. 2005. Comparing tree-ring proxies of environmental variability in the Canadian Rockies. [abstract] Annual Meeting of the Canadian Association of Geographers. London, Ontario.

Watson, E. (presenter), B. H. Luckman, G. T. Pederson, and R. J. Wilson. 2005. Environmental changes in the southern Canadian Rockies from multiple-tree ring proxies. [abstract] MTNCLIM 2005 program. Chico Hot Springs, MT. www.fs.fed.us/psw/mtnclim/index.html.

Welling, L., D. B. Fagre, J. Thomas, and K. Scott. 2005. Climate change in national parks: Moving from knowledge to action. Forecasting environmental changes: 2005 Conference on Science, Policy and the Environment, National Council for Science and the Environment, Washington, D.C.

Woessner, W. W., S. W. Running, D. F. Potts, J. S. Kimball, T. H. Deluca, D. B. Fagre, S. Makepeace, M. S. Hendrix, M. S. Lorang, B. K. Ellis, J. LaFave, and J. Harper. 2004. Flathead River Basin Hydrologic Observatory, northern Rocky Mountains. EOS Trans. American Geophysical Union, 85(47), Fall Meet. Suppl., Abstract H31C-0395.

WMI in the News

The Albuquerque Journal. October 17, 2004 edition featured Craig Allen and his research involving landscape change and climate change in the mountains of the western US, with an emphasis on long-term, place-based science.

The American Alpine Journal. By Bernadette McDonald. Vol 45(77) 2003, p. 430. International year of the mountains. Referenced an Fagre's work in Glacier National Park pertaining to glacial recession.

Appalachian Voice. June 2005. Interviewed Dan Fagre about climate change studies in Glacier National Park.

Audubon. By Tom Yulsman. December 2003, p. 38-43. Meltdown: To see how the Earth's glaciers are vanishing, look no further than Glacier National Park, where ice formations thousands of years old may be gone in 30. Article based on interview with Dan Fagre, three USGS photos of Grinnell Glacier published.

Avenue (Calgary, Alberta). By Andrew Nikiforuk. July 2004. Interviewed Dan Fagre about climate change studies in Glacier National Park.

Backpacker Magazine. December 2004. Interviewed Dan Fagre.

Banff Centre for Culture. By Andrew Nikiforuk. July 2004. Interviewed Dan Fagre about climate change studies in Glacier National Park.

BBC radio. Biology of longevity: Nate Stephenson was interviewed for its upcoming two-part radio series called "Lifespans," which explores the biology of longevity. Stephenson discussed factors that allow giant sequoias to live more than 3,000 years.

BBC radio. By N. L. Stephenson. December 2004. Thinking like a plant: Connecting biogeography to fluxes of energy and water. FLUXNET Open Workshop, Florence, Italy. www.bbc.co.uk/radio4/science/lifespans.shtml.

Bozeman Daily Chronicle. 2004. Climate causing changes in Glaciers.

Business Week. By John Carey. August 16, 2004, p. 60-69. Global warming. Global warming is the premier story with photos appearing on p. 69.

Chemistry: AS Level and A Level. By Brian Ratcliff, et al. 2004. Cambridge University Press. Chemistry textbook published three USGS photos of Grinnell Glacier, 12,000 copies plus new additions planned.

Christian Science Monitor. By Gail Jokerst. July 2004. Interviewed Dan Fagre about climate change studies in Glacier National Park for upcoming article.

CNN Nightly News with Aaron Brown. David Fitzpatrick and camera crew hiked and interviewed Dan Fagre in Many Glacier Valley on July 16, 2004. The 2-3 minute segment aired on CNN Nightly News on July 21, 2004. Dan discussed the receding glaciers and what it means for mountain ecosystems. Provided glacier photographs and graphics for their use.

The Coloradoan – www.coloradoan.com. By Kevin Darst. March 19, 2005. RMNP ecosystem in danger: Groups pledge to work together to solve area's air-quality problems.

The Daily Inter Lake. By Chery Sabol. January 29, 2004, A1, A3. Avalanche derails train, US 2 closed again by slides. Photo and quotes by Blase Reardon, USGS avalanche specialist.

The Daily Inter Lake. By Susan Gallagher (AP). May 2, 2004, p. A1, A2. Glaciers going, going... Data document retreat of noted rivers of ice in Montana. Large front page photo of Dan Fagre and article about glacial recession, numerous Fagre quotes, USGS repeat photo pair of Boulder Glacier printed on page 2 of article.

The Daily Inter Lake. By Jim Mann. July 28, 2004 A1. Man critical after fall into crevasse. Dan Fagre quoted about conditions on Grinnell Glacier.

The Daily Inter Lake. January 30, 2004, A1, A3. Tracks Reopen, US 2 Remains Closed at Essex. Quotes by Blase Reardon, USGS avalanche specialist.

The Daily Inter Lake. By William Spence. February 1, 2004, A1, A3. Weather vane getting a workout at Logan Pass; Gusts up to 102 mph. Blase Reardon interviewed about USGS weather station and weather patterns at Logan Pass.

The Denver Post. By Katy Human. January 18, 2005. Alpinists' ice-dreamy mountains melting away.

Explore Magazine (Canada). August 2004. Interviewed Dan Fagre.

Explore Magazine (Canada). By Andrew Nikiforuk. July 2004. Interviewed Dan Fagre about climate change studies in Glacier National Park.

Flathead Living Magazine. By Becky Lomax. September 30, 2004. Blase Reardon interviewed regarding avalanche forecasting and spring safety during the opening of the Going-to-the-Sun Road, Glacier National Park.

Flattop Mountain SNOTEL Snowpack (webpage). Water Year 2003, produced by Blase Reardon, http://nrmsc.usgs.gov/research/ftm_snow.htm.

The Forestry Source. By Steve Wilent. Craig Allen was interviewed on Nov. 9, 2004 regarding climate interactions with forest dieback in the West.

Great Falls Tribune. By Sonja Lee. September 5, 2004. p. 1A. Glacier National Park – A Natural Laboratory. Cover photo and story about glacier recession.

HBO. Craig Allen was interviewed and filmed about science issues related to dying trees and climate change connections for an upcoming special to air in 2005, tentatively entitled "Melting Planet."

High Country News. Betancourt, J. L., T. W. Swetnam, C. D. Allen, and M. Savage. 2003. Fire in the West: It's no simple story.

High Country News. By Michelle Nijhuis. July 19, 2004. Global warming's unlikely harbingers: The West is heating up — and bark beetles are moving in for the kill. Craig D. Allen and Nate Stephenson quoted in its feature article about the impact of climate warming and drought on pine beetle infestations and extensive tree mortality.

Hungry Horse News. By Rick Hanners. March 11, 2004, A1, A3. Bombing debate in Glacier Rumbled to Martz' office. Dan Fagre and Blase Reardon interviewed regarding avalanche events in January.

Hungry Horse News. By Chris Peterson. January 15, 2004, A1, A6. Climate in Glacier a concern. Dan Fagre and other park scientists interviewed about climate change in Glacier.

Hungry Horse News. By Richard Hanners. August 19, 2004. A1, A5. Researcher says Glacier no stranger to climate swings.

IMAX. August 2004. Dan Fagre provided a support letter to IMAX producers who are seeking funding to film in Glacier Park with a theme of national parks in danger.

KAJ-TV broadcast. August 12, 2004. Interviewed Dan Fagre at the Park Science Conference.

KOFI radio. KOFI-Talk show. January 14, 2004. Blase Reardon, USGS avalanche specialist, participated in avalanche awareness panel discussion.

KPCC radio. May 31, 2005. Jon Keeley was interviewed regarding invasive species issues for an upcoming program on Mediterranean plant communities in southern California. The story will feature the University of California's Stunt Ranch Santa Monica Mountains Reserve, which contains chaparral and oak woodlands. A human-caused fire in November 1993 burned 17,000 acres in the reserve; researchers are tracking the regrowth of vegetation on charred slopes.

KPCC radio. July 6, 2004. Nate Stephenson and Phil van Mantgem were interviewed about the possible effects of climatic changes and other stresses on forests. The discussion included possible ways to manage forests to be more resilient to stresses.

KSL-TV (NBC affiliate in Salt Lake City, UT). By John Hollenhorst. November 23, 2004. Reporter and cameraman visited Grinnell Glacier in summer 2004.

KVMR-FM radio (Nevada City, CA). July 13. Jon Keeley interviewed live about fire regimes and climate change.

Los Angeles Times. Large Forest Fires Occurred in Past Too. Jon Keeley commented on research by others published this week in the journal Nature in which evidence in sediment deposits indicated that past large, severe fires occurred in the western U.S. during a warm, drought-plagued period in the Middle Ages.

Men's Health Magazine. By Dennis Watkins. June 14, 2005. Blase Reardon interviewed about glaciers.

Missoula Independent. By Jeff Woods. February 5-12, 2004. Vol. 15, No 6, p. 14, 15, 16. The big drip – Why Glacier National Park's namesakes are melting, and why we should care. Feature article interviewed Dan Fagre about USGS climate change studies and the future of glaciers in Glacier National Park.

Missoulain. By Michael Jamison. February 1, 2004. A1, A8, A9. Glacier study gains ground. Dan Fagre interviewed about effects of recent grant award on USGS climate change research.

Missoulian. By Michael Jamison. January 25, 2003. Survey of Glacier's glaciers shows half as many as 1960s. www.missoulian.com/articles/2003/01/25/export1783.txt.

Montana Senior News. October/November 2004. Pages 58, 59, and 87. Dan Fagre interviewed about shrinking glaciers and climate change.

National Geographic Adventure Magazine (book excerpts reprinted). By Peter Matthiessen. 2003. End of the Earth: Voyages to Antarctica. Quotes a USGS prediction about glaciers in Glacier National Park melting by 2050.

National Geographic Magazine. By Daniel Glick. September 2004, p. 13-33. The Big Thaw. Dan Fagre quoted in feature article.

National Geographic Magazine (website). By Daniel Glick. August 2004. The Big Thaw. Excerpt from article which interviewed Dan Fagre about Glacier National Park's glacier recession. (<http://magma.nationalgeographic.com/ngm/0409/feature2/index.html>).

Nature. January 28, 2005. Fire and Grassland Evolution. Jon Keeley was interviewed regarding a fellow researcher's recent study in the journal *New Phytologist*, in which global modeling shows many of the world's great grasslands disappearing in the absence of fire. Keeley has been investigating a related topic, fire and the expansion of tropical and subtropical (e.g., southern Arizona) grasslands, and how previous models of global CO₂ changes do not seem to explain changes in grasslands documented for the Late Miocene. (<http://www.nature.com/news/2005/050124/full/050124-16.html>).

The New York Times. By Jeffrey Selingo. May 7, 2004. Travel section front page. Going to Glacier? You Should Hurry. Article mentions USGS scientist's prediction that glaciers will be gone by 2030.

Off-Piste. By Heath Korvola. March 2004, p. 6-7. A day in the life: Glacier National Park spring avalanche patrol. Article featured Blase Reardon's and Chris Lundy's avalanche forecasting work in Glacier National Park.

Pew Center on Global Climate Change. January 2004. Requested USGS repeat photos for a segment in preparation for the Washington Post's Kid's Post.

Prologue. By Eagle Valley Library District, Eagle, CO. Winter 2005, Vol. 3, Issue 1. Front page photo for High Country Speaker Series.

The Rocky Mountain News. By Jim Erickson. August 30, 2004. Pollutants raining down on Rockies: Nitrogen buildup putting national park's ecosystem at risk - and it could get worse, research shows.

Science. All Downhill from Here? By Kevin Krajick. March 12, 2004, p. 1600-1602.
Article on treeline advance cites Dan Fagre's work in Glacier.

Science. 309, 27, 2005. Review of climate plotting web page
www.nrel.colostate.edu/~jhicke/climate_data.

Science News. By Sid Perkins. Fall 2003. Interview about global change research and
glacial retreat in Glacier National Park.

Science News. By Sid Perkins. October 4, 2003, Vol 164(14) p. 215. On thinning ice –
Are the world's glaciers in mortal danger? Article on world-wide glacial recession
showing USGS photo pair of Grinnell Glacier.

Senior News. By Gail Jokerst. July 2004. Interviewed Dan Fagre about climate change
studies in Glacier National Park.

Sonora Union Democrat. By Dhyana Levey. January 20, 2005. Tree disease in forest
studied. Phil van Mantgem interviewed about infections of white pine blister rust
in sugar pines in the Sierra Nevada.
http://www.uniondemocrat.com/news/story.cfm?story_no=16328. A USGS and
NPS study published in Ecological Applications examined a unique long-term
data set that documents 2,168 sugar pines over 15 years at several sites in the
Sierra Nevada. All populations had high frequencies of infections that were often
associated with tree death, although crowding was a frequent cause of death as
well.

Texas Education Agency. By Robin Dufner. July 2004. Science assessment test.
Requested two photos of Grinnell Glacier for a statewide science assessment
test to be administered spring 2005.

TIME Magazine. August 16, 2004. Why the West is burning: A five-year drought has
parched soils, lowered reservoirs and weakened forests. And if the past is any
guide, the dry spell could go on for decades. Craig Allen interviewed.

Weekly Snowpack Report. Prepared by Blase Reardon. Winter 1999-2003. SNOTEL
graph updates, provided to park rangers and road crew.