Summary and Abstracts from
Sudden Aspen Decline (SAD) Meeting

Fort Collins, Colorado, February 12-13, 2008

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In recent years the aspen research and management community has witnessed increasing accounts of unexplained aspen die-offs across the Rocky Mountain region. In response, two meetings were held to address the issue; this paper summarizes the most recent gathering, a symposium held in Fort Collins at the USDA Forest Service, Rocky Mountain Research Station, on February 12-13, 2008. This report presents a brief summary of workshop findings along with a synopsis of the state of aspen research in the western United States organized in the following subject categories: SAD case studies, research & methods, and aspen organizations. Abstracts of presentations made at the meeting are then presented in each of the above categories, followed by an email address where the corresponding author may be reached with questions or comments.

SAD Case Studies--Wayne Shepperd provided an overview of recent studies along with a definition for the SAD phenomenon: *death of mature overstory with an absence of subsequent regeneration*. He reports a ten-fold increase in suspected SAD mortality for western Colorado based on aerial survey data. He further describes research priorities for assessing the consequences of SAD. Each of the case studies presented slightly differently forms of decline; only the work done in southwest Colorado (Hargrave; Worrall *et al.*) found significant levels of overstory mortality coupled with lack of regeneration and presence of root mortality. Campbell *et al.* noted only 1-2% of aspen coverage on Utah's Fishlake NF meets the SAD criteria, although they do recognize other common damages and causes for minimal regeneration. Ciesla noted a host of causal agents in elevated mortality counts along the Colorado Front Range, but further states, "Many of the affected stands have ample aspen regeneration in the understory. Those lacking regeneration are in areas where either wild or domestic ungulates are present in significant numbers." In Arizona, Fairweather & Geils report very high mortality rates (in some cases), but also noted browsing damage from elk and deer. Philip Miller gave descriptive results and photo documentation from western Colorado showing high levels of sprout damage from cattle browsing and, in some instances, long-term conversion to parklands over the past two decades. Hoffman e*t al.* reported preliminary results of aspen mortality surveys in Utah, Nevada, and western Wyoming. A high rate of mortality is evident—about 1/3 of trees dead in declining stands; about 2/3 of those trees died within the last two years—although regeneration rates are variable and "no single biotic factor [is] responsible for the observed aspen dieback." Baker & Shaw examined The Forest Service FIA database at a larger (state) scale than most of the case studies presented. They conclude that unusual rates of aspen death were not found in the data, but that the combination of region-wide demographics (stand age) and recent drought are expected to result in widespread stand die-offs as aspen surpass 100 years of age. Blodgett *et al.* report on a Wyoming assessment of aspen health based on their statewide systematic survey. Their most common causal agents of stress and mortality were stem cankers (67%) and root pathogens (60%). They hint at an overarching factor which is leading to this widespread damage and mortality in aspen.

Two common threads emerge from the totality of the case studies: 1) relatively high mortality near the lower elevation margins of the aspen distribution and, 2) the impact of drought. The most severe cases of SAD, combining these elements, seem to occur on low elevation south and southwest slopes (Worrall *et al.*).

Research & Methods—Methods-oriented presentations described a variety of intriguing approaches to studying aspen community health. While Blodgett *et al.* propose a method for sampling aspen health on a systematic grid, their contribution toward supplementing/confirming aerial detection surveys holds great promise. Campbell *et al.* reported on lessons learned from over 30 locations, using a variety of treatment methods, conducted over the past 25 years on the Fishlake NF in south-central Utah. At least for this study area, they found, "It is rare that a stand with aspen present would not produce suckers…" Campbell *et al.* advise fencing of recently disturbed stands and more aggressive management (i.e., burning) for aspen which has been encroached by conifers.

Katie Haggerty presents preliminary results from an experiment conducted near Lyons, Colorado (Front Range) on the effects of radio frequencies on aspen seedling growth. Using shielding devices, she found that there was higher growth and brighter fall coloration in the shielded seedlings versus those that were unprotected. Since the test site was remote from sources of radio frequencies, her experiment suggests that this apparently omnipresent factor may be deleterious to aspen seedlings—and likely other plants—across wide landscapes.

Dr. Karen Mock updated us on ongoing genetic studies in two Utah locations. Mock and colleagues have used 50m grids to assess genetic diversity within continuous aspen stands. While vegetative reproduction is thought to be the dominant regenerative mode of western aspen, the work of Mock's lab suggests a strong presence of greater genetic diversity within stands; one and two stem genotypes are commonly scattered among larger clones at both study sites. Another finding is the apparent recent, or ongoing, nature of seedling establishment—perhaps suggesting low-level seedling occurrence on a continuous, rather than episodic, basis.

An example of methodological potential, but not explicit experimentation, was given by Randy Hamilton of the USDA Forest Service, Remote Sensing Application Center. Hamilton suggests that many of the contemporary aspen decline/status questions may be answered most cost effectively through use of remote sensing technology. For example, regional assessments of conditions, which may be cost prohibitive, may be conducted in a matter of months given adequate background information. A key point of using this technology is that it must be supported by strategic ground surveys (i.e., ground "truthing" targeted phenomena).

Aspen Organizations—Recent developments in aspen management issues and advances in aspen ecology have spawned (at least) three new organizations. The Northern Rockies Aspen Working Group, corresponding roughly with U.S. Forest Service Region 1, was set up to address aspen issues in that region across agency boundaries. The Western Association of Fish and Wildlife Agencies (WAFWA) Habitat Committee recognizes the critical role that aspen plays in wildlife habitat, and further understands that overabundance of some wildlife may contribute to aspen declines. WAFWA membership consists of state and province (Canada) wildlife professional working in collaboration with federal land management agencies. Finally, a special session was held at the Fort Collins SAD workshop to initiate a region-wide science/management consortium under the title Western Aspen Alliance (WAA). The chief role of the WAA is to facilitate and coordinate research and technology transfer of aspen science for the betterment of aspen ecosystems.

Beyond the summaries provided here, issues related to long-term aspen decline and associated changes in resource value have, in large part, made the study of aspen systems a "hot topic" in forest and range ecology and management. Though a recent USDA Forest Service publication (Shepperd *et al.*, 2006) documents trends in aspen ecology since the landmark publication *Aspen Ecology and Management in the Western U.S.* (DeByle & Winokur, 1985), the pace of research related to aspen systems appears to be increasing. There are four broad areas where growth in aspen research is taking place, or is expected soon: First, the most consistent topics of the past decade have been the spatial assessment of historic aspen extent, aspen decline, and (of late) focus on partitioning/assessment of persistent and seral stands (Rogers, 2002; Kulakowski *et al.*, 2004; Di Orio *et al.*, 2005; Bartos 2001; Campbell & Bartos 2001; Bartos & Campbell, 1998; Kurzel *et al.*, 2007; Elliot & Baker, 2004).

Second, work is being conducted in several areas of applied basic ecology. Shepperd (2001) has discussed applications of a regeneration model—the "aspen triangle"—using forest manipulations. Water yield work is being conducted to compare water budgets for successional levels of aspen-conifer stands (LaMalfa & Ryel, 2008). The work presented here by Dr. Karen Mock, and related studies, will likely introduce new lines of inquiry related to aspen genetics, long-term stand development, and genotypic variation and preference in aspen clones. Numerous faunal and floral diversity publications are emerging which highlight the disproportionate value of aspen stands in landscapes dominated by conifers (Rogers *et al.*, 2007a, b; Ripple *et al.*, 2001; Kleintjes Neff *et al.*, 2007; Richardson & Heath, 2005).

Third, an important aspect of recent aspen research has been in the development of inventory and monitoring protocols to assess extent and conditions. Protocols to assess decline are provided at the stand level (Burton, 2004) and in larger landscapes (Worrall *et al.*, 2008; Rogers, 2002) for the western U.S. Fourth, an area of emerging promise is that of social and aesthetic/tourism contributions of aspen ecosystems exemplified by the work of McCool (McCool, 2001) and summarized in Shepperd *et al.* (2006).

In summary, the research cited here emphasizes burgeoning topics related to aspen decline, but is by no means an exhaustive listing. The work presented at the Fort Collins Sudden Aspen Decline meeting highlighted another potential area of research; one logically tied to the presumptive inciting factor of climate change/drought and interactions with stand structure. Though each of the case studies below may not meet the definition of SAD presented here by Shepperd, common themes are relatively rapid die-off of mature stands, possibly stressed by predisposing factors, and those considered marginal either physiographically or due to past management practices.

A final thought is the need for a more complete understanding of aspen ecology and management. In the greater scheme of aspen research over the past several decades, it should be noted that SAD appears to be affecting between 1-20% of the western aspen today. While this is certainly an issue of concern, it should not be lost upon managers that the past 100 years, or so, of paucity in large-scale disturbance has likely had a much larger effect on aspen ecosystems in the region. Thus, solutions to the "aspen problem" will of necessity incorporate understanding of both short- and long-term processes at the ecosystem level.

SAD CASE STUDIES

Sudden Aspen Decline in the Western U.S.: Introduction and Background
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Sudden Aspen Decline (SAD) is characterized by mortality of mature trees that die quickly within a year or two and the lack of new sprouting after the overstory mortality. Younger age classes and advanced regeneration are often not affected to the same extent as mature overstory trees and remain alive if present in an aspen stand prior to the onset of overstory mortality. Recent research indicates that lateral roots of mature trees are affected too, which likely explains the lack of new suckers in affected stands. Although stands on all topographic positions, moisture regimes, and soil types are affected, SAD is more prevalent at lower elevations and on southerly exposures. Cytospora cankers, poplar borers, and other damage or stress agents are often associated with mortality epicenters, but not thought to be the underlying cause of SAD.

SAD has been reported for several years throughout the west from Arizona to Alberta. The affected acreage is growing, but so far has only affected a minority of the total aspen acreage in the western United States. However, SAD has affected critical aspen habitats in some locations. Aerial surveys in Colorado show an exponential increase in SAD from 30,000 acres in 2005, to 138,000 acres in 2006, and 338,000 acres in 2007.

Based on current knowledge of SAD, we conclude that it is not normal succession or natural replacement of one generation of aspen by another. Since roots appear to be affected, SAD is really mortality of mature aspen without successful regeneration. Other stresses (disease, drought, browsing) contribute to SAD and climate is likely involved. Critical knowledge needs include: (1) developing effective protocols for monitoring SAD, (2) estimating how long (or far) will SAD continue, (3) assessing the ecologic consequences of SAD, and (4) testing potential management actions to address SAD.
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Aspen Condition and Management Activities in Southern Utah
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The Fishlake National Forest hosted an aspen die-off working tour with about 10 participants in June 2007. Tour objectives were to observe examples of aspen die-off; identify possible contributing factors; begin to quantify the magnitude of the phenomenon; and consider ways to develop a risk analysis. We observed frost damage of landscape proportions during the tour and agreed to revisit several areas in 2008. Aspen die-off is now referred to as sudden aspen decline (SAD). During the tour, we estimated SAD on the Fishlake NF to be in 1-2% of the aspen occupied areas. The markedly low amount, or absence, of aspen regeneration is a key factor to confirm a SAD event. Thus, SAD is not frost damage; where a recent fire went through an aspen stand; or when the absence of regeneration is due to excessive utilization by ungulates. Also, SAD may not be able to be assessed in the first season because the suckering response is often not manifest until the season following the “stress” event observed in the aspen stand. The most dramatic example of SAD noted thus far in southern Utah occurs on Cedar Mountain, southeast of Cedar City. Even in this example, the possibility remains that aspen regeneration occurred initially and was subsequently browsed. In summary, aspen roots will generally produce suckers when a stand is treated. Protection is essential in many situations before aspen regeneration can survive and establish. Prioritize treatments in stands where conifers are replacing aspen; wait for nature to treat other areas.

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Aspen Decline and Other Factors Affecting the Health of Aspen on the Colorado Front Range

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Factors affecting the health of aspen forests along the eastern front of Colorado are reported. These data were collected via aerial and ground surveys conducted from 2005-2007 under contract to the Colorado State Forest Service.

An outbreak of western tent caterpillar, *Malacosoma californicum*, is underway in the Sangre de Cristo/Culebra ranges. In 2006, 4,800 acres of aspen forest were defoliated. The area of defoliation increased to 20,500 acres in 2007. In the Wet Mountains, a severe storm event on 07 June 2007 caused blowdown and breakage of aspen on 500 acres and stripping of foliage on 10,000 acres. Extensive defoliation of aspen by late spring frost occurred over much of Colorado in 2007 and affected areas were still aerially visible in late August.

Areas of classic sudden aspen decline were mapped in 2006-2007 along the western portions of South Park, the Laramie River Basin, and the Colorado State Forest in low elevation aspen climax stands. Symptoms include: early fall coloring and death of trees in groups or waves. Symptoms often begin at the edge of stands and spread inward. Tree mortality occurs over a 1-2 year period. Woodborers and cytospora canker are associated with the dead aspen and are considered contributing factors. Many of the affected stands have ample aspen regeneration in the understory. Those lacking regeneration are in areas where either wild or domestic ungulates are present in significant numbers. It is predicted that affected stands with ample aspen regeneration will be repopulated with young aspens. Those stands lacking aspen regeneration will revert to short grass prairie.

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Aspen Decline in Northern Arizona

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An accelerated decline of aspen communities has occurred across northern Arizona, following frost and several years of drought. We began evaluation and monitoring of affected aspen at the stand-level on the Coconino National Forest (NF) in 2003, followed by the Apache-Sitgreaves NF in 2004. This monitoring project describes mortality levels, regeneration condition, and stand and site variables that are influencing decline. Preliminary results show that elevation, which varies from 6,800 to 9,300 feet, is a key factor in both tree species composition and severity of decline. Lower elevation sites (<7,500 feet) are on northerly aspects and are

dominated by aspen with a ponderosa pine and oak component. Over 90% of aspen stems have died on these low elevation sites. Mid- and high-elevation sites were on various aspects with a mix of conifer species and mortality levels that varied by NF. On the Coconino NF 61% aspen stem death occurred in mid-elevation sites and 16% in high-elevation sites. On the Apache-Sitgreaves NF mortality levels were approximately 43% at both mid- and high-elevation sites. Although aspen sprouting was variable, ungulate browse damage was rampant everywhere. Widespread mortality of mature aspen trees, chronic browsing by ungulates, and advanced conifer reproduction is expected to result in rapid vegetation change of many ecologically unique and important sites.
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Monitoring the Condition of Aspen in the Northern and Intermountain Regions
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In 2006 we initiated the establishment of permanent Evaluation Monitoring (EM) plots in Regions 1 and 4 to determine the cause of aspen dieback and defoliation that had been detected in aerial survey. In the year prior to plot establishment, aerial pest detection surveyors identified aspen stands exhibiting overstory dieback symptoms. We used this data to establish 75-permanent plots in accessible symptomatic stands throughout the range of aspen in Utah, Nevada, and western Wyoming. In 2007, fifty-one aspen stands were surveyed in southern Idaho. Northern Idaho and Montana will be surveyed in 2008 to complete the proposed three-year schedule.

Preliminary results of the 2006-2007 permanent plot data indicate that the average mortality of all surveyed overstory aspen trees within the remotely sensed stands was 31%. Of these dead trees, 69% had died within the last two years. Ninety-six percent of living trees were reported to be afflicted with at least one, and up to three, signs or symptoms caused by specific damage agents, and 43% had moderate to severe damage. The most frequently observed damage agent was present on 22% of all living aspen. Aspen sprouts, a significant indicator of aspen clone health, were present in 86% of the plots during the understory evaluation component of the survey. Sprout density ranged from 0 to nearly 12,000-stems/acres and averaged nearly 2,000 stems per acre. In Utah, 56% of the sprouts showed evidence of grazing damage, but in Idaho only 22% showed evidence of grazing.

This rapid assessment of declining aspen stands superficially suggests that there was no single biotic factor responsible for the observed aspen dieback and defoliation. Eventual synthesis of these data with site factors, hydrologic, and the other regional survey data should provide more insight into the impacts of this pulse of mortality and damage.
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Aerial Survey of Aspen in Southwest Colorado Since 2005

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The Region 2 Forest Health Management annual forest insect and disease aerial survey has mapped sudden aspen decline (SAD) across the San Juan Public Lands (SJPL) since 2005. Findings suggest that up to 52,000 acres, roughly 15% of the aspen cover type on the SJPL, exhibit SAD characteristics. Aspen timber is an important commercial species in the area and both the total affected area and recent rapid increase of SAD across the SJPL is alarming to land managers. Stand exam data was collected in the Haycamp Point area to ground truth the aerial survey data. The sampling protocol used a slight modification to the Region 2 common stand exam sampling protocol. The modification was used to describe the tree class as either normal or abnormal (for live trees) and salvageable or unsalvageable (for dead trees). The data illustrated a wide and variable range of forest health conditions in a relatively small area and was used in the silvicultural assessment to plan a salvage timber sale. The final salvage sale covered 122 acres of low elevation (8,200'-9,100'), south-southwest facing stands. Commercial fiber volume per acre varied widely across the planned logging units. Logging units with the highest commercial volume per acre exhibit at least 10% mortality and multiple SAD disease agents. In these units less than 70% of the individual trees designated for harvest are alive and disease free. Logging units with the lowest commercial fiber volume yield per acre contain at least a 40% live stem component, however because multiple SAD disease agents are present, only a small proportion of the individual trees designated for harvest are alive and disease free. Stands with less than a 40% live stem component were deemed commercially unviable. All told, the estimated commercial fiber volume per acre harvested as part of the salvage operation is roughly one-third of a typical 'green' aspen sale on the forest. Monitoring regeneration success will be a priority in this area and monitoring results will be applied to future planning efforts.
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Aspen regeneration in Western Colorado

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The author presented a collection of photos from 1994-2008 showing damage caused to aspen seedlings and saplings from browsing by cattle and wildlife. In 1993, Miller visited an aspen clearcut block, logged in 1992, where a dense stand of sprouts had become established. One-hundred percent of the seedlings he examined were damaged by browsing, principally cattle. In 1994 Miller revisited the cutblock and took a photo that shows cattle foraging. By 2007 this cutblock of about forty-nine acres had been converted to an open park with some surviving but badly damaged seedlings. What he had seen led Miller to investigate other aspen clearcut blocks on the Uncompahgre National Forest. In almost all cases he found there was a portion of most cutblocks converted from forest to degraded mountain park invaded by non-native ground vegetation and invasive weeds. While many of the cutblocks had significant stands of undamaged seedlings and saplings there always seemed to be areas of sacrifice.

Damage to aspen caused by elk winter bark feeding is also shown which has made mature trees susceptible to diseases such as stem cankers and heart rot.

Miller has observed that the cumulative effect of browsing on aspen seedlings and

saplings by livestock and wildlife is the principal reason for the failure of aspen regeneration. The only effective method of preventing browsing damage is to fence aspen cutblocks to exclude both livestock and wildlife for ten to fifteen years. Without fencing a partial solution is to retire grazing permits.
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Sudden aspen decline in southwest Colorado
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Sudden aspen decline (SAD) has increased rapidly in recent years, approaching 350,000 acres in Colorado in 2007, or 13% of aspen cover type. We investigated the severity, site/stand factors, and causes associated with SAD in southwest Colorado. First, we documented landscape (based on GIS-DEM analyses) and stand factors (based on stand exams from two sites on the San Juan NF). There was a strong inverse relationship between elevation and damage, damage tended to occur on south and southwest aspects, was most severe in open stands with large trees, and regeneration was poor in damaged stands. We observed five biotic agents most frequently associated with mortality: Cytospora canker, poplar borer, bronze poplar borer, and two aspen bark beetle species. We proposed a hypothesis of causal factors in a decline context: *Predisposing factors*: low elevations, south to west aspects, low density, stand maturity; *Inciting factors*: warm drought conditions; *Contributing factors*: secondary, biotic agents mentioned above. The second phase is an intensive field survey with 76 plots completed on four National Forests. Preliminary analyses indicate: (a) Regeneration has not responded significantly to crown loss; (b) Root mortality varied from 0 to over 90% of root volume and was correlated with crown loss, and damaged plots had significantly higher volume of dead roots than healthy plots; (c) Regeneration decreased significantly as root mortality increased in damaged plots, but not in healthy plots; (d) Crown loss did not vary significantly with depth of soil mollic layer; (e) Crown loss did not vary significantly with average or oldest age of sampled codominant/dominant trees. There are significant management implications and may be loss of aspen cover type where aspen stands are declining and regeneration is inadequate. Marginal regeneration may be further compromised by such factors as amount and duration of ungulate browsing.
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Characteristics of Aspen and Aspen Mortality
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We examined Forest Inventory and Analysis (USDA Forest Service) data from 2006 and earlier to characterize aspen and aspen mortality in Arizona, Colorado, and Utah. Most of the aspen stands are older than 80 years, and we know that aspen stands are short lived, rapidly

breaking up after 100-120 years. We compared attributes of stands with mortality and those without, and found no trends in site index or stand age. Any trends may be obscured by the fact that aspen stands usually start life with thousands of suckers, but as they mature mortality occurs constantly to reduce stand density to several hundred stems. Many of these stands are approaching the limits of stand density index maximum (SDImax), so mortality must occur if the stand is to continue to grow.

Similar to findings in pinyon pine, at specified latitudes, the average elevation of aspen plots with mortality was found to be several hundred feet lower than the average elevation of aspen plots without mortality. Pinyon pine, ponderosa pine, Engelmann spruce, and aspen are all experiencing mortality rates greater than the average from 1980-2000. However, since 1991, aspen mortality has exceeded the 20 year average only 6 times. We believe that this mortality is consistent with the effects of prolonged drought.

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Aspen forest health survey in Wyoming

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This study documents common diseases, insects, and damage agents associated with aspen stress and mortality in Wyoming. Observations were made from 2003 to 2006. Surveyed stands were systematically selected using a 3-mile grid, ownership, vegetation type, and accessibility layers in a geographic information system. The survey included state, federal, and tribal lands. Based on a recent state-level vegetation classification (Wyoming GAP data), all major forest cover types found in Wyoming were included. For each causal agent, significant impacts were recorded as present or absent. Significant impact was defined as “stressed” if > 25% of the trees had > 1/3 of the stem or crown affected and “mortality” if > 5% of the trees had recently died based on visual inspection. Thirty of the 300 stands surveyed were classified as aspen cover type. Results indicate that the most common causal agents of stress and mortality among aspen were cankers 67% (mainly *Cytospora chrysosperma*, *Encomia pruinosa*, and *Cryptosphaeria lignyota*), Ganoderma root disease 47% (*Ganoderma applanatum*), Armillaria root disease 13% (*Armillaria* spp.), animal damaged 10%, foliage rust 3% (*Melampsora* spp.), and poplar borer 3% (*Saperda calcarata*). The *Armillaria* fungus was detected in 27% of the stands, but was only confirmed to be causing root disease in 13% of the stands. Stands and trees were usually affected by multiple causal agents; root diseases and cankers often occurred in the same stand. The root pathogens, *G. applanatum* and *Armillaria* spp., and the canker pathogens, *C. chrysosperma*, *E. pruinosa*, and *C. lignyota*, are responsible for much of the observed aspen mortality in Wyoming. The widespread synchronized occurrence of these pathogens suggests at least one broad-scale predisposing factor. These results warrant more detailed studies of aspen using a denser sampling design.

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RESEARCH & METHODS

Aspen Restoration Efforts on the Fishlake National Forest: Lessons Learned

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More than 30 different areas with aspen, totaling at least 35,000 acres, have been treated during the past 25 years on lands administered by the Fishlake National Forest in south-central Utah. Treatments included aspen harvests, conifer harvests, prescribed burns, combinations of these treatments, wildland fire use, and wildfire. Many of these areas show excellent, or acceptable, success for aspen regeneration. However, responses have been mixed; not all have done well, and others essentially do not have any aspen regeneration remaining in the treated area. Several lessons can be learned from these treatments on the Fishlake NF. Aspen will respond to a variety of treatments done during every season of the year. It is rare that a stand with aspen present would not produce suckers, usually abundant, if the hormonal response is stimulated. Protection may be necessary for young aspen suckers to establish and thrive. Many areas have been fenced; some have high fences to exclude wildlife while other fences exclude only livestock. Use fire as an element of the treatment if advanced conifer regeneration is abundant and likely to compromise successful aspen regeneration. Mixed-conifer forests with scattered aspen present have the highest priority for restoration; treat often and make the actions large.
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The Influence of Radio Frequency Pollution on Aspen Seedlings

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This experiment investigates possible effects of exposure to radio frequency (RF) background pollution on aspen seedlings. The experiment was conducted in a rural area in Colorado: 40, 17', 17.9" N latitude and 105, 16', 52.15"W longitude, at an altitude of 5600 feet, on a north-facing slope in the Little Thompson river valley. The location was distant from any RF source, including electrical power lines.

In the spring 2007, three treatment enclosures were established: RF shielded (Faraday-caged), mock-shielded, and unshielded. Nine aspen seedlings in gallon pots were placed in each treatment enclosure. All factors: light level, humidity, airflow and temperature were equal between the shielded and mock-shielded environments. The un-caged seedlings were exposed to higher light level (full sun), had higher air flow, and generally lower humidity, since they were not in a screened enclosure. After two months the RF-shielded group had produced significantly more active lead length and leaf area, and the average leaf size was significantly larger than leaf size in the two RF-exposed groups. Differences in growth between the mock-shielded and unshielded groups were slight and not statistically significant. In early October 2007, the shielded group's leaves turned a range of bright fall colors, and those leaves were substantially free of leaf fungus. At the same time, in the two exposed groups, leaves were green-yellow and a

high percentage of leaf area was affected by leaf fungus. It seems clear that RF pollution is having an adverse effect on growth and dormancy in aspen seedlings.
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Remote Sensing for Aspen Management
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Land managers in the western United States often lack fundamental information on the location, quantity, and status of aspen (*Populus tremuloides*) stands. This information is needed to plan, implement, and defend aspen restoration activities, but it is often difficult and costly to obtain. However, advances in remote sensing technologies can provide cost-effective ways to obtain spatial and quantitative information about aspen to support aspen restoration activities at national, regional, and field management levels. Spatial information, in the form of maps, documents the location of aspens and decline. Quantitative numerical information, derived from statistical samples, quantifies aspen occurrence, and decline. National and regional land managers can use the maps and quantitative information to increase awareness about aspen decline and help garner support and additional resources to restore aspen ecosystems. Remote sensing products can also help them prioritize the distribution of funds to those areas of greatest need. At the field level, remote sensing helps resource managers understand the problem and identify and prioritize areas for restoration treatments.

Key to using remote sensing for assessing aspen is collecting complimentary field data to relate ground conditions to aerial photography or satellite imagery. Field data should characterize the canopy as seen from above and account for the spatial resolution of the imagery as well as GPS, registration, and other positioning errors. In many cases, adjusting standard field sampling protocols slightly can satisfy both remote sensing requirements and standard field-sampling objectives.
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Summary of Recent Aspen Genetic Research in Utah
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Aspen are capable of reproducing sexually or vegetatively, although the proportion of these reproductive strategies varies across the species range. Throughout its range, aspen ramets are regenerated primarily via vegetative reproduction. Although viable seeds are produced, seedling establishment occurs only in a relatively narrow range of circumstances. This tendency toward vegetative reproduction is pronounced in the landscapes of intermountain western North America, leading to the establishment of large multi-ramet clones. The size and spatial distribution of clones is thought to be a function of age, inter- and intraspecific competitive interactions, disturbance frequency, and biotic or abiotic habitat components. Large clones and the paucity of observed true seedlings in western populations have led to the hypothesis that aspen in xeric regions may represent ancient genets which have persisted vegetatively since their establishment shortly after the last glacial maximum, or perhaps much earlier. We used genetic tools to quantify clones and map clonal boundaries in two Utah study areas: Swan Flats (Logan

Canyon) and Fish Lake. We found a surprisingly high number of genetically unique clones in both areas, most of which were represented by only 1-2 ramets on a 50m sampling grid. Furthermore, there were comparatively few somatic mutations detected within each clone, or genet. We conclude that sexual reproduction among aspen in our study areas is a stronger contributor to standing genetic diversity at the population level than the accumulation of somatic mutations. Sexual reproduction may well be rare and episodic, but is not a negligible process in these landscapes. Further, the low rate of somatic mutations suggests that sexual reproduction may be a current phenomenon in these xeric landscapes. Our data were not consistent with the presence of a few ancient clones dominating western landscapes, as has been the management paradigm for this species.
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Aspen forest health survey in Colorado, Wyoming, and South Dakota (proposed)
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Recent reports have indicated extensive aspen mortality throughout the western United States. Agency staffs, citizens, and politicians want recommendations regarding this situation. Information obtained from aerial surveys cannot tell us the severity of mortality, the condition of regeneration, or specific causal factors. In 2008 an aspen forest health survey will commence with the objectives to: 1) evaluate tree and regeneration (sapling and seedling) health; 2) quantify frequencies of causal agents as a percentage of individuals affected; 3) generate hazard/spatial distribution maps of the extent and severity of aspen mortality in the region; and 4) analyze hazard maps in relation to recent aerial detection surveys and meteorological, Forest Inventory and Analyses, and other data. Initially, 480 plots will be installed in the Black Hills, Bighorn, and Shoshone National Forests in South Dakota and Wyoming. Additional plots will be installed in 2009 and 2010 in the Medicine Bow National Forest (Wyoming) and national forests of northern Colorado. A sampling grid will be used to systematically select stands on national forest lands based on aspen vegetation type and accessibility. Two sets of 3 circular, permanent-plots will be established in each stand (three 1/50 acre for trees; three 1/500 acre for regeneration). At plot center, site information including elevation, stand age, slope, and aspect will be recorded. Variables recorded for trees will include species, diameter, and condition (living/dead), and for aspen trees crown health. For regeneration, species and number of living and dead will be recorded. Associated stress and mortality agents will be recorded for all aspen trees and regeneration.
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ASPEN ORGANIZATIONS

Northern Rockies Aspen Working Group

Tim Benedict, Helena National Forest, Helena, MT

The Northern Rockies Aspen Working Group was officially sanctioned February, 2007. Our vision is to become an inter-agency working group with direct collaboration with other regions, states, universities, and interested organizations. Our primary commitment is to work together toward restoration and enhancement of quaking aspen in the Northern Rockies and across the West. Our group activities were field trips of past fires and an Aspen Project, development of an aspen cover type map, and planning of an Aspen Workshop (10/1-3/08, Butte, MT). Sudden aspen decline (SAD) may be delayed in our region. A key element of SAD appears to be drought. Some indicators of drought are below normal precipitation (i.e. south central division of Montana) and snow levels and large sized fires in parts of Montana. We look forward to working collaboratively with the SAD investigators and others across the West to help all of us further our mutual goal of aspen restoration and enhancement.
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Western Association of Fish and Wildlife Agencies – Aspen Habitat Committee

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Several decades of research has shown the value and need to actively manage aspen ecosystems. Increasingly, ecologists, wildlife biologists, foresters, and other professionals within the Forest Service and Bureau of Land Management recognize the need to increase the scope of aspen restoration efforts. Yet while these agencies control most of the aspen in the West, they require state and local partners to sustain efforts over time. Because wildlife and water are public trust responsibilities of each state, the states have a resource obligation to better manage aspen communities, too. Given evidence that browsing by elk and deer in some instances may be reducing restoration success, the states play a pivotal role in ensuring science-based restoration activities are successful. While action is best accomplished locally, a west-wide, coordinated approach is needed to better provide a reliable source of funding for research and project implementation. Formal agreements, such as Memorandums of Understanding, for state and federal cooperation are also needed to ensure consistency of purpose across state and federal boundaries.

The purpose of the aspen sub-committee of the Western Association of Fish and Wildlife Agencies (WAFWA) Habitat Committee is to promote the long-term health and restoration of western aspen ecosystems in order to sustain fish and wildlife populations dependent on them by: 1) coordinating with regional and local aspen working groups regarding their aspen ecosystem restoration concerns or needs; 2) elevating aspen ecosystems management and funding as a high priority at federal, state, and local levels; 3) providing a forum for input by agencies and conservation partners that are actively engaged in aspen restoration; 4) providing a forum for states and provinces within the WAFWA to discuss and address aspen conservation issues; 5) increasing the public understanding and awareness of the functions and the public trust benefits of healthy, functional aspen ecosystems.

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Western Aspen Alliance

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Robert Campbell, Fishlake NF, Richfield, UT
Wayne Shepperd, Rocky Mountain Research Station (retired), Fort Collins, CO

A special session was held at the end of the Fort Collins SAD meeting to agree upon principles for initiating the Western Aspen Alliance. Twenty individuals from academic, management, and stakeholder communities agreed to move forward with the creation of Western Aspen Alliance (WAA). The overall goal of the WAA is to facilitate effective and appropriate management of aspen ecosystems in Western North America through coordinated scientific efforts and information transfer. Currently, the alliance is a partnership between the USDA Forest Service, Rocky Mountain Research Station and Utah State University's College of Natural Resources. Inclusion of other partners is a welcome and expected element of WAA's organizational outlook. Programmatic emphasis will be placed in the following five areas:

1. Communication: develop needs/expertise network, technology transfer, workshops/conferences, and publications.
2. Spatial assessments: determine the geographic extent of Sudden Aspen Decline (SAD), seral/stable aspen stands, and historic aspen coverage.
3. Basic research: stand structure, community composition, genetics, herbivory (wild/domestic), water yield, and biodiversity/trophic interactions issues.
4. Management/monitoring: approaches to sustainability, developing aspen-specific monitoring protocols, and utilizing existing monitoring databases.
5. Social: catalog aspen resources, evaluate economic contributions and potentials, and assess value/use.

We intend to form working groups based on these issues, as well as pursue additional aspen topics as they come to light. We welcome your input and participation!
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