

## **Final Report to the Joint Fire Science Program**

Announcement 2003-2, Task 3

Project Title: Effects of blowdown, beetle outbreak, and fire history on the behavior and effects of the 2002 fires in western Colorado

JFSP Project No. 03-2-2-01

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Project Location: Routt and White River National Forests, western Colorado

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### **BRIEF DESCRIPTION OF PROJECT:**

We examined relationships between pre-fire forest conditions and the behavior and effects of the severe 2002 fires in subalpine forests in Colorado. The study was based on high-quality and unique pre-fire data on the extent and severity of fires, blowdown, and beetle outbreak in areas of Routt and White River National Forests that were affected by the 2002 fires. The objectives of this research were to analyze and describe the influences of the pre-fire disturbance history on the extent and severity of the 2002 fires and ensuing forest recovery in subalpine forests of western Colorado.

Regional and landscape analysis of our pre-existing data and recent Forest Service spatial data sets of the 2002 fires were conducted in a Geographic Information System (GIS) for two study areas: the Routt Divide (RD) in Routt N.F. and the area of the Big Fish Lake (BFL) in the North Fork of the White River in White River N.F.. These analyses focused on the interactions between sites' disturbance history and the spread and severity of the 2002 fires. These two landscape-scale studies constitute the primary work of the project. A third study was conducted at the stand-scale to analyze the post-fire tree regeneration in relation to finer-scale disturbance history and fire severity as determined from the monitoring of permanent plots.

## SUMMARY OF FINDINGS TO DATE

### **1. Disturbance history and fire severity of the 2002 Big Fish Lake (BFL) fire in White River National Forest.**

We investigated the combined effects of past disturbances, current vegetation, and topography on spatial variability of the severity of a fire that burned approximately 4500 ha of subalpine forest during the extreme drought of 2002 in northwestern Colorado. Ordinal logistic regression was used to spatially model fire severity in relation to late 1800s fires, a 1940s spruce beetle outbreak, forest cover type, stand structure, and topography.

The late 1800s fires reduced the probability of burning in 2002, and the 1940s beetle outbreak slightly increased the probability of fire, particularly at high severity. Aspen (*Populus tremuloides*) and lodgepole pine (*Pinus contorta*) stands, which established after the late 1800s fires, were less likely to burn, whereas Engelmann spruce (*Picea engelmannii*)–subalpine fir (*Abies lasiocarpa*) stands were more likely to burn. The highest elevations (3100 m) had the lowest probability of burning, whereas intermediate elevations (2900–3100 m) had an increased probability of burning at high severity. The influences of the late 1800s fires and 1940s beetle outbreak on stand structure and forest cover type may be more important than their direct effects on fuels. The most important predictors determining fire severity were stand structure, forest cover type, the late 1800s fires, and elevation.

Although, in other studies, the effects of pre-burn stand conditions and topography declined with increasingly severe fire weather, in the case of the 2002 fire in Colorado, these predictors explained 42% of the variability of fire severity. Thus, these results suggest that pre-burn stand conditions are important influences on burn severity even for fires burning during extreme drought.

Full details of the findings are in Bigler, Kulakowski, and Veblen 2005 attached as Appendix 1.

## **2. Disturbance history and fire severity and spread of the 2002 Routt Divide (RD) fires in Routt National Forest.**

Disturbances are important in creating spatial heterogeneity of vegetation patterns that in turn may affect the spread and severity of subsequent disturbances. Between 1997 and 2002 extensive areas of subalpine forests in northwestern Colorado were affected by a blowdown of trees, bark beetle outbreaks, and salvage logging. Some of these stands were also affected by severe fires in the late 19th century. During a severe drought in 2002, fires affected extensive areas of these subalpine forests. We evaluated and modeled the extent and severity of the 2002 fires in relation to these disturbances that occurred over the five years prior to the fires and in relation to late 19th century stand-replacing fires.

Occurrence of disturbances prior to 2002 was reconstructed using a combination of tree-ring methods, aerial photograph interpretation, field surveys, and geographic information systems (GIS). The extent and severity of the 2002 fires were based on the normalized difference burn ratio (NDBR) derived from satellite imagery. GIS and classification trees were used to analyze the effects of prefire conditions on the 2002 fires.

Previous disturbance history had a significant influence on the severity of the 2002 fires. Stands that were severely blown down (66% trees down) in 1997 burned more severely than other stands, and young (120 year old) postfire stands burned less severely than older stands. In contrast, prefire disturbances were poor predictors of fire extent, except that younger (i.e., 120 year old) postfire stands were less extensively burned than older stands. Salvage logging and bark beetle outbreaks that followed the 1997 blowdown (within the blowdown as well as in adjacent forest that was not blown down) did not appear to affect fire extent or severity. Conclusions regarding the influence of the beetle outbreaks on fire extent and severity are limited, however, by spatial and temporal limitations associated with aerial detection surveys of beetle activity. Fire extent in these forests is largely independent of prefire disturbance history and vegetation conditions. In contrast, fire severity, even during extreme fire weather and in conjunction with a multiyear drought, is influenced by prefire stand conditions, including the history of previous disturbances.

Overall, our findings do not support the commonly held belief that bark beetle outbreaks and associated tree mortality increase the likelihood of subsequent fire occurrence.

Full details of the findings are in Kulakowski, and Veblen In Press attached as Appendix 1.

## **3. Post-fire tree regeneration based on monitoring of permanent plots.**

Forest recovery following disturbance varies with disturbance type and with forest composition. Although development following individual disturbances has been studied

in many subalpine forests, compounding disturbances can sometimes have unpredictable effects on ecosystem development, especially if the time between disturbances is insufficient for the ecosystem to recover from the initial disturbance. In 2003 we established 2,160 6.6-foot by 3.3-foot (2-m by 1-m) permanent plots to monitor regeneration in subalpine forests of Routt and White River National Forests. These plots were located in stands that varied in recent disturbance history (spruce beetle outbreak then 2002 fire; blowdown then 2002 fire; only 2002 fire) and in pre-fire forest type (aspen, lodgepole pine, and spruce-fir). We complemented these permanent plots with broad-scale sampling of regeneration.

Regeneration following the 2002 fires varied with pre-disturbance vegetation, which was largely shaped by prior disturbance history. The abundance of new stems (seedlings and ramets) was greatest in stands that were dominated by aspen, second highest in stands dominated by lodgepole pine, and lowest in stands dominated by spruce and fir prior to the fires. Regeneration also varied between similar stands that were affected by a single versus multiple disturbances. The abundance of new stems was greater in stands that were only burned in comparison to those that were blown down and then burned.

Despite the expectation that quaking aspen rarely establish successfully from seed, we found abundant establishment of aspen seedlings following the 2002 fires. We are currently analyzing the biophysical factors associated with this unusual episode of aspen establishment.

#### **4. Management implications.**

The management relevance of the scientific findings of this project and related research are summarized in the following two reports:

D. Kulakowski and T.T. Veblen. In review. Historical range of variability assessment for forest vegetation of the Routt and White River National Forests, Colorado. 117 pages. Draft HRV report. Appendix 3.

Romme, W.H., J. Clement, J. Hicke, D. Kulakowski, L.H. MacDonald, T.L. Schoennagel, and T.T. Veblen. 2006. Recent forest insect outbreaks and fire risk in Colorado forests: A brief synthesis of relevant research. Colorado Forest Restoration Institute, Report (refereed), 24 pp. Appendix 4.

The first report is currently under review by the Rocky Mountain Regional Office of the Forest Service and the respective National Forests. Following revision it will be reviewed by a panel of anonymous reviewers selected by the Ecological Society of America (under a contract with the FS), revised, and then published by the Colorado Forest Restoration Institute. We estimate that the report will be published in mid-2007, but the precise date depends on when we receive the reviews from the FS and ESA.

The second report is a joint venture between our research group at CU Boulder and a group at Colorado State University that was triggered by numerous requests for

scientific opinion on the implications of current bark beetle outbreaks for fire risk in Colorado forests.

The management relevance of the research conducted under this project has been communicated to federal land managers, the scientific community, and policy makers at numerous opportunities (see Presentations below). In September 2006, D. Kulakowski testified by invitation before the House Subcommittee on Forests and Forest Health. Kulakowski testified on the topic of the relationship between insect outbreaks and forest fires as it relates to proposed Congressional legislation aimed at mitigating fire hazard in the western US.

Table of Deliverables and Accomplishments

Deliverable	Accomplishment
1. Report on effects of pre-fire disturbance history and vegetation on the extent and severity of the 2002 fires	<p>1a. Peer-reviewed scientific article:</p> <p>C. Bigler, D. Kulakowski, and T. T. Veblen. 2005. Multiple disturbance interactions and drought influence fire severity in Rocky Mountain subalpine forests. <i>Ecology</i> 86:3018-3029.</p>
	<p>1b. Peer-reviewed scientific article:</p> <p>D. Kulakowski, and T.T. Veblen. In press. Effect of prior disturbances on the extent and severity of a 2002 wildfire in Colorado subalpine forests. <i>Ecology</i>.</p>
	<p>1c. Report to the Forest Service</p> <p>D. Kulakowski and T.T. Veblen. Historical range of variability assessment for forest vegetation of the Routt and White River National Forests, Colorado. 117 pages.</p> <p>In July 2004, this report was submitted to the Rocky Mountain Regional Office of the Forest Service for review by personnel from Routt and White River National Forests. Estimated publication date is July 2007.</p>
	<p>1d. Report</p> <p>Romme, W.H., J. Clement, J. Hicke, D. Kulakowski, L.H. MacDonald, T.L. Schoennagel, and T.T. Veblen. 2006. Recent forest insect outbreaks and fire risk in Colorado forests: A brief synthesis of relevant research. Colorado Forest Restoration Institute, Report (refereed), 24 pp.</p>

2. Report on the effects of pre-fire disturbance history and vegetation on forest recovery following the 2002 fires	Data are currently being analyzed and a manuscript will be submitted by November 2007
3. GIS layers of disturbance history will be made available to the respective National Forests	The GIS layers of the fire history (stand-origin maps) for the BFL and RD study areas were sent to White River and Routt N.F.s, respectively.
<b>Technology Transfer and Outreach</b>	
1. Linkage with Federal Cooperators	1a. At the initiation of the project we conducted a two-day field trip and workshop in the BFL and RD study areas with our two Federal Cooperators (C. Regan, A. Cadenhead) and other Forest Service Personnel.
	1b. We met with the Federal Cooperators in Denver, Boulder, and Glenwood Springs several times to discuss the progress of the project during 2004 and 2005. A. Cadenhead and other F.S. personnel provided FS GIS data layers used for part of our research.
2. Presentations	2004  T.T. Veblen, D. Kulakowski, and B. Kurzel. Ecology, issues and restoration in Colorado's aspen forests. Keynote Address to Colorado Forest Restoration Conference, Glenwood Springs, CO.  T.T. Veblen. Fire history and vegetation changes in Colorado forests. Keynote Address to the Colorado Elected Officials Wildfire Conference, Frisco, CO.

	<p>2005</p> <p>C. Bigler, D. Kulakowski and T. Veblen. Multiple disturbance interactions and drought influence fire severity in Rocky Mountain subalpine forests. Annual meeting of the Ecological Society of America.</p> <p>C. Bigler, D. Kulakowski and T. Veblen. Disturbance interaction and fire severity in Rocky Mountain subalpine forests. Annual meeting of the Association of American Geographers.</p> <p>D. Kulakowski. and T. T. Veblen. The effects of previous disturbances on the extent and severity of the 2002 fires in northwestern Colorado. Conference proceedings: The Association of American Geographers Annual Meeting.</p> <p>D. Kulakowski, T. T. Veblen, C. Regan, and C. Bigler. Effects of blowdown, beetle outbreak, and fire history on the behavior and effects of the 2002 fires in western Colorado. Joint Fire Science Program Principal Investigators Workshop. *Received award for the best presentation.</p> <p>T. Veblen, D. Kulakowski and C. Bigler. Spruce beetle outbreaks in Colorado. Bark Beetle Workshop (sponsored by U.S. Forest Service) at Snowbird, Utah</p>
	<p>2006</p> <p>D. Kulakowski and T. T. Veblen. Fire history altered stand susceptibility to spruce beetle outbreak in the 19th century in the Grand Mesa area, western Colorado. Conference proceedings: The Association of American Geographers Annual Meeting. Chicago, IL. March 7-11.</p> <p>T. Veblen. Historic range of variability of Colorado's forests. Workshop on Future Range of Variability in Colorado's forests. Glenwood Springs, CO</p> <p>T. Veblen. Fire history and historic range of variability in Colorado's forests. Longs Peak Chapter of the Society of American Foresters, Fort Collins.</p> <p>D. Kulakowski. Invited testimony before the House Subcommittee on Forests and Forest Health. United States House of Representatives, Washington, D.C.</p>

## APPENDICES

Appendix 1. C. Bigler, D. Kulakowski, and T. T. Veblen. 2005. Multiple disturbance interactions and drought influence fire severity in Rocky Mountain subalpine forests. *Ecology* 86:3018-3029.

Appendix 2. D. Kulakowski, and T.T. Veblen. In press. Effect of prior disturbances on the extent and severity of a 2002 wildfire in Colorado subalpine forests. *Ecology*.

Appendix 3. D. Kulakowski and T.T. Veblen. Historical range of variability assessment for forest vegetation of the Routt and White River National Forests, Colorado. 117 pages.

Appendix 4. Romme, W.H., J. Clement, J. Hicke, D. Kulakowski, L.H. MacDonald, T.L. Schoennagel, and T.T. Veblen. 2006. Recent forest insect outbreaks and fire risk in Colorado forests: A brief synthesis of relevant research. Colorado Forest Restoration Institute, Report (refereed), 24 pp.