# The Evolution and Application of Wildland Fire Assessments in Colorado

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**Abstract**

Wildland fire assessment is an attempt to use spatial analysis to highlight priorities for program management. The techniques rely on mapping risks, hazards and values, which are aggregated to determine treatment and attack priorities. The "Red Zone Map" has become a euphemism for the wildland urban interface in the State of Colorado. Completed in 1996, Colorado is among the first to conduct a state wide assessment. Since then, assessments have gone through several iterations and refinements. Along with evolution in process, fire policy has influenced the application of assessments to deliver key information in tactical applications, refinement of ecological classification, and landscape assessments for planning across jurisdictions. Interagency efforts are providing for effective use of spatial databases and techniques are being exported to other states. This paper examines techniques and traces the evolution in the use of strategic and tactical information and its critical influence on program delivery and cooperative efforts in fire management.

**Introduction:** Along with much of the western United States, Colorado has continued to experience an increasing impact of wildland fire. It contains a wide range of fire regimes from short to long return intervals, influenced by weather patterns, topography and fuel loading. With some exception in grassland systems, public land ownership and forest cover types make the western two thirds of the state an area of increasing concern with the continued urban expansion. Land managers face increasing pressure to deal with suppression, prevention and fuels treatments in light of interface communities and a wide range of public attitudes.

Fire history in the state includes a series of fire fighter fatalities that influenced the evolution of fire policy. Battlement Mesa, Vaughan Lake, South Canyon, Missionary Ridge, Big Elk and Hayman are among incidents that have contributed to the emotional legacy that continues to influence fire managers across the country. The South Canyon Investigation, Interagency Management Review Team, Fire Management Reviews for both the USDA Forest Service and Colorado Bureau of Land Management, citations from the Occupational Safety and Health Administration continue to have profound impacts. Detailed reviews of the Hayman and Missionary Ridge Fires provided insights on fire behavior, impacts to communities and assessments of the impacts of previous fires and fuels management on the fire spread. The resulting evolution of fire policy placed a key emphasis on fire fighter and public safety, recognized the role of fire in maintaining ecosystem functions and processes. It has also identified the need to reduce the fuel loading and to address issues across landscapes regardless of jurisdictions

**Background:** In 1996, an interagency group developed a pilot project to conduct a wildland fire assessment on a state wide basis. The project was developed in part to respond to the Federal Wildland Fire Program and Policy Review which directed federal land management agencies to "jointly establish an accurate, compatible and accessible database of fire and

ecosystem related data" as a basis for fire management and fire reintroduction decisions. The project established a platform for agencies and states to work together to develop plans that address the needs regarding health of the landscape, the needs of affected communities and a tool to communicate about fire management to the public. Project partners included representatives from the Bureau of Land Management, the National Park Service, Colorado State Forest Service and the USDA Forest Service.

The goal of the project was to address three key land management questions:

- Where can we tolerate fire and what can we do to promote the natural role of fire?
- What are the probabilities for catastrophic fire and how do we improve preparedness?
- What are the opportunities to increase efficiency and avoid redundancy?

The effort resulted in the production of the Colorado Statewide Assessment, the first attempt to apply assessment techniques to address fire issues at that scale. It demonstrated that agencies can cooperate and though challenging, various databases can be integrated. Constructed in a Geographical Information System (GIS) database, it quickly identified areas with the highest risk of catastrophic impacts by wildland fire. Public safety and property protection continue to identify areas of wildland urban interface as among the highest risk for damage and loss. Mapped in red, these areas continued to be referred in the local vernacular as "the Red Zone".

**Process:** Disaster management focuses on the key points of readiness, response and recovery. The essence of capability often lies in the ability of managers to triage. Planning, both strategically and tactically are critical for success and the elements of risk assessments are proving to have common denominators. While techniques and objectives may differ, the risk assessment process shares a common approach. At its core, risk assessments are an iterative process that includes the mapping of risks, hazards and values. The process ranks and aggregates map layers within the landscape to develop sensitivity, goals and priorities. The Colorado experience includes this basic approach.

Risk can be defined as the probability of the event. It is a compendium of fire occurrence and ignition patterns. Hazard is defined as the characteristic of the event. They include physical or biological features, which result in similar fire behavior characteristics. Derived from topological maps, vegetation maps and fuels inventories it provides an indication of flammability and allows for a composite map of fuel type and condition. Values are those that are affected, either positively or negatively by the event. Ranking can be based on quantifiable and detailed date if it is available. An ordination process, it allows for combining databases of different standards, an important consideration for interagency planning and cooperation. Simplicity in the ranking process remains the trademark and the attraction of the process. Given a set of criteria, it relies on planners to develop a relative ranking of high, moderate or low for each mapping layer. Sensitivity of the assessment may be increase by adding a ranking of extreme. Layers are then aggregated to provide a comprehensive view of existing conditions and provide an indication of areas of greatest exposure. It can be designed at various scales to provide tiered planning, linking resource needs, community values and managerial issues.

**Application:** The process compiles a common data base for interagency planning and allows for linkages to be made among various levels of planning resolution. Its strength is in its simplicity and adaptability. In large part its simplicity and the ability to reach basic

conclusions easily and the visual aspect of its products makes it easy to explain and comprehend. Fire managers and administrators can better refine program objectives, integrate resource needs and determine the best investments of limited funding. At the largest scales it provides for interagency planning, allows for a broader assessment of off site effects and assists in identifying critical linkages across administrative boundaries. At midlevel resolutions it provides a means to refine program objectives and priorities, land allocation. At the finest resolutions it forms the basis for emergency responses in what is often dynamic and complex situations, sets the parameters for management prescriptions and offers a record of project accomplishments. Utilizing the emerging technology in information systems, the process lends itself well to refined analysis of complex landscapes and fire modeling. Participants can begin the process with existing data and refine it as new, better or different data becomes available. It serves as a strong communication tool among, fire practioners, resource specialists and managers. More importantly, it provides a forum to interact with affected publics, legislators and local agencies to surface concerns regarding public safety and the array of fire tools.

Current natural resource policy continues to press for change in approaches to land management. There is an increasing demand to view effects on landscapes and understand linkages between ecosystem functions and processes. Discussions regarding historical range of variability, concepts of lethal versus non lethal fire, fire return intervals, severity of disturbance, forest health, all contribute to attempts to identify areas at risk. As a result there are numerous attempts at ecological assessments with varying criteria and at various scales. Habitat conservation, connectivity, levels of sustainability, watershed condition, invasive species, impacts of various land uses, continue to press change and place demands for alternative solutions. Off site affects, down stream impacts and the management of smoke are but a few examples of the increasing complexity of fire planning. When you factor social concerns, values of stakeholders and agency mission and culture, the task can become daunting. Our continuing concern lies in the fact that many assessment efforts are independent of each other. There is no obvious acceptance of protocols, terminology or common focus. Often, information is used to support biased conclusions or applied beyond the intent of the assessment. We believe interagency planning and implementation remain crucial to successful management of fire, both wild and prescribed, Varying agency budgets, missions and scope make it imperative that planning techniques focus on common denominators. Developing analysis techniques which allow for inclusion of differing data standards remain a key to multiple scale, multiple agency planning. We further believe that planning should be a process not a product. As such, adaptive management techniques will continue to refine a common approach. We believe the Fire Assessment process that we have outlined offers the frame work for spatial analysis, linking strategic and tactical plans. Its serves as a vehicle for leveraging energy, funding and linking mission capability to ecological need.

**The Colorado Experience:** Evolution in fire policy and management direction continues to influence the use and application of risk assessments. The statewide effort in 1996 continues to serve as a foundation. In 1997, the National Office for the Bureau of Land Management issued direction for all State Offices to conduct a Level I Analysis. The objective of the analysis was to streamline and articulate preplanned suppression response, identify areas for application of prescribed fire and strengthen the linkages of fire management to Land management Plans. The BLM Level I analysis served as a basis for refining the values layer.

Resource specialists, not fire planners built the layer. In summary, it asks other resources specialist to categorize the landscape into four classes based on the relative tolerance to fire. They range from:

- Where can you not tolerate any fire? These areas require full control in suppression actions and would not be conducive for prescribed fire.
- Were can you tolerate fire with active suppression? These areas offer a wider range of suppression options and may tolerate some prescribed fire activity aimed at hazardous fuel reduction.
- Where is fire compatible with management goals and activities? These areas have resource management objectives that are enhanced by the use of fire.
- Where is fire essential part of ecosystem function and processes? While we recognize fire remains a key component of all ecosystems, these are areas in which administrators can exercise the full range of appropriate management responses and offer options for areas of large scale reintroduction of fire, naturally or by management ignition.

In short, the effort demonstrated the effective use of common planning techniques and decision criteria. The process identifies joint opportunities and priorities. Furthermore, it provides stakeholders with a consistent approach to the landscape.

In 1996 a group of scientists, specialist and managers gathered in Pingree Park, Colorado, for an Indexing Resource Data Workshop. The group was brought together to address the risk of fire to watershed, habitats, air quality, and effects of fire on people and forest. It also explored approaches to mapping ecological attribute, disturbance regimes and modeling for emissions. The collective effort was focused on the mountainous western portion of Colorado. While its approach was cantered around watersheds, it extracted some of the basic fire modeling from efforts conducted in State wide assessment. The work confirmed that "existing resource data can be used to estimate and portray wildfire hazards and risks in sufficient spatial detail to be useful as a strategic planning and communication tool…" (Sampson, et al, 2000)

The workshop and the publication encouraged a look at assessments at a finer resolution. Following an active fire season in 2000, The Colorado State Forest Service attempted to apply the same process in what was termed, mid-level assessments. Concurrent with the effort there was a growing interest to generate community based fire management planning. The State Office of the Bureau of Land Management in concert with Colorado Counties Incorporated spearheaded the effort. Efforts continue to refine planning and more importantly engage a wider cross section of stakeholders, agencies and representatives of local governments.

At the onset of the 2000 fire season, there was a growing interest in obtaining "real time" information of major fires on the national scale. A series of Federal agencies and technical specialist built GEOMAC, a web based system that provided mapping databases for major fires reported through the Incident Reporting System, from the National Interagency Fire Center in Boise. It had no direct bearing on the application of assessments but the product was developed and archived with US Geological Service, here in Denver. The principles attached to that project imported ideas, applications and techniques in further refining fire assessments. Experiences gained and refinements in data layers allowed us to explore wed

based applications. As a result the Rocky Mountain Region became the first to display its fuels management program on a web database, accessible to stakeholders.

Nationally, USDA Forest Service prepared a report to the Government Accounting Office (USDA (2000). The Cohesive Strategy articulated the agency's focus on the need to address hazardous fuels reduction with a deliberate focus on community protection, watershed condition and species viability. More importantly, it directed the agency to fund and build its program on fire regimes and condition classes. All of those elements were present in the State, most critically on the Front Range of Colorado. With efforts already underway at large watershed projects, there was an opportunity to apply those concepts on the ground. The upper drainage of the South Platte River became a focal point for a collective, interagency effort. As projects expanded, fire ecologists introduced a fuels classification system based on fire regimes and condition classes. Fire regimes, defined by fire return intervals and general vegetative association. Condition classes based on how many fire cycles were missed. While all those efforts continue to be refined, it added to the ability to build a broad and interagency database.

To support the Cohesive Strategy and national-level fire planning and risk assessment (Schmidt et. al. 2001) produced seven, coarse-scale, 1-km 2 resolution spatial data layers. Four of these layers were developed to evaluate ecological conditions and risk to ecosystem components:

- Potential Natural Vegetation Groups, a layer of climax vegetation types representing site characteristics such as soils, climate, and topography.
- Current Cover Type, a layer of current vegetation types.
- Historical Natural Fire Regimes, a layer of fire frequency and severity.
- Fire Regime Current Condition Class, a layer depicting the degree of departure from historical fire regimes, possibly resulting in alterations of key ecosystem components.

The remaining three layers were developed to support assessments of potential hazards and risks to public health and safety:

- National Fire Occurrence, 1986 to 1996, a layer and database of Federal and non-Federal fire occurrences.
- Potential Fire Characteristics, a layer of the number of days of high or extreme fire danger calculated from 8 years of historical National Fire Danger Rating System (NFDRS) data.
- Wildland Fire Risk to Flammable Structures, a layer of the potential risk of wildland fire burning flammable structures based on an integration of population density, fuel, and weather spatial data.

Fire Regime Condition Class (FRCC) describing the degree of departure from historical fire regimes was developed to assist Managers to describe regional trends in current conditions and to support fire and fuel management program development and resource allocation.

The 2000 Fire Season was also instrumental in placing national focus on the issues of cost of suppression and the impacts to the communities. After a series of reports and reviews, the National Fire Plan was born. It was focused on the following key points: Increasing fire fighting capability; rehabilitate and restore lands affected by wildfire; expand the effort in fuels management; provide assistance to communities and provide for accountability. Federal

agencies and a host of state partners revived their efforts with program funding delivered by the plan. The Western Governor's Association became an integral player and in turn released a companion effort entitled: 10 year Comprehensive plan. These two plans became critical in the focus and development of program through the West. Critical to policy makers, managers and stakeholders was how to focus on areas of highest risk. Several iterations had already occurred in Colorado and refinements included population density, broader scale application of fuels conditions and locations of planned projects.

**Fire Ecology:** At the mid-scale a pilot project was conducted in the Trout and West Creek watersheds of the Pike-San Isabel National Forest in Central Colorado. Maps and interpretations were developed to support prioritization, planning, and effects analysis for fuel and ecosystem restoration to achieve National Fire Plan Cohesive Strategy objectives (Strohm and Hann 2002 in press)

The Trout West Planning area is characterized primarily by Ponderosa Pine and Douglas-fir. Based on the national definitions of Fire Regime (Table 1) the planning area was divided in Fire Regime Potential Vegetation Types (FRPVT). Then the vegetation development dynamics tool (VDDT) (Beukema and Kurz 2001) was used as the platform for a standardized succession and disturbance model to develop an estimate of the historic range of variation (HRV). The HRV represents the natural landscape dynamics that would occur without active fire suppression and other modern anthropogenic influences over a long time period under the current climate.

**Table 1 - Natural (Historical) Fire Regime Classes**

Natural (historical) fire regime classes from Hardy as interpreted by Hann and Bunnell for modeling landscape dynamics for National Forests and Grasslands in the lower 48 states: (Hann and Bunnell 2001)

| Fire Regime Class | Frequency (Fire Return Interval) | Severity | Modeling Assumptions |
|---|---|---|---|
| I | 0 - 35 years, Frequent | Low | Open forest or savannah structures maintained by frequent fire; also includes frequent mixed severity fires that create a mosaic of different age post-fire open forest, early to mid-seral forest structural stages, and shrub or herb dominated patches (generally < 40 hectares (100 acres)). |
| II | 0 - 35 years, Frequent | Stand Replacement | Shrub or grasslands maintained or cycled by frequent fire; fires kill non-sprouting shrubs such as sagebrush which typically regenerate and become dominant within 10-15 years; fires remove tops of sprouting shrubs , which typically resprout and dominate within 5 years; fires typically kill most tree regeneration. |
| III | 35 - 100 | Mixed | Mosaic of different age post-fire open forest, early to |

| Fire Regime Class | Frequency (Fire Return Interval) | Severity | Modeling Assumptions |
|---|---|---|---|
| | years, Less Frequent | | mid-seral forest structural stages, and shrub or herb dominated patches (generally < 40 hectares (100 acres)) maintained or cycled by infrequent fire. |
| IV | 35 - 100 years, Less Frequent | Stand Replacement | Large patches (generally > 40 hectares (100 acres)) of similar age post-fire shrub or herb dominated structures, or early to mid-seral forest cycled by infrequent fire. |
| V | > 100 years, Infrequent | Stand Replacement | Large patches (generally > 40 hectares (100 acres)) of similar age post-fire shrub or herb dominated structures, or early to mid to late seral forest cycled by infrequent fire. |

Existing vegetation was assessed and a values layer based on land use and housing density was developed. Utilizing a variety of tools (Spatial Tools, Arcview, Arcinfo, Excel), a comparison was made between HRV and current vegetative conditions within each FRPVT. The cumulative similarity of all classes between the two was calculated to derive the overall Condition Class of the FRPVT. A "Priority Treatment" map that displayed the areas contributing significantly to overall departure, that are most likely in need of fuels reduction treatments was prepared. (Strohm and Hann 2002 in press). The priority of treatment was based primarily on ecological condition (Table 2) and the need of restoration treatments. In short return interval fire regimes such as Ponderosa Pine and Douglas-fir departure from HRV can be successfully used as a surrogate for hazard to identify priority treatment areas.

**Table 2 - Condition Classes**

Condition Classes from Hardy as interpreted by Hann and Bunnell for modeling landscape dynamics and departure from historical (natural) range of variability for National Forests and Grasslands in the lower 48 states:

| Class | Departure from Historical or Natural Range of Variability | Description |
|---|---|---|
| Condition Class 1 | None, Minimal, Low | Vegetation composition, structure, and fuels are similar to those of the historic regime and do not pre-dispose the system to risk of loss of key ecosystem components. Wildland fires are characteristic of the historical fire regime behavior, severity, and patterns. Disturbance agents, native species habitats, and hydrologic functions are within the historical range of variability. Smoke production potential is |

| Class | Departure from Historical or Natural Range of Variability | Description |
|---|---|---|
| | | low in volume. |
| Condition Class 2 | Moderate | Vegetation composition, structure, and fuels have moderate departure from the historic regime and predispose the system to risk of loss of key ecosystem components. Wildland fires are moderately uncharacteristic compared to the historical fire regime behaviors, severity, and patterns. Disturbance agents, native species habitats, and hydrologic functions are outside the historical range of variability. Smoke production potential has increased moderately in volume and duration. |
| Condition Class 3 | High | Vegetation composition, structure, and fuels have high departure from the historic regime and predispose the system to high risk of loss of key ecosystem components. Wildland fires are highly uncharacteristic compared to the historical fire regime behaviors, severity, and patterns. Disturbance agents, native species habitats, and hydrologic functions are substantially outside the historical range of variability. Smoke production potential has increased with risks of high volume production of long duration. |

**Front Range Partnership:** June 2002, brought about a substantial impact to the Interior West. The status of "largest fire in state recorded history" was noted in five Western States. In Colorado, the Hayman Fire, Missionary Ridge Fire and the Mt Zirkle Complex, could each have claimed that status. The Hayman Fire affected four counties and impacted municipal water to the city of Denver. Its impact brought focus to an effort that has come to be known as the Front Range Fuels Partnership. More importantly it brought together the Pike/San Isabel NF, the Arapaho/Roosevelt NF and the Colorado State Forest Service to deal with issues in an unparallel scale. Running for over two hundred miles long and 50 mile wide it forced agencies to provide a seamless planning effort and commonality in approach. Two critical efforts influenced the use of spatial analysis. First was the recovery of the dramatic Hayman Fire. After a scientific review of fire behavior, impacts to communities, the enormous effort of rehabilitation began with need to identify burn severity, slope stabilization, revegetation, flash flood warning and removal of hazards. Second was a large scale assessment to deal with the entire Front Range. Fire risk assessments served as a foundation of the effort which included hydrology, habitat protection, community protection, land use patterns, land ownership and various other efforts to refine the analysis. The project evolved into an interagency effort which chartered the Front Range Fuels Partnership. In 2002 the Colorado model was shared with Wyoming which adopted the process to refine state and county planning efforts for fire response and mitigation efforts. Similar efforts have been conducted in Utah, Maryland, New York and California.

**Future:** The effort has been expanded to determine the scope and scale of issues at a regional level. Managers directed fire ecologists, technical specialists and planners to lead the next effort to look at the extent of insect and disease infestations, critical habitat requirements, and watershed priorities, overlaid on the latest fire risk assessment. The objective is to look at overall land health and build strategic plans to address and ever increasing threat to forested lands. By looking broadly at a five state region managers hope to first prioritize and focus efforts in areas with greatest risk of loss or impact. It hopes to streamline planning and investments of funds and skills to address areas and programs with greatest need. It is hoped that the region will key in on several areas of large scale partnerships, thereby increasing effectiveness of coordinated treatments.

There are a number of efforts to underway to determine priorities and needs for land management. Use of remote sensing and spatial analysis continue to evolve and expand refinements in the application of assessments.

The Fire Regime Condition Class(FRCC) concept is now a fundamental theme in fire management planning direction, performance measures, and accomplishment reporting for fuels treatment projects. National direction requires that a process for measuring and describing FRCC's be applied during land management planning or in the initial stages of project planning by an interdisciplinary team.

At the National Level a Interagency project called LANDFIRE – has been initiated to provide the "spatial data and predictive models needed by land and fire managers to prioritize, evaluate, plan, complete, and monitor fuel treatment and restoration projects, essential to achieving the goals targeted in the Cohesive Strategy and National Fire Plan" (USDA FS and USDI 2002)

The spatial data and predictive models are to be designed so that they can be used for various levels of management, from the national level (coarse scale) to the local level (fine scale). The
LANDFIRE products can be broken into three main groups: 1) maps that characterize vegetation and fire regimes, 2) maps that characterize fuel conditions, and 3) maps and models used to evaluate ecosystem status and fire hazard and potential status. (USDA FS and USDI 2002).

Recently, to provide national, uniform guidance for implementing provisions of the Implementation Plan for the 10-Year Comprehensive Strategy and the *Memorandum of Understanding for the Development of a Collaborative Fuels Treatment Program* the Wildland Fire Leadership Council agreed upon a process to establish broad, nationally compatible standards for identifying and prioritizing communities at risk. The Council agreed to use the NWCG publication *"Wildland/Urban Interface Fire Hazard Assessment Methodology"* as a reference guide in developing a risk assessment process for communities,. At minimum, Fire Occurrence (risk), Fuel Hazard, Values to be Protected (Values at Risk) and Protection Capability will be evaluated to assess the relative degree of exposure each community (landscape) face. (NASF 2003)

**Conclusion:** The Rocky Mountain Region is developing protocols for large scale rapid assessments with foundations in risk assessment processes to determine a wide variety of issues. From land health, use patterns, to critical habitat needs, and the impact of invasive species, all stemming from fundamental process used to determine relative risk of fire. We

believe the assessment process has served to bring databases and varying data standards to a process to support both strategic and tactical decision making.

We remain guarded about extending conclusions beyond the limits of the information generated. In some cases the pictures that are painted by various map layers lead others to arrive at decisions beyond the intended analysis. In an era where speed of information is complied and quickly moved, we remain concerned about standards and protocol. We try to portray that the value of the exercise is not in generating map products but the power of spatial analysis and relational databases.

It remains a challenging and rewarding endeavor. What started as a means to identify fire risk, attack planning and treatment priorities, now serve as a foundation for determining land health. What started as an effort to provide strategic fire planning has generated a relative tolerance for ecosystem disturbance with an increasing array of resource disciplines. What started as a fire planning project has now served as a basis for multivariate analysis, spawned a series of interagency partnerships and provided a means to engage stakeholders. It has indeed become a process, well beyond its original envisioned product.

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