Prescribed Fire Lessons Learned

Escape Prescribed Fire Reviews
and
Near Miss Incidents

Initial Impression Report

June 29, 2005

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Submitted to
Wildland Fire Lessons Learned Center

Summary of Escaped Prescribed Fire Reviews and Near Miss Incidents

What key lessons have been learned and what knowledge gaps exist?

Introduction

This analysis is the first known attempt to take a comprehensive look at escaped prescribed fire reviews and near misses. A total of 30 prescribed fire escape reviews and 'near misses' (see Appendix A and B) were analyzed to discover what, if any reoccurring lessons were being learned, or whether they were indicating emerging knowledge gaps or trends. It is estimated that Federal land management agencies complete between 4,000 and 5,000 prescribed fires annually. Approximately ninety-nine percent of those burns were 'successful' (in that they did not report escapes or near misses). This can be viewed as an excellent record, especially given the elements of risk and uncertainty associated with prescribed fire. However, that leaves 40 to 50 events annually we should learn from. This report is intended to assist in that effort.

Evaluating formal reviews and After Action Reviews (AAR) can be a tool for burn personnel to expand their knowledge and supplement their own direct experiences. When reviews go beyond policy and accountability questions they can provide information that can add to our own direct experiences by broadening exposure to what can occur. Learning from other experiences may help avoid undesired outcomes.
The intent of this report is not to point out 'wrong decisions', but rather it is to use all these individual 'events' to see if there are common themes and/or 'weak signals' occurring with these escapes and near miss events. The main focus of the analysis was to look for things prescribed fire practitioners could use as they prepare for future prescribed fires. Are there some factors that prescribed fire planners and/or burn bosses have been repeating in isolation? If so, what should be shared with others involved in the planning and execution of prescribed burns to continue to improve outcomes?

Methods

Three questions drove this inquiry: Can comparing these reviews allow us to glean important or emerging trends? Can these reviews help all agencies to learn? and Are we asking the right questions? Next, I posed three straight-forward questions: of the analysis addresses straightforward questions. Are there common reported 'causes' contributing to the escapes/near misses? Are there repeated findings and 'lessons learned' cited in the reviews? What are these? Lastly, I looked for potential emerging trends or patterns gleaned from collectively evaluating all the reviews. The trends or patterns may indicate a 'blind spot' that was not previously apparent without looking at all the reports together as opposed to an individual basis.

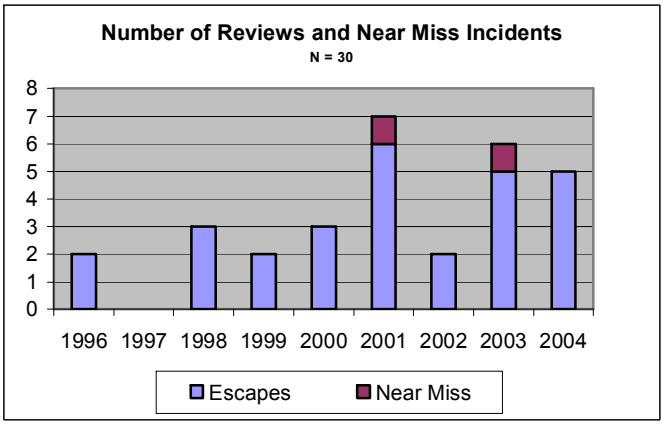
The Dataset

Formal and information documentation from four federal land management agencies (FS, BLM, NPS and FWS) was evaluated in this assessment. Unlike the BLM, the FS did not appear to have a consistent formal review and documentation process. Both the FWS and NPS had too few samples collected to determine their questions and processes, even though current policies for these agencies provide a standardized process

I reviewed 30 reports written for escapes or near-misses that occurred between 1996 and 2004. Only documents submitted to the Wildland Fire Lessons Learned Center (LLC), collected from agency websites by agency personnel, or located in personal 'collections' were used in this assessment (see Figure 1). It is unknown where and how many other reports may be available. This is an indicator that knowledge is not commonly retained and shared from these experiences so agencies have a greater likelihood of repeating 'mistakes.'

Of these 30, most were formal escape prescribed fire reviews, several were draft review documents one was in a power point presentation, and two were After Action Reviews (AAR) of 'near miss' incidents. Most often the review was conducted at the request of an agency administrator following agency policy. The two 'near misses' were not declared escape prescribed fires, but the After Action Reviews provided valuable insights so were included in this analysis.

Figure 1 Number of reviews by year used in this analysis from 1996 to 2004



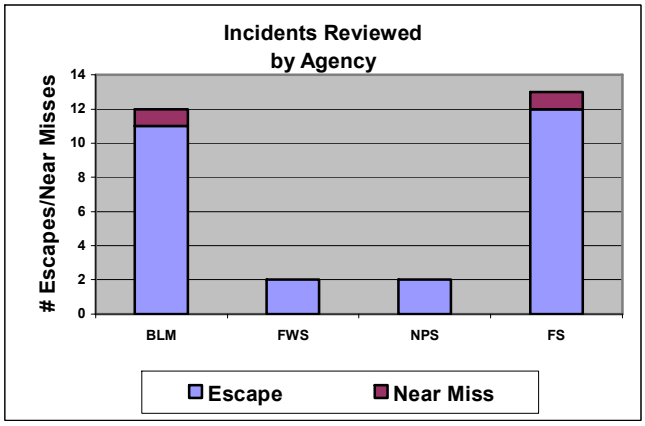
NOTE:
It should not be construed that the years are problematic years since not all agencies systematically report escapes or near misses.

Geographic area covered includes: several regions of the Forest Service including Northern Rockies (R1), Rocky Mountain (R2), Southwest (R3), Intermountain (R4), Pacific Southwest (R5), Southern (R8) and Alaska (R10). Reviews from Department of Interior agencies including BLM District and Field Offices; National Park Service units; and Fish and Wildlife Service were also used (see Figure 2). The states in alphabetical order (and number of reviews from each state) include Alaska (1), Arizona (5), California (3), Colorado (1), Florida (1), Idaho (2), Kansas (1), Montana (1), Nevada (1), New Mexico (3), Oregon (1), South Dakota (1), Utah (6) and Wyoming (3). Several vegetation-fuel complexes discussed in the reviews including: ponderosa pine, mixed conifer, and sub-alpine fir, pinyon/juniper, chaparral, sagebrush/aspen, oak brush, grass, and activity fuels (slash).

The escapes or near miss incidents span from February to October. Most of the escapes were ignited in May (7) and June (5). Both near miss incidents occurred in September. Due to the many geographic areas represented in the sample it was not possible to evaluate any trends related to season. The amount of acres planned for ignition ranged from less than 5 acres up to several thousand acres for individual burn blocks. Several of the more recent escapes involved ignitions on multiple large-scale burn blocks.

Figure 2 Number of reports by agency used in this analysis.

NOTE:
It should not be construed any one agency has more or less escapes than another since escapes and near misses are systematically reported.



NOTE: this analysis evaluated 30 total events, 28 of which were escapes over a nine-year period or an average of 3 per year (less than 8% of the estimated 40 to 50 escapes occurring annually on average). Of the 99% 'successful' burns we, as an 'organization' have no idea about the 'near misses' and 'successful saves' that have occurred. Many other escapes and near misses have occurred, but it is unknown how much formal or informal documentation exists from which we could gain experience. Of the thirty reports evaluated, several mentioned other escapes and near miss events, but only one report (one of the near misses) could be connected to another escape prescribed fire reviewed during this analysis. However, several escaped prescribed fire reviews involved multiple landscape-sized projects ignited either simultaneously or days apart, so they were covered in one review document.

Background

The concepts of a High Reliability Organization fit with the planning and execution of prescribed fire

A High Reliability Organization (HRO) is one that experiences less than it's fair share of incidents. Being and acting like a HRO should apply to organizations using prescribed fire to accomplish land management objectives. The use of fire is a high-risk business that operates in a highly variable environment yet needs to produce reliable outcomes. The excerpts provided below from *Managing the Unexpected* (Weick and Sutcliffe 2001) are here to set the context. This analysis is an initial attempt at applying the practices and principles and practices of how a HRO would evaluate escaped prescribed fires and near miss incidents.

All High Reliability Organizations Heed Close Calls and Near Misses

(from Keller October 2004)

High Reliability Organizations:

Regard close calls and near misses as a kind of failure that reveals potential danger, rather than as evidence of the organization's success and ability to avoid danger. They pick up on these potential clues early on—before they become bigger and more consequential.

Know that small things that go wrong are often early warning signals of deepening trouble that provide insight into the health of the whole system.

Treat near misses and errors as information about the health of their systems and try to learn from them.

Are preoccupied with all failures, especially the small ones.

Understand that if you catch problems before they grow bigger, you have more possible ways to deal with them.

There are five practices of a HRO that can be grouped into two functional categories (Weick and Sutcliffe 2001).

Mindful 'Anticipation' of the Unexpected
Preoccupation with Failure
Reluctance to Simplify
Sensitivity to Operations

Mindful 'Containment' of the Unexpected
Commitment to Resilience
Deference to Expertise

Results

What questions are being asked in an escape review ?

Since reports were often generated to meet agency direction the questions mostly focused on policy and accountability issues. The most common questions were:

A. Is agency policy, guidance and/or direction adequate? Was is followed?

Initial observation – Most of the reviews determined that good or sound policy and guidance existed. However, when review teams looked at whether policy was followed, the answer was not always a yes. In a few cases, review teams also compared the local level direction relative to national direction. In at least four cases the finding was the same. The local direction was not consistent or was outdated relative to existing national direction at the time of the escape.

B. Was the burn plan prepared and executed relative to agency policy? Was it a 'good' plan?

Initial observation – Few reviews concluded that burn plans did not meet policy. However most listed several weaknesses or noted parts missing in burn plans. Common areas cited as weak within the burn plans included complexity and risk assessments, and thoroughness of the ignition, holding and contingency plans. Another reoccurring issue was the lack of fire behavior calculations. Sometimes the fuel model did not accurately represent the fuels and potential fire behavior of the burn area. The fuel model selected generally under-predicted potential fire behavior. Another reoccurring problem was that all the fuel types within the burn area were not evaluated and incorporated into the burn plan. Some of the reviews also noted that burn personnel failed at times to follow what was in the burn plan. This includes obtaining spot weather forecasts or monitoring weather and other prescription parameters for the timeframes specified prior to ignition. Not all procedures were followed during execution. Reviews noted that required documentation was often poor or lacking.

C. Was the planning and execution of the prescribed burn done by qualified personnel?

Initial observation –In only two of the reviews were questions concerning the qualifications of burn personnel an issue. In one case the burn boss was from another agency so the reviewing agency was uncertain if the individual was qualified and needed to verify qualification documentation with the other agency. In the other case, the question was whether proper certification procedures were followed. However, several of the reviews noted that burn bosses, while 'qualified', were often 'inexperienced' with the fuel type(s), which contributed to the escape of the prescribed burn.

In addition, I noticed a trend towards including questions beyond policy, accountability and qualifications. Such reviews are moving toward 'lessons learned' and what needs to be improved and applied to future projects. Two reports included in this analysis did not involve an escaped prescribed fire, but shared near misses which indicates a movement beyond focusing on accountability.

Other Observations

Other questions raised were developed based on issues that were specific to that particular event. However, it was interesting to note there were some common themes among those areas evaluated by review teams. At least 10 of the 28 escaped fires burned onto private ground. Therefore, one area added on often looked at how well collaboration, communication and coordination occurred with the public and between cooperating agencies.

Not all reviews evaluated the linkage of the environmental document to the burn plan. Often when this was done there were missing mitigations from the NEPA document that were not incorporated into the burn plan.

All stopped at the point of looking at actions beyond the escape although most noted that there was safe and successful transition from the prescribed fire to suppression actions.

Agencies are not yet fully behaving as a learning organization -- escapes and near misses are not systematically and routinely reported, evaluated, and shared.

What are the Common 'Surprises'?

The 'surprises' came in three areas – Fuels and Fire Behavior, Weather and Communication and Coordination. Many prescribed fire practitioners have already experienced one or more of these types of 'surprises' possibly all on the same prescribed burn whether the burn escaped or not. Several of the prescribed fire reviews and near misses expressed 'surprise' about the fire behavior they saw from the various vegetation-fuel complexes. In some cases, the personnel involved with the burn knew to expect something different than what models predicted, but the fire behavior (either rate of spread and/or flame lengths) was not even imaginable. A re-occurring theme mentioned by the reviews was that many escapes occurred because conditions were not 'normal' (e.g. periods of drought, warmer and drier than normal). When burns were implemented, burn personnel 'failed to adjust operational procedures' to account for the 'abnormal' conditions.

Since surprises, expectations and the ability to manage the unexpected are linked together; therefore it is important to focus on what surprised burn personnel, and why. In *Managing the Unexpected* Weick and Sutcliffe (2001) state that 'surprises' come in many different varieties. Prescribed burn personnel have experienced many of the 'varieties of surprise' listed below. Weick and Sutcliffe describe what can occur if we blindly follow expectations and do not update them with new information.

> *"The continuing search for confirming evidence postpones the realization that something unexpected is developing. If you are slow to realize that things are not the way you expected them to be, the problem worsens and becomes harder to solve. When it finally becomes clear that your expectation is wrong, there may be few options left to resolve the problem."*

Varieties of Surprise

1st Form – Something appears which you had *no expectation, no prior model* of the event, no hint that it was coming.

2nd Form – The issue is recognized, but the *direction* of the expectation is wrong.

3rd Form – Occurs when you know what will happen, when it will happen, and in what order, but you discover the *timing is off*.

4th Form – Occurs when the expected *duration* of the event proves to be wrong.

5th Form – Occur when the problem is expected, but the *amplitude* is not.

see Chapter 2 pages 35-39

Surprises in Fuels and Fire Behavior - In numerous reviews, the rate of spread, flame length and resulting spotting caused much of the challenge for burn personnel. Fuels are often the source of unexpected or overlooked sources of trouble. One burn boss related this example of unexpected fire behavior in a fuel type involving standing dead pinyon-juniper: the trees had been bug-killed with no needles left on the crown yet during burn operations the fire was able to move into the crowns of the standing dead trees and sustain fire spread through the aerial fuels much like a typical crown fire. In this case, an adequate control line stopped the spread of fire so the prescribed fire did not escape. Another example of unexpected fire behavior came from a small pocket of fuels adjacent to the burn area boundary. The small pocket of fuels was not the dominant fuel type within the burn area and was not noted in the burn plan as a potential source of heat and spotting.

Another reoccurring 'surprise', reported in several escapes was greater than 'normal' fuel loading due to seasonal variation (greater moisture increased fine fuels) or a change in land management activities (area rested from grazing for 2 years prior to the burn actually being implemented). The change of conditions was not captured or discussed in the burn plan nor noted prior to ignition which would have caused a plan to be re-evaluated for complexity, risk and/or adequacy of contingency plans.

What are we not 'seeing clearly'? Are we not appreciating how complex burns are?

The use of natural barriers – change in fuel or vegetation type, moisture gradient either by changing topography or nighttime recovery often failed to check the spread of fire or put the fire out. In several cases changes in fuel or vegetation types were planned to check the spread of fire. In one case, aspen stands were to be used as a natural barrier to fire spread, but the aspen did not check spread as expected because the burn was not implemented during the planned season. In another case, a 'swamp' adjacent to the burn area was planned as a natural barrier. However, when the burn was implemented conditions had changed (i.e. the swamp was dry) and this area did not contain the spread. Prior to ignition burn personnel did not check whether this area would stop the spread of fire. With several prescribed burns, nighttime humidity recovery was expected to stop or check the spread of fire. In each case, burn personnel did not gather on-site information to confirm whether the area did experience sufficient humidity recovery. The review teams recommended that prescribed burns relying on this technique should staff the area through the night and monitor on-site conditions.

Surprises in Weather – Surprises in weather often combined with or caused other surprises to occur. A number of reviews stated that 'drought' conditions were believed to be a contributing factor. In several cases changes in moisture (increased precipitation) changed the amount of fine fuels present at the time of the burn which was not accounted for in the burn plan. Unexpected winds (strength, duration, etc) were very common contributing factor to many escapes.

Proximity of thunderstorms to burns may be another emerging knowledge gap or indicates a gap in 'sense-making'. Burns that reported strong, erratic winds resulting from thunderstorm development nearby were 'surprised' by the effect. One case related that the storm was forecasted, they could see the cells developing miles away from the burn area, but felt that since the storm was approximately 30 miles away, they would be 'ok"' and proceeded with ignition. Another prescribed burn escaped due to the effects of a

nearby thunderstorm. The weather forecast did predict the development of thunderstorm activity, but burn personnel did not recognize the potential impact to the prescribed burn.

Surprises in Communication and Coordination – This was a common theme among the largest and most notable escapes (Lowden, Cerro Grande, Sanford, Cascade II and North Shore Kenai Lake). Other reviews noted concerns when burning adjacent to non-agency lands. Two re-occurring themes were lack of proper notification and recommendations for developing agreements with adjacent landowners. Problems with lack of proper notification occurred prior to burning and/or timely notification once the prescribed burn had escaped burn boundaries. Proper notification of the individuals or agencies affected by an escape was often delayed because they did not know whom to contact. Developing relationships and contacts well before ignition followed by notification just prior to burning was a common recommendation. In cases where the prescribed burn escaped onto private ground an agreement with the landowner prior to the burn would have eliminated the need for declaring an escape. The lack of coordination and communication among key burn personnel and assisting/cooperating agencies or units also appeared to be a re-occurring theme in several escapes.

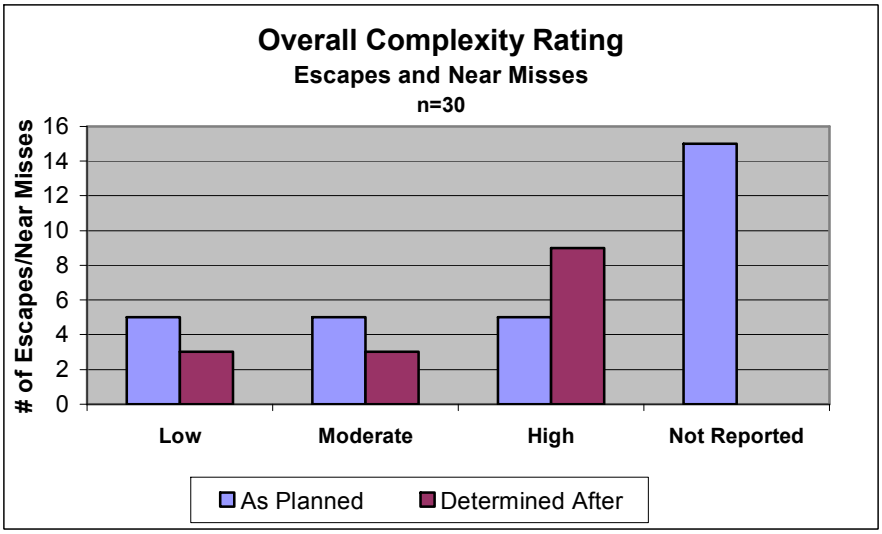
What are the Common 'Surprises'?

Two patterns were observed and explored in this analysis. The first pattern was the tendency to underrate overall prescribed fire complexity using the NWCG complexity rating system. A second pattern emerged when chronologies of escaped prescribed burns were examined and evaluated for common causal factors. Although not all reports mentioned the overall complexity rating, most did indicate there were problems with how individual elements of the complexity rating system were addressed (e.g., underrated, missing rationale or reasons a particular rating was selected, or was inconsistent with the agency's policy). This avenue was not explored further to determine if there were elements consistently underrated.

Complexity - All agencies evaluated currently use the National Wildfire Coordinating Group (NWCG) complexity rating system (NWCG January 2004 NFES 2474). The complexity rating system consists of 14 elements to evaluate and determine risk, potential consequences and technical difficulty. The rating system is relatively comprehensive, and is designed to aid in selecting the correct level of difficulty. An initial rating is recommended during project planning and development followed by a final rating, which is done during burn plan development. The overall complexity rating was not systematically reported as part of the escaped prescribed fire review process. Half of the burns did not have the overall complexity rating reported although several within this group did note that elements of the complexity rating within the burn plan needed improvements (e.g. rationale for rating missing and if rated 'high' mitigations were not included in the burn plan per policy). There was a fairly even distribution between Low, Moderate and High complexity of those that did report the overall complexity rating of the burn (Figure 3). Review teams concluded that many burn plans with an overall rating of Low or Moderate were 'underrated' in complexity. That is, they were actually High complexity instead of Low or Moderate (see Figure 3). In several cases, one noted cause for underrating complexity was due to the preparer not following agency direction.

A separate theme occurred when individual burns were rated Low to Moderate but then were implemented at the same time. Review teams noted burns conducted simultaneously would not warrant the same overall rating as the individual burn. In other words, two Low complexity burns implemented at the same time did not necessarily still rate a Low. Also noted in these cases was that burn personnel should have considered

changing the level of management oversight when conducting burns simultaneously (i.e. burn boss level switching from a RxB3 to and RxB2). However, the NWCG system specifically states that the "rating system is for a single prescribed fire project".
Figure 3 A comparison of overall complexity ratings for all projects reviewed. One column shows the complexity rating as determine during burn plan development versus the complexity rating determined during the review process.



Chronologies – There were two distinct groups in terms of the length of time from test burn to escape declaration. Prescribed burns either escaped very quickly or escapes occurred several days after the main ignition period while in the patrol and monitoring phase. The chronologies of at least **12 of the 28 escapes** indicate that from the time of the 'test burn' or ignition it **took 6 hours or less** before they were declared an escape or should have been declared an escape (see Tables 1-3). Several more occurred before the ignition phase was complete. Weather changes (winds increased and/or shifted direction and relative humidity dropped over short timeframes) were associated with these events, leading to spotting. However, there are other factors often associated with these events. Many reviews indicated the fire behavior was more than expected or anticipated and burn personnel did not fully realize what kind of fire behavior to expect. Also, the fuel complex either inside or outside the planned boundary caused unexpected fire behavior that was often not addressed in the burn plan. Another connected reason for burn personnel being mislead about what kind of fire behavior to expect was the incorrect selection of fuel model(s) during burn plan development. Fuels models selected for burn plan development often underrepresented fire behavior.

Another factor mentioned several times was lighting at the upper end of the prescription which caused prescription parameters to be exceeded often during the peak of the day. However, it was not always a 'surprise' to burn personnel that the prescription parameters would be exceeded during the ignition period. Sometimes burn personnel would start earlier in the morning in an attempt to compensate for the expected trend in conditions. However, either the conditions occurred sooner than expected or delays in implementation caused the ignition phase to be ongoing when the conditions exceeded the prescription parameters. Burns were sometimes lit outside of prescription parameters.

A final factor was the test fire was not conducted in a representative location. Test fires were conducted in locations that were in cooler or moister locations or conducted in fuels

with a different kind of fire behavior than the burn area. At the selected locations fire behavior was lower (lower flame lengths or rate of spread) misleading burn personnel.

Commonalities of prescribed fires that were declared an escape the day of ignition

The vegetation-fuel complex played the biggest role as the immediate causal factor in escapes. Several of the escapes noted that increases in fine fuel loading due to seasonal variation 'surprised' them. Burn plans were prepared assuming 'normal' fuel loading so during execution burn personnel may not have accounted for this influence. One burn boss did note the changed conditions and made some adjustments to holding forces to compensate. However, other factors including not fully appreciating the influences of the fuel type still resulted in an escape. In several cases, the escape occurred during the 'test fire' phase.

Another noted factor was that spotting occurred early and/or frequently during ignition phase, and in some cases during the test fire or black-lining phase. Spotting, according to some burn bosses, is a common occurrence with prescribed burning.

"A thorough recon of the area surrounding a burn unit is invaluable. Think about the worst case scenario, and then imagine the worst case going bad, then go back and plan your contingency".

Lesson learned from an escape fire review

Commonalities of prescribed fires declared an escape during the patrol and monitoring phase

Weather was commonly reported to have gotten progressively warmer and drier prior to escape. The reviews often cited that the weather was known to be 'more than normal' for the time of year. Increased winds or a wind 'event' that increased wind speeds for a short period of time contributed to the burn being pushed outside of the allowable burn area. In most cases, the burns were patrolled on a daily basis. In burns of longer duration the patrols noted activity increasing in the burn unit (smokes or open flaming of fuels). In some cases the patrols noted 'smokes', but thought they would not threaten boundaries. In some cases, personnel knew other prescribed burns had recently escaped within their geographical area. However, in spite of these 'signals' there were no changes in actions such as altering mopup protocols or utilizing heat detecting equipment, etc. In some cases, not having someone directly assigned as the lead for a prescribed fire until declared out caused lapses in awareness of the situation and direction to change procedures.

One review provided six useful signals that may indicate conditions are not normal and suggest changes to operational procedures.

1) No significant precipitation in nearly two months.
2) Receiving severity funding just prior to igniting a burn.
3) Fire restrictions have just been lifted for your area.
4) Thousand hour fuels are at or below critical levels (or other levels that indicate they are available to burn)
5) There is a pattern of below normal moisture (precipitation) for more than one year.
6) Trends for dead and live fuel moisture are they at or below long-term averages.

Go/No Go - It is easier to light a burn than not to light one.

It is easy to let the 'pressure to produce' override the signals (ignore them or don't look for them) indicating that a burn may not be best executed that day or even that year.

Other Observations of Repeated Lessons Learned and Recommendations.

Many escapes began to take place well before the first spot or slopover. A repeated recommendation for future prescribed burns started with project design and the environmental assessment. Burn block boundaries that were not developed based on known fire behavior characteristics were often a contributing factor in the escape. In some cases, resource specialists selected areas without input for logical or realistic control points. This limits options to successfully implement a prescribed burn or delayed a burn because changes needed to be analyzed and disclosed in an environmental document. Having expertise in fire behavior and practical experience with prescribed fire will help resource specialists to develop 'logical' burn blocks.

Review teams often cited one key weakness with overall burn plan development. The weakness noted was burn plans for complex burns that did not have sufficient depth and detail to match the complexity of burn. Large-scale burns will likely have multiple aspects, variable vegetation-fuel complexes, resource objectives and constraints that require more complex planning and burn organization to implement successfully.

Conclusions and Recommendations

The disparate types of information across the agencies made an assessment of this nature challenging, particularly tracking potential knowledge gaps or identifying developing trends, and especially without being able to access all existing reports. Despite this, the collected data do converge on several important lessons that we as a fire community need to learn. These are outlined below.

Reviews of all escapes and near misses should be consistently conducted, collected and stored in a centralized location to assist the community in learning from its experiences. A consistent framework with common questions and documentation would help make future lessons learned efforts more meaningful and samples more robust. While individual reviews provide opportunities for the local unit to learn, consistency would better assist this learning across Agencies. Such a consistent interagency framework to conduct reviews of escapes and near misses could assist all practitioners and agency administrators to identify knowledge gaps. As Weick and Sutcliffe (2001) recommend, sharing of near misses may tell us more about reliability than escapes, but they also provide us the opportunity to ensure that we take signals as a sign that things are 'ok' or 'not ok' until proven otherwise

The NWCG Complexity Rating System Guide should be explored to look at how to handle cases where burns are simultaneously lit potentially changing complexity, management oversight and organization structures. Is it true we underrate complexity? If so, why and in what context? Is there a tendency to underrate overall complexity or individual elements – risks, potential consequences and/or technical difficulty -- because experience with particular situations is low so it is not recognized as a potential source of problems?

Is there a tendency to underrate because adequate resources and skill levels are not available to the unit (e.g. a hesitancy to identify a burn as more complex because an RxB2 or RxB1 is not on the unit or readily available).

There maybe a gap between the intended use of the complexity rating system and policy. Per policy, a final complexity rating is to be done and included in the signed burn plan. This freezes the rating for implementation. There is no mechanism or direction to aid burn personnel to reevaluate overall complexity or trigger the need to increase the level of detail in burn plans when multiple plans are implemented at the same time.

Vacancies in key positions were noted in several reviews as having an important impact on fire operations. The recommendation in the reviews was to fill vacant positions to help relieve the stretched workforce experiencing expanding programs.

We continue to be surprised by fuels and fire behavior. Why? Have we lost our knowledge base and skills in identifying the carrier of fuels and selecting the most appropriate fuel model? Or, are we dealing with vegetation-fuel types that are more complex or different than we have experiences with or fuels models to represent? Likely, both of these issues are causes as well as others. Due to limitations of the models to reflect reality practitioners may be reluctant to use these tools. Even with the limitations of fuel models and fire behavior modeling these tools assist with identifying sources of problems. However, continued training in usefulness and shortcomings of fuel and fire behavior models may help prescribed fire planners.

Other specific recommendations include:

- Continue to share lessons learned with other fire management personnel to broaden experiences levels.

- Investigate mechanisms to minimize possibility of escape the day of ignition. For instance, checking fuel receptivity outside the unit may be as important as how it burns inside the perimeter. Test all fuel types. If there is more than one fuel inside or outside the planned boundary we should be aware how each of these are going to respond. Holding and contingency forces then can be ramped up or down accordingly.

- Monitor leadership assignments and personnel transitions closely to ensure someone is directly assigned as the lead for a prescribed fire until the fire is declared out.

Next Steps to Become a HRO

Achieving and maintaining high reliability requires not just intellectual understanding, but translation of this into practice. This review of reviews has not revealed any earth-shattering weaknesses; all weaknesses summarized above have been known previously. What it has done is to further highlight several trends and points of weakness in our practice. How do we move forward from here? This section is included in the hopes that it will stimulate further discussion…and actual change in our practice.

'Reviews' need to be approached as a tool for learning and be clearly separated from disciplinary actions. Did you have a good plan? Did you follow the plan? Did you execute it with qualified people? These are all good accountability questions. However,

accountability and learning from undesired outcomes are often at odds with each other. Accountability can lead down a path of blame after which opportunities for learning disappear. If fire use practitioners are going to move toward becoming a learning organization then we have to examine our 'failures' as an HRO. Reviews for learning should use questions that help evaluate expectations, assumptions, surprises and blindspots.

Further develop and integrate efforts exploring how to become a learning organization and operate consciously use the principles of a High Reliability Organization. Efforts so far include conducting After Action Reviews and Managing the Unexpected workshops. Both of these have been useful pathways to explore and should be developed to further integrate these concepts into daily practice.

Agencies need to further explore/validate the emerging trends such as a tendency to 'underrate' complexity, look at why this is happening and what we need to overcome that tendency. Another area that may need further work is to look at why some vegetation-fuel complexes seem to repeatedly 'surprise' practitioners especially the more flammable fuels like cheatgrass and pinyon-juniper. Another area that seems to be a struggle is for practitioners to recognize risks and develop burn plans for complex landscape scale burns. One way to overcome this tendency is to encourage burn plan development by a team (prescribed fire planner, burn boss, holding and ignition specialists) because more eyes, and more experiences will be added to the preparation of the plan.

How can we avoid being blinded by burn plans (Weick and Sutcliffe 2001)? Federal land management policy requires burn plans. How can we strengthen their use? One option might include drawing on concepts from *Managing the Unexpected*,. A team could explore ways to overcome the trap of expectations and tendencies to seek confirming evidence. For example, increasing awareness through NWCG courses that burn plans could blind us (how and why does that happen?). Another possibility to consider are ways to develop burn plans with a balanced approach -- focus on what we do not want to have happen as much as we focus on what we do want to have happen. It could be stressed to prescribed fire planners they should focus on ways to look for 'disconfirming' evidence that they are not in prescription and put them in the monitoring plan. Since it is the policy of federal land management agencies that burn plans are required this area would warrant further exploration.

Agencies should look into ways to build line officer and agency administrator 'sensitivity to operations.' Only two of the most recent reviews explored and acknowledged the role of the agency administrator. One case commented on the active role of the agency administrator, but also noted they had not yet attended a mandatory training (i.e. Fire Management Leadership). The other case praised and acknowledged the active role of the agency administrator who was on-site while the burn was being conducted and played a keyed role once the prescribed fire had been declared an escape. Agency administrators will play a key role in operating as a HRO.

Acknowledgements

Intermountain Region (R4) FAM, particularly Dave Thomas, Regional Fuels Specialist for promoting learning organization, supporting and funding a detail program analyst to the Wildland Fire Lessons Learned Center to develop this analysis.

Tim Sexton, National Fire Use Specialist, Forest Service and Al Carrier, National Fuels Management Specialist-Operations, Bureau of Land Management for digging into their files and supplying additional escape prescribed fire reviews not electronically available.

This report is intended to further the mission of the Wildland Fire Lesson Learned Center:
Collect and analyze observations
Share lessons learned and best practices, and
Archive knowledge and information.

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Table 1 Timeline of Escaped Prescribed Burns Involving Fine Fuels (Grass and Grass-like) Vegetation-Fuel Complexes. In three out of five escapes, the fine fuels were not the targeted vegetation for burning.

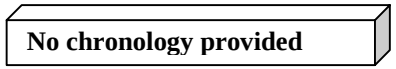
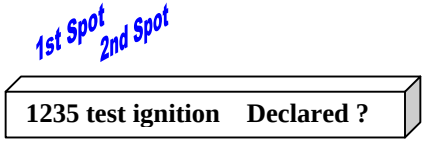
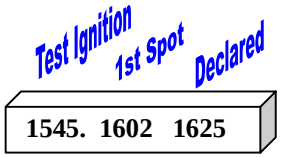
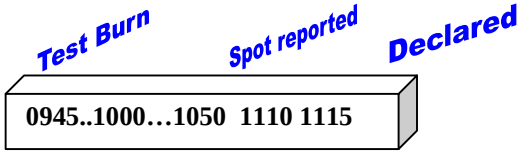
Burn Date Fuel	Time	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700
Pa-CA June 22, 1998 Cheatgrass	**During initial black-lining**	**Blacklining at upper end of prescription window. Plan written for normal conditions, but conducted with "abnormal" level of fully cured cheatgrass. Burn boss limited experience with fuel type.** 									
BQ-CA July 1, 1998 Heavier loading cured grass	**"shortly after ignition"**	**Two spots occurred "shortly after ignition. First spot contained. Second spot grew to 4 acres and prescribed burn declared an escape. Holding actions limited due mechanical failure of helicopter.** 									
Me-UT Sept 9, 2004 Cheatgrass	**During "test "burn"**	**Had no lookouts posted to look for spots. While more than the minimum holding forces were on-scene unable to respond quickly to slopover due to hindered access. Burn boss limited experience with fuel type.** 									
IL-AZ February 4, 2004 Reed Grass	**Less than 2 hours**	**Main ignition of unit began 15 minutes after test burn. Ignition stopped after 50 minutes. Possible spot across river was reported and confirmed in 5 minutes. Holding forces were unable to locate and control spot immediately due to thick smoke and access was also hindered.** 									

Table 1 (cont) Timeline of Escaped Prescribed Burns Involving Fine Fuels (Grass and Grass-like) Vegetation-Fuel Complexes.

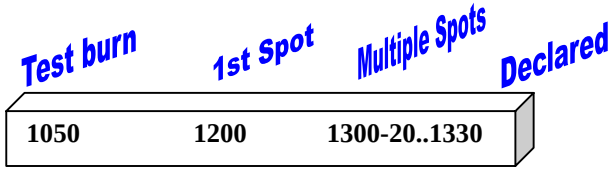
Burn Date Fuel Type	Time	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700
LR-CA July 2, 1999 Invasive weeds	Less than 3 hours										

Table 2 Timelines for Escaped Prescribed Burns Involving Shrubland/Woodland Vegetation-Fuel Complexes.

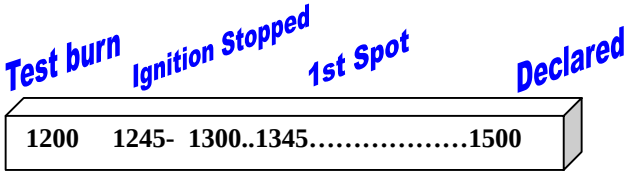
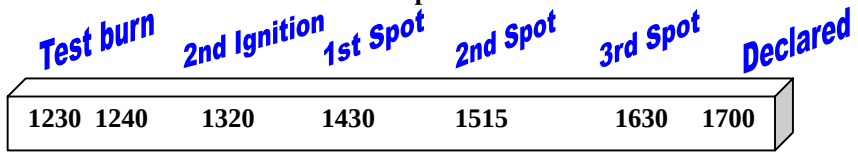
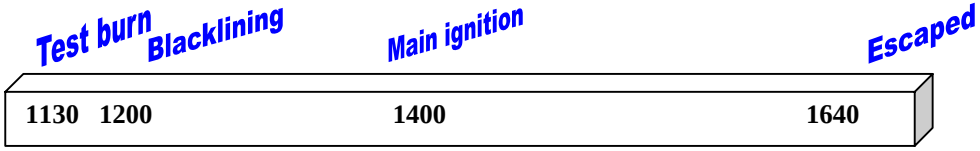
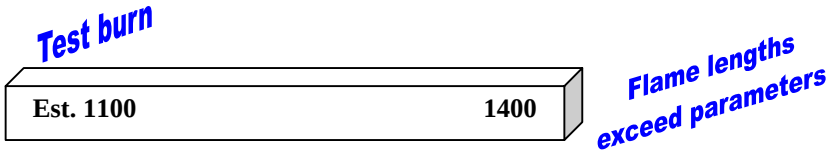
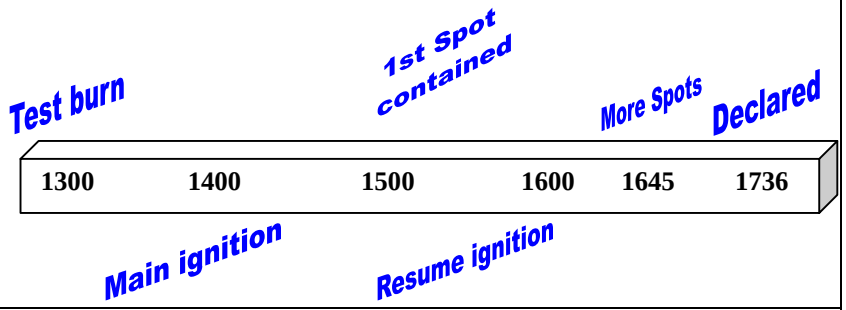
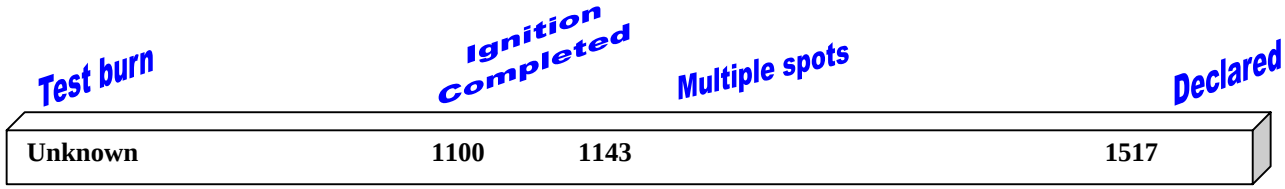
Burn Date Fuel Type	Time	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700
Bl-WY June 4, 2003 Pinyon/ Juniper	**3 hours**										
Ca-UT Sept 23, 2003 Heavy, oak brush	**5 hours**	**Main ignition of one area began 10 minutes after test burn. Approximately 1 hour later, ignition began in a second area away from the first. Multiple spots occurred some with rapid rates of spread. Test burn was not conducted in representative location.** 									
SC— April 10, 2003 Decadent bitterbrush & P/J	**5 hours**	**Prescribed burn not declared an escape when it should have been.** 									
IB-FL March 2, 2004 Southern Rough & swamp	**Less than 3 hours**	**Not declared an escape unit 5 days after ignition, but review determined the prescribed fire should have been declared within 3 hours of ignition due to fire behavior being outside of prescription parameters. No documentation of test burn.** 									

Table 3 Timeline of Escaped Prescribed in Forested and Slash Vegetation-Fuel Complexes. While most escapes in these vegetation-fuel complexes occurred days after ignition during the patrol and monitoring phase; however, several did occur during the ignition phase with two declared an escaped prescribed fire within six hours.

Burn Date Fuel Type	Time	0800	0900	1000	1100	1200	1300	1400	1500	1600	1700
Pi-NM March 12, 1996 Ponderosa pine, mixed conifer & P/J	Less than 2 hours	No mention of when test fire was conducted but lit in an area not representative of fuel conditions. Initial spot fires handled by holding forces.									
NR-UT June 28, 2001 Slash w/ subalpine fir	Less than 5 hours										
LJ-AZ May 5, 2004 Ponderosa pine & P/J	Same day as ignition. Unknown start time.										





Ignition was planned for and stressed during briefing the need to be completed by 0900 hours due to observed burning conditions. Ignition was not completed within timeframes due to logistical and mechanical problems.

Project Name	Yr	Agency	Unit	State	Planned Acres	Escape Size and Consequences	Complexity Rating	Veg/Fuel Complex	FBO Fuel Model & Modeling	Season of Ig (mo/day)	Length of time from Test Fire or Ig to being declared an Escape
Lizzie Springs	1996	BLM	Rock Springs District	WY	Not Reported (NR)	350, unknown if these acres were outside unit or total ac burned	Not Reported (NR)	Conifer including heavy subalpine fir timber with aspen. More fine fuel due to 2 yr rest from grazing.	Not Reported (NR)	Oct 2-4	8 days
Pinatosa	1996	FS-R3	Mountain Air RD, Cibola NF	NM	Total 9,000 in project, approx. 5,100 ac actually burned w/in planned area	2,000 acres unplanned including 300 ac pvt	High - aerial & hand	Multiple - ponderosa pine, mixed con & P/J, oak shrub	FM 9 & 10. Used FM 10 for BEHAVE runs.	12-Mar	1.5 hours No mention of test fire. Hand ignition began ~1130 hrs. Spot fires noticed between 1230-1300 by hand ignition crew, but able to control with holding resources. RxB fired main ridge inside unit with PSD; however fire spread downhill rapidly towards perimeter. Shortly after 1300 declared.
Banner Queen	1998	BLM	El Centro Resource Area, California Desert District	CA	650	NR	NR	Mature chaparral (chamise) w/ unusual amount of grass due to unusual amt of ppt with el Nino.	Used brush model, but did not account for amt of grass and dead/live ratio in brush	1-Jul	"shortly after" ignition. First ignited (test burn) @ 1235 hrs. Shortly after ignition two spot fires occurred. 1st spot was contained. 2nd spot grew to 2 acres then 4 acres getting into steep terrain and not safe for ground forces.

Project Name	Yr	Agency	Unit	State	Planned Acres	Escape Size and Consequences	Complexity Rating	Veg/Fuel Complex	FBO Fuel Model & Modeling	Season of Ig (mo/day)	Length of time from Test Fire or Ig to being declared an Escape
Fox Lake	1998	BLM	Klamath Falls Resource Area	OR	278	10 acres inside unit plus 29 acres on Pvt - timber lands	NR	NR	NR	29-Apr	5 hrs. Firing began in NW corner ~ 1130 after briefing. 1230 began having problems w/ spotting. 1300 stopped firing and took holding actions in NW corner. More spots along N-side line @ 1430. 1530 one acre outside unit on pvt ground. 1630 declared an escape.
Pahcoon	1998	BLM	Cedar City District, Dixie Resource Area	UT	Blacklining	NR	NR	Cheat grass with heavy "above normal" loading	NR	22-Jun	< 1day no chronology included. Spot fires or slopovers that were more than holding forces could handle was one of noted factors.
Lowden Ranch	1999	BLM	Redding Field Office	CA	100	2,000 including pvt + 23 homes	Low	Grass, oak brush & riparian veg. Forested outside		2-Jul	<3 hrs. Test fire @ 1050 hrs. Multiple spots at different locations. Declared @ 1330 hrs.
Wilson Gulch (missing append)	1999	BLM	Burley Field Office	ID	NR	NR	NR	Juniper		18-Aug	NR < 1 day. No chronology included

Project Name	Yr	Agency	Unit	State	Planned Acres	Escape Size and Consequences	Complexity Rating	Veg/Fuel Complex	FBO Fuel Model & Modeling	Season of Ig (mo/day)	Length of time from Test Fire or Ig to being declared an Escape
Cerro Grande	2000	NPS	Bandelier NM	NM	Three phase project. 1st of 3. Approx. 900	48,000 plus pvt w/ 280+ home/ structures	Moderate - hand	Multiple		4-May	1 day
EB-3	2000	BLM	Arizona Strip Field Office	AZ	3 acres "test" subunit	197 acres Damaged pvt property	NR - a burn plan was not prepared for this "test" unit	NR	NR	Ignited 3/31/2004. Declared 4/13/04	13 days.
Mt. Como	2000	BLM	Carson City Field Office	NV	Multi-unit project. 1st burn in 1997. EA done 1996	NR	NR - Elements rated as "high" missing rationale and mitigations. Hand ignition	Pinyon with litter/duff & brush that provided ladder fuel		Oct 18 Started Ig 1325 Done by 1700 Oct 20 Declared 1645	2 days Had 11 people & 2 engines to hand ignite area, but no direct access to unit for engines. Ignition went well, but fire burned into the evening & actively backed down hill all night. Next day no new ignition & tried to contain area already lit. A forecasted wind event kick up fire & spotted outside of unit from unburned island inside unit.

Project Name	Yr	Agency	Unit	State	Planned Acres	Escape Size and Consequences	Complexity Rating	Veg/Fuel Complex	FBO Fuel Model & Modeling	Season of Ig (mo/day)	Length of time from Test Fire or Ig to being declared an Escape
Alkali Rim (Near Miss)	2001	BLM	Worland Field Office	WY	1,200 to 1,500	N/A. This review was about the need to use escape routes during burn ops.	Low, but did not follow agency policy. Should have been Moderate	Juniper with sagebrush/ grass intermixed	N/A	20-Sep	N/A
Cordgrass (escape named Pin Oak)	2001	FWS	Marais Des Cygnes NWR	KS	80 acres	13.6 acres w/ 4 acres on pvt	Low	cordgrass	FM 3 inside FM 3 & 9 outside	28-Oct	11 days
Navajo Ridge	2001	FS-R4	Dixie NF	UT	Project 199, mult. units. 26 ac w/ 2 units previously lit	8.2 including pvt	NR	Lopped slash w/ subalpine fir and aspen outside units		28-Jun	4.5 hrs. Test burn conducted @ 1300 hrs w/ no holding problems. Ignition on unit occurred from 1400-1500 hrs. Ig stopped due to spotting, holding crews contained and Ig resumed @ 1700 hrs. At 1730 hrs, more spotting occurred and several slash piles were ignited. Declared at 1736 hrs. Contained 2000 hrs.
North Shore Kenai Lake (Draft)	2001	FS-R10	Chugach NF	AK	1,000	NR	Reported "complex" no doc. of analysis - aerial ignition	Bug-killed spruce	Not Reported (NR)	5-Jun	10 days. Area was monitored & patrolled according to the plan. Evening of 6/25 spotfires outside of unit discovered. Increasing winds caused spotfires to spread beyond the capability of local resources.

Project Name	Yr	Agency	Unit	State	Planned Acres	Escape Size and Consequences	Complexity Rating	Veg/Fuel Complex	FBO Fuel Model & Modeling	Season of Ig (mo/day)	Length of time from Test Fire or Ig to being declared an Escape
Pot Creek (DRAFT)	2001	BLM	Craig Field Office	CO	Black lining with 261 ac area	250 - 300 acres. Suppression cost $50.0 ths.	NR	Sagebrush	NR	4-Sep	~3 hours. Test fire completed by 1315 hrs. Ignition began around 1330 hrs. A "significant wind event" occurred 1525 hrs. w/ winds out of the west at 30-40 mph driving the fire across the east line. Winds reported to begin dying down around 2300 hrs.
Rock	2001	FS-R5	Tahoe NF	CA	200	201	NR	Long needle pine/white fir	FM 9 in, FM 10 outside. Continuous frost-killed brush @ escape	May 9th part of unit successfully ig. May 10 proceeded to complete ig	5 hrs. (2nd day of Ig) Test fire @ 0715 hrs. Ignition started @ 0800 hrs. RH drop dramatically bwtn 0800-0900 hrs, but still in prescription. 1030 hrs. RH drops to 19%. 1100 hrs RH 12%, winds increase to 5 mph. Contingency forces called. 1130 numerous spots, more resources ordered. 1222 hrs more spots which grew, more resources ordered. Declared 1230.
Wilson	2001	FS-R1	Lolo NF	MT	706	none outside planned boundary	High - aerial ignition.	Dry timber types, mostly northerly aspects	FM 2/10/9. FM selection not issue. Smoldering in Lrg 1000 hr fuels was	Four different days for ignitions. April 25-26, May 9 and May 11. Declared an escape May 24th.	29 days. Declared an escape due to "logistical and financial" concerns. The burn was NOT outside planned boundaries.
Anderson/ Danskin (this review covers 2 separate burn project areas)	2002	FS-R4	Boise NF	ID	3,500	405	High - aerial	PP/DF intermixed w/ sagebrush/ grass		15-May	4 days Two different landscape scale burns ignited the same day. Both units had previous ignitions weeks before. Snow remained on northerly slopes and checked surface spread of fire. High winds (30-35 mph) from a passing system caused both burns to escape planned boundaries at the same time.

Project Name	Yr	Agency	Unit	State	Planned Acres	Escape Size and Consequences	Complexity Rating	Veg/Fuel Complex	FBO Fuel Model & Modeling	Season of Ig (mo/day)	Length of time from Test Fire or Ig to being declared an Escape
Sanford (this review covers 2 separate burn project areas)	2002	FS-R4	Dixie NF	UT	3,500 total in 2 separate RxB	78,000	NR			Two separate days of Ig on two different burns 11 miles apart. April 22, May 13	30+ days
Blanco	2003	BLM	Albuquerque Field Office	NM	NR	NR	Low	Ponderosa Pine but w/ significant P-J	Incorrect FM selection - used FM 8. Review recommended using a combination of FM 4 & 6	4-Jun	3 hrs. Test fire 1200 hrs - 2-4' FL with occasional torching. Ig stopped 1245. 1300 hrs spot fire reported on top. 1345 hrs burn personnel unable to contain. Declared 1500 hrs. ~1600-1700 hrs more resources ordered (engines, tanker, T-1 crew).
Cascade II	2003	FS-R4	Uinta NF	UT	1,000 (in BP) Ignited 400 not in BP	7,828	High	Heavy, mature oak brush intermixed with aspen		23-Sep	5 hrs. Test burn @ 1230 hrs. Second ignition in different location 1320 hrs. Spots occurring in 3 different locations @ 1430 hrs, 1515 hrs & 1630 hrs. Declared 1700 hrs. 1720 hrs holding forces retreat to designated safety zones.
Cherry	2003	FS-R3	Prescott NF	AZ	Project 8,141 2nd of 3	150 ac slopover + 992 ?	NR - hand & aerial	Chaparral		16-Jun	1 day. Ignited 6/16. "Unpredicted wind event" shifted wind direction. 150 ac spot occurred and contained. 6/17 no new ig., mopping spot. New spot 6/17 @ 1300 hrs.

Project Name	Yr	Agency	Unit	State	Planned Acres	Escape Size and Consequences	Complexity Rating	Veg/Fuel Complex	FBO Fuel Model & Modeling	Season of Ig (mo/day)	Length of time from Test Fire or Ig to being declared an Escape
Petty Mountain Near Miss	2003	FS-R4	Ashley NF	UT	1,000	Not declared (Total ac burned 2,593)	NR	Primarily Sagebrush w/ aspen	Fuel Model 8 covered 80-90% of area with isolated pockets of FM 10.	24-Sep	Was not declared an escape.
Puma	2003	FS-R2	Black Hills NF	SD	Project 800 w/ 11 units. Completed 231 acres on 2 units prior to lighting another 2 units that escape.	NR	Low - hand BB. Reviewers questioned whether RxB3 was correct "management oversight"	Ponderosa pine		Blackline Unit 3 March 14 & 25, Ig on Unit 3 & 5 March 31. April 1 Ig & declared	1+ days? Had been "blacklining" on one of units during two previous times in March. March 31st continued blacklining on one and started on another unit. During interviews, burn personnel mentioned holding/spotting problems. No holding or monitoring overnight. Declared April 1st after fire behavior increased & made significant runs inside and out of target units.
Sink's Canyon	2003	BLM	Lander Field Office	WY	NR	12.76 acres outside MMA on PVT	Rated Moderate - WUI. According to BLM 9214 all WUI should be rated High	Majority NR, decadent bitterbrush & P-J	Majority FM 2, FM 6 not used in BP to account for brush inclusion.	10-Apr	5 hrs. Test ig @ 1130. 1200 hrs blacklining started. 1400 hrs ig of interior. 1640 hrs winds switch, RH drop & spots across line. Not declared, but later determined outside of MAA.

Project Name	Yr	Agency	Unit	State	Planned Acres	Escape Size and Consequences	Complexity Rating	Veg/Fuel Complex	FBO Fuel Model & Modeling	Season of Ig (mo/day)	Length of time from Test Fire or Ig to being declared an Escape
Impassable Bay (Compartments 16 & 117)	2004	FS-R8	Osceola RD, NF's of Florida	FL	1,500 in two units 16 = 1,000 117 = 500	32,000 + including state & pvt lands	Individual burns rated low, but burned together (adding helicopter & other mixed resources) indicated should have been Moderate to High. No documentation on "final" complexity rating.	Long-leaf pine & "swamp"	FM 7 (southern Rough) and FM 4 (dry swamp)	2-Mar	5 days before "officially" declaring an escape, but approx. 3 hours after ignition the burn was out of prescription & should have been declared. A test burn was conducted, but not documented. Estimated from report to have been around 1100 hrs. At 1400 hrs obs flame lengths of 20', (prescription called for 4-6') which exceed prescription.
Island Lake	2004	FWS	Imperial NWR	AZ	630 acres	Estimated 200 acres	Moderate	Cattails (8-10 ft), phragmites (common reed, 8-10 ft) also intermixed with salt cedar	Fuel model 3. Appropriate model selected but under - estimated potential fire behavior	4-Feb	< 2 hours. Test fire @ 0945 hrs. Fire behavior and smoke Rx met. Ig begins @ 1000hrs. At 1030 hrs. east flank widen w/ aerial ig. At 1040 hrs remaining unit lit in 2 passes. 1050 ig halted. 1105 hrs possible spot across river. Confirmed 1110 hrs. Declared 1115.
Long Jim III	2004	NPS	Grand Canyon NP	AZ	Project 5,050. 1st of 3 for 1,618		NR - one element of analysis was raised as an issue	Ponderosa pine w/ P-J FRCC 3		5-May	Ig time NR, but aerial ignition completed 1100 hrs. Spotting reported @1143 hrs. Declared @ 1517 est. 6+ hrs. Ignition was to be completed by 0900 hrs due to observed burning conditions during blacklining ops a week before and during test ignition that day.