The Role of Science and Policy in the Flagstaff Watershed Protection Project

ENV 555: Environmental Science and Policy Interface

Laura Brown, Megan Deane-McKenna, Miranda Perrone, Patrick Shin, Cole Webster

December 14, 2016

Introduction

Increasing frequency and intensity of wildfires in the western United States are a result of drought, rising temperatures, past forest management practices, and fuel buildup from nearly a century of fire suppression (Mottek Lucas, 2015). The damage caused by severe wildfire and the motivation to address fire risk are great: property damage, damage to infrastructure, and loss of wildlife habitat and watershed resources are common consequences. While many western cities seek solutions to protect watersheds, property, and habitats, there may be great socioeconomic barriers to these efforts, such as insufficient funding for treatments, the lack of utilization and demand for small-diameter wood and biomass (including insufficient infrastructure and supply of wood), conflict over social values regarding treatments, and the lack of accounting for social benefits, such as improved air, soil, water, recreation opportunities, and other nonmarket benefits (Hjerpe et al. 2009). The following paper details the efforts of the Flagstaff Watershed Protection Project (FWPP) to reduce wildfire hazard through forest fuels reduction treatments, such as the select removal (thinning) of excessive small-diameter trees and debris (slash) disposal followed by controlled burning to remove and recycle nutrients from plant material (pine needles and cones, branches, dead grasses, etc) and revitalize grasses and other understory growth (Flagstaff Watershed Protection Project FAQ 2016). FWPP is a collaborative effort between the City of Flagstaff (City), the Coconino National Forest (Forest Service), and the state of Arizona, to reduce the risk and consequences of catastrophic wildfires and post-fire flooding in the Rio de Flag and Lake Mary watersheds.

The Schultz Fire of 2010 (Figure 1) can be considered a catalyst for the creation and implementation of the FWPP. The Schultz Fire ignited on the east side of the San Francisco Peaks and spread throughout untreated acres of forest. According to a report published by the Northern Arizona University (NAU) Ecological Restoration Institute (ERI), the Schultz Fire burned over 15,000 forested acres, evacuated hundreds of homes, and led to heavy flooding from a combination of monsoons and hydrophobic soils from severely burned hillsides, which resulted in extensive property and ecosystem damage (Combrink et al., 2013). Official reports from city, county, state, and federal governments listed response and mitigation costs of the fire and subsequent flooding at nearly $60 million. However, Combrink et al. (2013) conservatively estimate the total impact of the Schultz fire at between $133 and $147 million.

Figure 1. The Schultz Fire of 2010, which burned about 15,000 acres south of the San Francisco peaks near Flagstaff, AZ (U.S. Forest Service, 2010).

With the consequences of the Schultz Fire in mind, 74% percent of voters approved Proposition 405 for the FWPP in Flagstaff's November 2012 general election. Proposition 405 allocated a $10 million bond to reduce the risk of high severity wildfires and subsequent flooding in the Rio De Flag and Lake Mary watersheds, both of which are crucial to the city's infrastructure and water supply (Figure 2). A high intensity crown fire with subsequent erosion and flooding in these areas has the potential to affect the ability to utilize these water resources. The Dry Lake Hills area of the Rio de Flag Watershed and the Mormon Mountain area of the Upper Lake Mary Watershed - both of which display similar conditions to those of the Schultz forest area before the 2010 fire (U.S. Forest Service, 2015a), are important water resources for Flagstaff and surrounding communities. The FWPP proposes to mitigate wildfire risk and subsequent flooding through forest fuel reduction treatments in these two areas.

Forest treatment plans can have different methods, connotations, and results depending on context. The development of the FWPP requires a distinction between forest treatments for ecological restoration and fuel reduction to manage potential wildfire. Ecological restoration is defined as "… the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (SER Primer, 2004 p. 3)." While ecological restoration seeks to restore ecosystems, fuel reduction approaches aim to mitigate fire risk and may use similar techniques as forest restoration, such as forest thinning, to improve growth and resiliency of forest stands (Clewell et al. 2004, Agee and Skinner, 2005). The treatments used in the FWPP will include traditional logging, hand thinning, prescribed fire, steep slope equipment logging, helicopter

logging, and cable logging (U.S. Forest Service, 2015a). Treatment implementation is underway and is expected to continue for the next 8-10 years.

This paper's focus is on the role of science in the policy development of FWPP on City of Flagstaff and Forest Service land. Contrasting perspectives, analysis of science, and the role of uncertainty will be evaluated. In addition, relevant policy documents, policy formation theories, and a discussion of the strengths and shortcoming of the project will be presented. While this paper will present the aspects mentioned above, it is not a complete and detailed review.

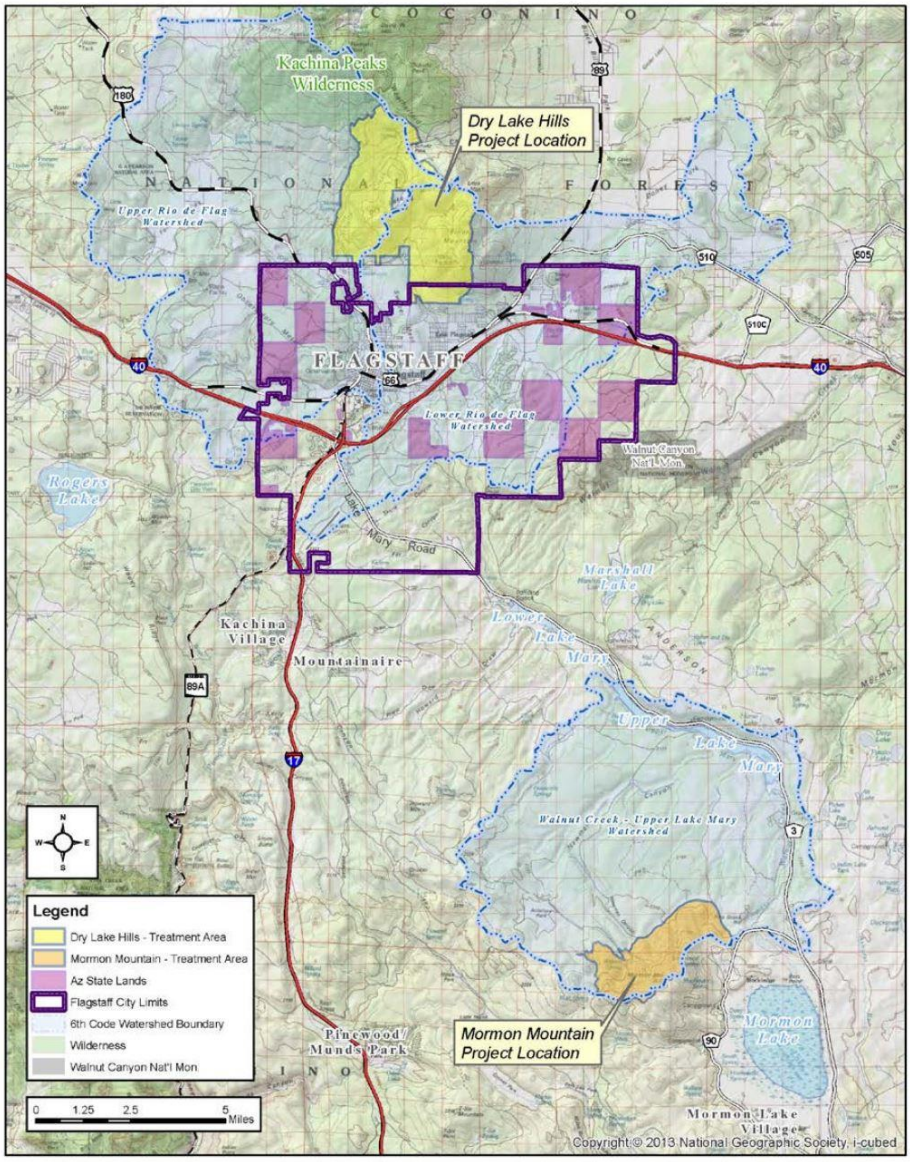

Figure 2. Map of the FWPP project site and the proximity to Flagstaff, AZ (U.S. Forest Service, 2015). The two treatment areas, Dry Lake Hills and Mormon Mountain, are shown with their respective locations within the Rio De Flag and Walnut Creek-Upper Lake Mary watersheds.

Contrasting Perspectives in Science

FWPP occurs on federal, state, and city owned land, requiring different regulations for each treatment area. This section will discuss the portion owned by the Forest Service because federal agencies are required by law to complete an Environmental Impact Statement (EIS) under the National Environmental Policy Act (NEPA) and allow for public comment and objections to the proposed alternatives and decision. The EIS process is a decision making tool which evaluates various action plans and the associated consequences to achieve a specified goal. An EIS requires the use of science to thoroughly detail the issue, and encourages public participation through comments and objections. The objection process requires a period of time for objection submissions to the pre-action EIS (U.S. Department of Agriculture, 2013). The City, Forest Service, State, the Center for Biological Diversity (CBD), Sierra Club, and many other organizations, including the citizens of Flagstaff and surrounding communities, are involved with FWPP as stakeholders. This section will examine contrasting perspectives of the science involved in the formation of FWPP, and will focus on the objections to the EIS from the CBD and the Sierra Club.

The main objections to the EIS addressed concerns about the Mexican spotted owl (*Strix occidentalis lucida*; MSO; Figure 3) and the approximate 6,029 acres of MSO habitat in the Dry Lake Hills and Mormon Mountain project areas. MSO is one of the largest owls in North America and has the largest geographic distribution of the spotted owls with a variety of biotic communities, including mixed conifer forests with minimal disturbance by humans, pine-oak forests, and rock canyons (McDonald et al., 1991). Nesting habitat of these owls is typically either in caves or cliff ledges in steep canyons or where forest structure is complex and contains multi-storied, uneven aged, mature or old growth trees with a high amount of canopy closure (McDonald et al., 1991). Forage habitat for this species in northern Arizona is generally more in unlogged forests and less in selectively logged forests (Ganey and Balda, 1994). However, generalizations of habitat use are difficult to make because of the varied patterns of this species. MSO is federally recognized as a threatened species under the Endangered Species Act (ESA; U.S. Fish and Wildlife Service, 1973), meaning federal agencies, like the Forest Service, are required by law to ensure that authorized activities, such as fuel reduction treatments, are not likely to destroy or negatively impact MSO habitat.

The main objective of the Forest Service in this project is to decrease fuels to reduce wildfire risk and post-fire flooding on the landscape. Fuels are defined as live and dead litter, twigs, and branches that could increase fire hazards (Agee and Skinner, 2005). Without treatment, fuels could continue to accumulate and high severity fire could consume MSO

Protected Activity Centers (PACs) and jeopardize future MSO habitat (U.S. Forest Service, 2015a). While fuel reduction is the main the goal for all stakeholders, the main source of contention is in relation to the associated treatments, especially on steep, hard to reach areas with a threatened species.

Figure 3. Photograph of Mexican spotted owl (*Strix occidentalis lucida*) pair (American Bird Conservancy, 2013).

The CBD framed their objection around threats to MSO and MSO habitat. The history between the CBD and the Forest Service spans decades and is important to note for the context of the CBD's objection to the FWPP EIS. In 1996, the CBD shut down all logging operations in the southwest for 16 months until the Forest Service implemented the federal recovery plan, which detailed action plans to protect and increase MSO population (Center for Biological Diversity, n.d.). A diverse group of stakeholders met on November 8, 2016 for a FWPP site visit at the City's Observatory Mesa treatment area. Those in attendance included members of the City, ERI, NAU, State, The Nature Conservancy, the authors of this paper, and a representative from the CBD. The representative stated that the Forest Service had, "messed a lot of things up in the past," and made the claim, "in my humble opinion, Mexican spotted owls still exist because of us". The tension and distrust between the CBD and the Forest Service is clear.

The CBD was mainly concerned with conserving MSO PACs and objected to road construction and mechanical harvesting treatments in areas with PACs. As evidence, they cited resolutions from their objections to the Four Forest Restoration Initiative (4FRI) EIS. 4FRI is a large scale forest ecological restoration project involving four National Forests in Arizona - the Kaibab, Coconino, Apache-Sitgreaves and Tonto. 4FRI uses similar treatments but the main

objective is forest ecological restoration, not fuel reduction treatments, as with FWPP (see Introduction for a discussion on these terms). The CBD demonstrated in their objection letter how the Forest Service agreed to not having road construction and mechanical harvesting in 4FRI, therefore, the Forest Service should be consistent in their decision making and not allow these actions in MSO PACs for FWPP (Lininger, 2015). Finally, the CBD focused on the language used in the proposed Amendment 1 for the Coconino National Forest Plan mentioned in the Draft Record of Decision for the FWPP. The proposed Amendment would allow treatment in high-priority locations, such as MSO PACs during breeding season, to prevent high-severity wildfire (U.S. Forest Service, 2015b.). The Amendment is based on the language used in the MSO Recovery Plan (U. S. Fish and Wildlife Service, 2012), which states how wildfires are the most significant alteration of MSO habitat and, therefore, have the greatest potential for loss of habitat. The CBD was deeply concerned with the language used by the Forest Service in Amendment 1 because it is "... a specific, one-time variance [for managing MSO habitat in the FWPP project area] (Lininger, 2015, pg 9)", yet the CBD notes how the Forest Service had already created an Amendment for other projects (i.e 4FRI) using the same language (Lininger, 2015). In short, the CBD was concerned the Forest Service would continue making "one-time" Amendments for every project to bypass their ESA requirements in addition to ignoring the MSO Recovery Plan, which states no mechanical or fire treatments, road/trail building or maintenance should occur within PACs during the breeding season unless followed by careful review of biologists and fuel-management specialists (U. S. Fish and Wildlife Service, 2012).

Ultimately, this objection was resolved by the Forest Service in a discussion between representatives from each group. Official documentation of the resolution states the inclusion of increased and extended monitoring for MSO and MSO habitat, both formally and informally, to see the response of PACs to road construction during breeding season. In addition, 0.57 miles of temporary road located in PACs was removed from the project area (U.S. Forest Service, 2015b). After talking with the representative from the CBD at the site visit, the apparent resolution, besides the official documentation, was trust in a wildlife biologist hired by the Forest Service. The CBD believed the Forest Service was listening to the biologist's recommendations and how their needs were being represented by the biologist.

The Sierra Club's primary concern, as expressed in comments and in their objection letter, was the use of cable logging to treat steep slopes and the effects of this treatment in regard to equipment noise and reduction in canopy cover in MSO habitat (Gitlin, 2015). The Sierra Club believed the costs of the proposed treatment did not outweigh the benefits. The Sierra Club evaluated the Forest Service's decision to use cable logging as a means to save

treatment money at the expense of long-term negative MSO habitat effects and soil erosion (Gitlin, 2015). The Forest Service provided three action alternatives, and a no action alternative, in their Final Environmental Impact Statement (FEIS) (U.S. Forest Service, 2015a). In the official Record of Decision (ROD), the final treatment (Alternative 4) was a blend of Alternative 2 (cable logging) and Alternative 3 (helicopter logging). After evaluating all alternatives, the blended treatments in Alternative 4 ensured the least amount of impact to MSO while accomplishing the purpose and need. In response to the Sierra Club's comments and objection letter, the Forest Service cites the minimal impact of Alternative 4 and emphasizes that although MSO habitat may be temporarily impacted, over time the habitat would be more resilient and fire risk would be minimized (U.S. Forest Service, 2015b). The Forest Service also referenced the U.S. Fish and Wildlife Service's (FWS) biological opinion in the objection response. The biological opinion, which is based on 2012 surveys, recommended cable and helicopter logging for the reduction of ground disturbance from heavy machinery on steep slopes, which minimizes soil compaction and bare soil exposure (two of the Sierra Club's other concerns). The FWS also stated that if the forest was not thinned properly the risk for stand replacing fires would persist, which is a much greater threat to MSO habitat than the proposed alternative (U.S. Fish and Wildlife Service, 2015). The Sierra Club did not withdraw the objection but did not litigate, likely because of the resolution accepted by the CBD.

In addition to how the CBD and Sierra Club framed their objections around MSO habitat, the City and Forest Service made an intentional decision to frame FWPP as fuels reduction treatments instead of a restoration project. This decision was made to reduce public confusion and ensure support (Mottek Lucas, 2016; Burke, 2012; U.S. Forest Service, 2015a). As Luntz (1998, pg 133) highlights, "facts only become relevant when the public is receptive and willing to listen to them." Because the public had just experienced the Schultz Fire, the impetus for fuels reduction was incredibly relevant and the public was urgent to act on wildfire prevention. The campaign by the City used the Schultz Fire to connect emotionally with the voters. Most reasoning is unconscious and requires an emotional connection before the facts can be heard and acted upon (Lakoff, 2010). For the public to listen to and understand the current science, it is essential that the science is framed within a "systems frame," or context which is relatable to the audience (Lakoff, 2010). The Schultz Fire provided a common experience that triggered an emotional response and aided in voters' willingness to listen to the campaign in favor of fuels reduction treatments and to pass the $10 million bond. More discussion on the science used in the City's campaign and from other stakeholders is discussed in the sections below.

Assessment of Scientific Instruments

Data, Analysis, and Interpretation

Each stakeholder uses science in order to fit their organization's objectives. The City and the Forest Service both use science to justify treatment in the FWPP areas while the CBD and the Sierra Club use science to object to treatment in these areas. This section aims to examine the science used by each stakeholder to justify their decisions or opinions. The initial examination of science will focus on written prescriptions, the Environmental Impact Statement, Record of Decision, and objection letters by the CBD and the Sierra Club. Further examination of science in the FWPP will follow in the "uncertainties" subsection.

The prescription for the Observatory Mesa Natural Area portion of the FWPP will be used as an example to examine the science used by the City in their treatment formation. Observatory Mesa contains a 475-acre harvesting unit in Section 18 (Figure 4). The harvesting guidelines (Millar, 2016a) contain the stand history, overall treatment goals, objectives, guidelines, and the specific prescriptions for the Section 6 area (Figure 4, Figure 5). Although the City and the Forest Service have explicitly stated that the FWPP is a fuel reduction project (Arizona Rural Policy Institute, 2014; Mottek Lucas, 2015; Mottek Lucas, 2016; U.S. Forest Service, 2015a; U.S. Forest Service, 2015b), members of the City are treating the areas as restoration sites (Mottek Lucas, 2016; Millar, 2016). Millar (2016a) cites literature heavily focusing on presettlement forest structure and composition in relation to frequent fires in Southwestern ponderosa pine forests and the ecological restoration of these areas (Covington & Moore, 1994; Covington et al., 1997; Moore, Covington, & Fule, 1999; Nystrom et al., 1999; Schneider, Sánchez Meador, & Covington, 2016; and Reynolds et al. 2013). The prescriptions are informed by the generally accepted historic reference conditions of Southwestern ponderosa pine forests and are widely accepted in the scientific community. For example, Covington & Moore (1994), according to Google Scholar, has been cited 908 times; Covington et al. (1997) cited 639 times; and Moore et al. 1999 has been cited 425 times; there is little dispute over the historical reference conditions of these forests in the scientific community.

The methods used in the literature include recreating forest stand structure and fire regimes based on early (mid-1800s) qualitative descriptions from historical photographs and journal entries, which characterize open, park-like clumps of trees with dense grass cover. Quantitative methods were also used based on the analysis of soil type, presettlement trees and dendrochronological data, fire scars, and various types of modeling, among other methods. Although the amount of citations does not necessarily equate to "getting the science right", the literature used by Millar (2016a) to create prescriptions are informed by the best current

understanding of the ecosystem (Figure 5). Differences in amount of thinning between plots is based on current forest conditions and potential wildlife nesting zones.

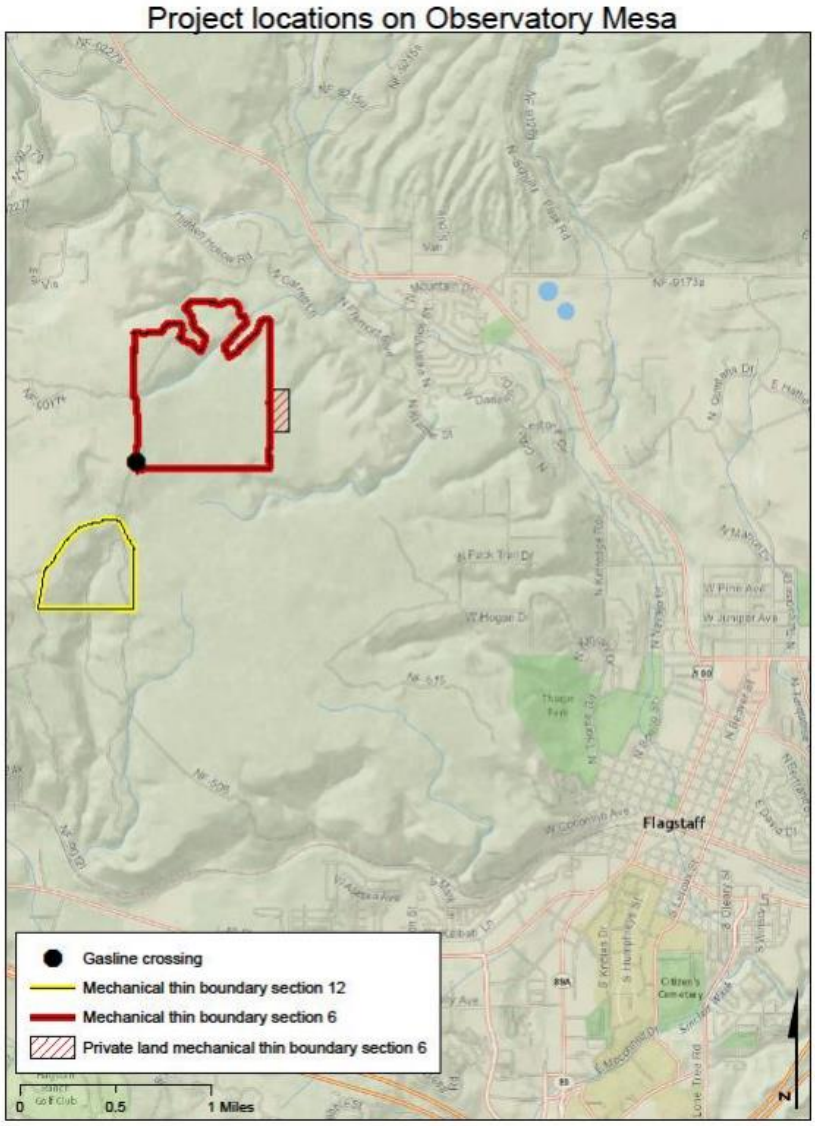

Figure 4. General location of section 6 and 12 project site on Observatory Mesa Natural Area (Millar, 2016a)

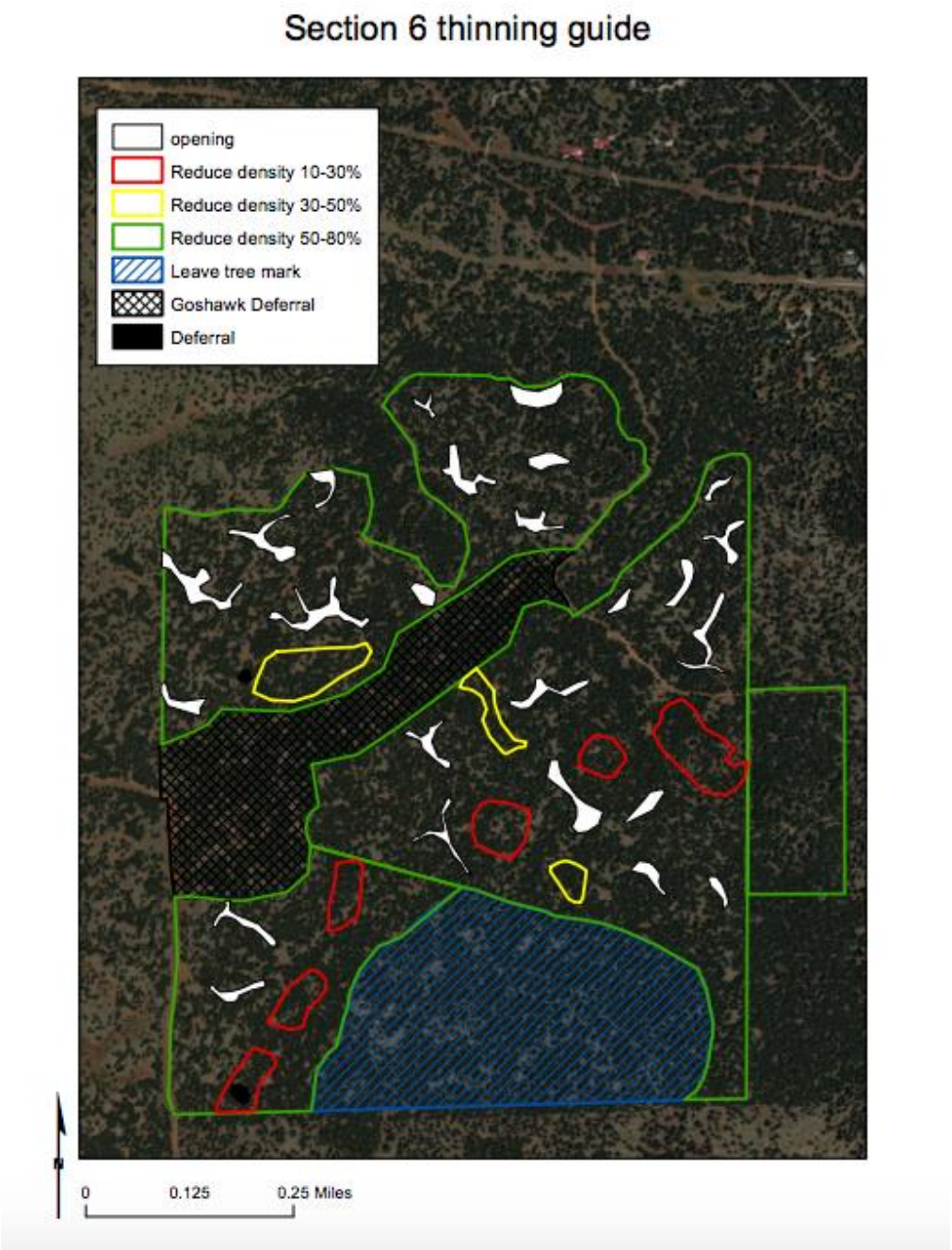

Figure 5. Section 6 Thinning Guide (Millar, 2016a)

The science used by the Forest Service is based on the FEIS and the ROD. In the FEIS, the Forest Service has an extensive list of references (23 full pages) and the majority of the science cited is relatively newly published (2000-present). It would be impractical to analyze all of the science involved in creating the 627-page FEIS document. For the purposes of this paper, the analysis of Forest Service's science will focus on the MSO-related issues brought up by

objections from the CBD and the Sierra Club. Because the City does not own federal land, the NEPA and objection processes are not required for proposed treatments; therefore the objections and science used by the CBD and Sierra Club only pertain to the proposed treatments on Forest Service land and do not pertain to the treatments on City land.

Center for Biological Diversity

As discussed in the Contrasting Perspectives in Science section, the CBD's objection letter (Lininger, 2015) largely centers on potential MSO issues. The CBD cites NEPA and the ESA for the requirement by law of the Forest Service to consider the best available science or to state an explanation for the departure of using the best available science. Here, best available science is a legal requirement from section 7 of the ESA, more specifically 16 U.S.C. 1536(a)(2), for government agencies to "use the best scientific and commercial data available'' when evaluating a proposed action's impact on an endangered species. Best available science is also used by Forest Service regulations in the planning rule as and the National Forest Management Act of 1976. The Council for Environmental Quality also published guidelines to use the best available science and technical information in relation to NEPA (Beveridge & Diamond 2010). In these documents, best available science means high-quality in following the scientific method and peer review to validate the findings and methods used (Sullivan et al. 2006). The CBD first argues that the proposed road construction in PACs is contrary to best available science and cites U.S. Fish and Wildlife Service (2012) and U.S. Fish and Wildlife Service (2015) as evidence, which are also cited by the Forest Service (U.S. Forest Service, 2015a; U.S. Forest Service, 2015b). The CBD mainly objects to the treatment because the Forest Service does not state a reason as to why road building is essential to the project in PACs. In response, the CBD cites a Forest Service published synthesis on forest roads (Gucinski et al. 2001) with mention to the decline of soil productivity due to road construction on steep slopes and the fragmentation of wildlife habitat, which the Forest Service had noted in the cumulative effects section of soil and water resources in the FEIS (U.S. Forest Service 2015a). CBD also cites Trombulak and Frissell (2000) in their statement "new roads can permanently impair soil productivity even if their use is temporary", however, the words "soil productivity" cannot be found in this review of the ecological effects of roads on terrestrial and aquatic communities. Although the CBD accuses the Forest Service of not using the best available science, the CBD does not add new or different perspectives in this section and the science used by CBD objects to road building impacts on soil productivity, not MSO. CBD states the

concerns of soil productivity directly relate to conservation of MSO habitat (Lininger 2015) but do not actually support their claim.

The CBD also objects to fuels reduction treatments occurring during the MSO breeding season because the treatments go against the best available science. The CBD mainly cites U.S. Fish and Wildlife Service (2012) and (2015), which are also cited by the Forest Service. The need for treatments to occur during the breeding seasons is explained in U.S. Forest Service (2015b) and the treatment is aimed to limit the duration of treatment effects. The Forest Service emphasizes the need to act quickly to reduce the potential of severe wildfire that would alter MSO habitat and livelihood (U.S. Forest Service 2015b). Lastly, the CBD objects to the potential amount of incidental take of MSO and again cites U.S. Fish and Wildlife Service (2012) and (2015). Incidental take describes an activity that may cause harm or kill an endangered or threatened species. The FWS states that the implementation of the FWPP and 4FRI will not exceed incidental take (U.S. Fish and Wildlife Service 2012), which the Forest Service also cites (U.S. Forest Service 2015a; U.S. Forest Service 2015b). CBD criticizes the FWS biological opinion as "arbitrary and capricious" for this statement and believes it is not based on fact, but does not provide contrasting science and instead speculates the incidental take will be exceeded from cumulative effects of other projects (Lininger, 2015).

Overall, the CBD objection and interpretation of the project is not an issue of the best available science; rather it is concern for the road construction's cumulative effects because of the possibility of similar actions from 4FRI activity and the need of the Forest Service to provide additional rationale for treatment occurring during MSO breeding season. The CBD has since withdrawn their objection because of the resolution mentioned in the Contrasting Perspectives in Science section.

Sierra Club

The Sierra Club's objection letter opposes the use of cable logging because of the potential long-term negative effects on MSO habitat (Gitlin, 2015). Although Forest Service previously acknowledged comments made by the Sierra Club on the impacts of cable logging, the Sierra Club's objection is based on the belief that the Forest Service did not provide adequate reasoning for the inclusion of this treatment method.

In the first part of the objection, the Sierra Club expresses concerns for the risk of ecological harm to MSO because of the 267 acres of snag removal (for safety purposes) in the helicopter logging areas. The Sierra Club references studies on the California spotted owl (*Strix occidentalis occidentalis*) as evidence, however, they do not make a connection as to how this

species is similar to the Mexican spotted owl or how the studies referenced are pertinent to the FWPP. Out of the four referenced articles on spotted owls, three of them are studies specific to the California spotted owl (Bond et al., 2009; Roberts et al., 2011; Lee et al., 2012) and one is a study on the short-term effects of wildfire on the three subspecies of spotted owl (Bond et al., 2002). Although the Sierra Club's connection between MSO and the California spotted owl is ambiguous, the science used is somewhat ambiguous as well. For example, the Sierra Club references the Bond et al., (2009) study on California spotted owls twice to support habitat preferences in areas where total basal area (including high basal area of snags) is more important than burning in predicting spotted owl presence. The referenced study examines the effects of fire on 7 owls from 4 territories, a small sample size compared to the other literature Sierra Club referenced, where the total sample sizes were >30 individuals. Although the Sierra club references literature on spotted owls, the literature used does not support their objection nor does it add any new science or pertinent information on MSO in relation to the FWPP. The Forest Service disclosed the effects of MSO and MSO habitat in the FEIS and cites U.S. Fish and Wildlife Service (2012) and (2015) among many other articles about MSO and MSO habitat, which are the best available science. In the Final Record of Decision (U.S. Forest Service 2015b), the Regional Forester, Calvin Joyner, responded to the Sierra Club about the objection letter and further explains the science used in the FEIS.

The Role of Uncertainty

Science does not provide clear solutions to land management problems because of inherent uncertainty (Ludwig et al., 1993). Uncertainty plays a large role in the FWPP, especially in regard to MSO, MSO habitat, and wildlife studies in general. Wildlife targets of study, like the MSO, are mobile, have varying ranges, varying habitats and preferences for breeding and foraging, and react to environmental changes differently (Murphy and Noon, 1991). Land management agencies, like the Forest Service and the City are required or strive to use the best available science to influence and support land management decisions that can have impacts on threatened species. As mentioned above, science was used by all parties to support their professional opinions on the FWPP. Below are prominent examples of uncertainty used in the FWPP.

The CBD uses uncertainty in their objection letter to oppose treatment. Scientists from FWS were used by the Forest Service to provide a biological opinion on the treatment in regard to MSO and MSO habitat. The Forest Service had to defend the science against the objections made by the CBD. As mentioned above, the CBD stated that the FWS biological opinion on the

amount of incidental take was not based on fact (Lininger, 2015). The CBD interprets the statement by FWS, “We do not expect that each year owls associated with four PACs may be taken as a result of short-term disturbance and/or habitat alteration; however, we think the potential is there in any given year (U.S. Fish and Wildlife Service 2012 p.37)” as the FWS admitting that the incidental take of MSO will exceed the authorized limit. The key word is potential. Science is not based on fact, but as a conservation advocacy organization, the CBD is making use of the precautionary principle to make sure the Forest Service does not break the law in exceeding the authorized limit of incidental take. Freudenberg et al., (2008) describes the precautionary principle as justification of whether uncertainty should or should not be used as reason to avoid regulations in the absence of scientific consensus. If there is no scientific consensus on whether or not something is harmful, then the burden of proof that it is not harmful falls on those who are taking the action (i.e. Forest Service). The CBD used the precautionary principle and uncertainty in their objection to err on the side of caution with regard to the MSO rather than to take action and potentially harm the livelihoods of the species.

The precautionary principle as well as the uncertainty involved in the science were also used to gain support for the fuel treatments by the City of Flagstaff and the Forest Service, who stated that the community will be safer with fuel treatments now, rather than potential catastrophic wildfire and flooding later. This was especially prominent during the 2012 campaign. Scientists from NAU, ERI, FWS, and Forest Service were used to influence the City and voters to pass the bond legislation (Mottek Lucas 2016). Fire and post-fire flooding models were developed by scientists to show citizens the potential effects of severe wildfire in the Rio de Flag watershed (Figure 6). Although models are abstractions of reality and based on uncertainty, the potential of severe fire and flooding, especially after the post-fire effects and costs of the 2010 Schultz fire, helped convince voters to approve the project bond.

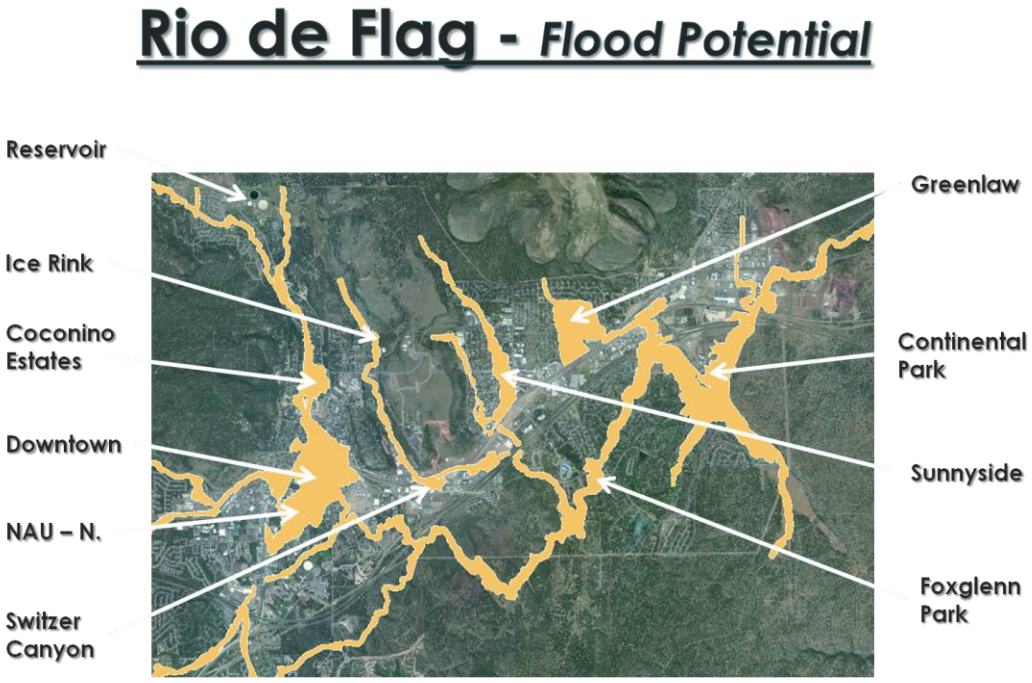

Figure 6. Map of potential flood zones after severe wildfire and monsoons (Yes on 405, 2012)

Important policy documents

Before project planning took place, the City of Flagstaff and Coconino National Forest established their roles and communication commitments to the FWPP. They developed two Memoranda of Understanding and a Master Participating Agreement that described their duties as they cooperated on the project (U.S. Forest Service 2013b, 2013c, 2013d). Since the FWPP is primarily funded by the City, but mostly taking place on Forest Service land, the City would make the financial decisions and the Forest Service would conduct the environmental planning and permitting (Mottek Lucas, 2015). The Forest Service would maintain ultimate land management authority on Forest Service land. The portion of the FWPP taking place on City of Flagstaff ownership would be managed under the City of Flagstaff Open Space Strategic Plan (2015) as the Observatory Mesa Natural Area.

The vast majority of applicable policy documents were from federal regulations. As a federal land management agency, the Forest Service is governed by several important federal environmental laws and policies. Some of the regulations are specifically designed to protect designated plants, wildlife, and their habitats, while others are more broad and govern any federal agency actions that may have environmental impact. These policies were addressed by the Forest Service during the environmental planning process.

The Forest Service is required to abide by federal laws and policies that specifically regulate wildlife management. The ESA is designed to conserve threatened ecosystems that endangered species rely upon (U.S. Fish and Wildlife Service, 1973). The ESA requires all federal agencies to ensure that none of their actions will negatively impact a federally listed species. The MSO Recovery Plan was developed by the U.S. Fish and Wildlife Service to provide management guidelines for MSO in concordance with the ESA requirements for managing a threatened species (U.S. Fish and Wildlife Service, 2012). Additionally, the Forest Service operates under the National Forest Management Act (NFMA), which requires federal agencies to sustainably manage wildlife (U.S. Forest Service, 1976).

In addition to wildlife specific regulations, the Forest Service must comply with NEPA (Council on Environmental Quality, 1969). NEPA is a broader law that requires all federal agencies to consider the impact of their actions on the natural and physical environment. The NEPA process requires federal agencies to produce one of three analysis products, depending on the project's potential for environmental impact. In order of least to greatest potential impact, these analysis products include: a categorical exclusion, an environmental assessment, or an environmental impact statement. For the FWPP, the Coconino National Forest prepared the most in-depth analysis required by NEPA - an EIS.

The EIS process begins with a Scoping Period. A Proposed Action document was prepared by the Flagstaff Ranger District of the Coconino National Forest in April 2013. It was designed to notify the public that the agency would conduct an EIS to evaluate and disclose the potential impacts of the FWPP (U.S. Forest Service, 2013). The Proposed Action was soon followed by the Notice of Intent, which began the official 30-day Scoping Period, in which the public could participate in the EIS process by providing feedback on the proposed project. This feedback was used to develop the issues and alternatives analyzed in the Draft EIS.

The next step of the EIS process is the Analysis Period. The Analysis Period begins with a Draft EIS (DEIS). Using the feedback generated during the Scoping Period, the Coconino National Forest created three action alternatives, and one no-action alternative, of which the environmental impacts were individually analyzed (U.S. Forest Service, 2014). Following the publication of the DEIS, there was a 45-day Public Comment Period in which the public was encouraged to comment on the DEIS analysis. The Coconino National Forest took into account the public comments to modify alternatives and to revise the analysis of potential impacts from these alternatives, which were then used in the Final EIS. The Final EIS included more detailed information on socio-economic impacts, temporary roads, and scenery examples of cable logged forests (U.S. Forest Service, 2015a).

The last step of the EIS process is the decision. The final decision is made by the NEPA Responsible Official, in this case the Forest Supervisor of the Coconino National Forest. A Record of Decision was published that provided information about the various alternatives considered in the EIS analysis and the rationale for the chosen decision. The decision chosen for the FWPP was unique in its blending of alternatives, rather than just selecting one alternative. The decision allows for adaptive harvesting to enable flexibility in deciding the best logging method on a site level, MSO specific treatments and monitoring, ability to temporarily close recreation areas, and a strategy to retain valuable large trees (U.S. Forest Service, 2015b).

As a federal agency, the Forest Service was required to follow the above mentioned environmental regulations that are designed to protect listed species and consider the overall environmental impacts of the agency's actions. These processes also provide public transparency and promote public involvement in government actions that may affect not only the environment, but public livelihood.

Policy Theory Application

The policy processes involved in the formation of the FWPP reflect characteristics of a myriad of policy formation theories; the streams model of policy formation, the issue attention cycle, the rational model, and the influence of stakeholders. Observations regarding the role of public involvement and collaboration are particularly relevant and will be discussed.

The streams model presents the decision to craft policy as the result of a window of opportunity created by the merging of three streams: the politics stream, the problem stream, and the policy stream (Birkland, 2010). While the policy stream encompassess "the state of politics and public opinion," the problem stream describes attributes of the issue (for example, whether the problem is getting better or worse, the extent to which it exists in public consciousness), and the policy stream explores potential solutions. In the case of the FWPP, densely fuel-loaded forests in and surrounding Flagstaff are a result of past management practices and fire suppression; these forests embody the problem stream. Before human settlement, these forests would be naturally controlled by frequent, low intensity fire (Covington and Moore, 1994). The problem of overly dense forests advances over time as fire risk increases with drought, rising temperatures, and increasing fuel loads from dense forest regeneration, increased disease, and downed logs that can create fuel ladders (structures that can carry a ground fire into the main crown and canopy). The Schultz Fire in 2010 (Figure 1) brought the problem of overly dense forests to attention, affecting public opinion of the issue

and forcing politicians, as well as citizens, to recognize the need for fuels reduction, thereby merging the politics and problem streams. With the convergence of these two streams, ideas began to trickle through the policy stream and a window of opportunity based on the convergence of the problem, the politics, and policy was created. As a result of this window of opportunity, the decision to form ameliorative policy was made and the policy formation process itself began to gain focus and momentum.

The concept of the issue attention cycle, which describes the public perception of an issue in terms of stages of heightened interest and boredom, applies well to the Schultz Fire (Downs, 1974). In the “pre-problem stage”, the issue of dense forests prone to wildfire existed, but the public paid little attention. The “alarmed discovery and euphoric enthusiasm” stage occurred when the Flagstaff community was threatened of this issue with the Schultz Fire in 2010, and the resulting floods which caused infrastructural, public property and cultural damage, and the tragic loss of a life. This overwhelming interest in the problem was shown by the 73.6% voter acceptance to Proposition 405, which passed the 10 million dollar bond that would fund the FWPP (Mottek Lucas, 2015). The “realizing cost of significant progress” stage describes the EIS process in which both monetary and non-monetary costs are determined in the planning procedure. The monetary costs were evaluated throughout the EIS formation and the FEIS includes a table that evaluates four possible alternatives and summarizes all foreseeable costs. In terms of non-monetary costs, the comments and objections gauged the public concern for wildlife such as the MSO, and for temporary closures and degradation of recreational trails (U.S. Forest Service, 2015a). One of the challenges associated with this stage is the possibility of unanticipated future costs arising after implementation begins. The “gradual decline of intense public interest” stage represents the current issue attention cycle conditions where the Flagstaff community slowly loses attention to the FWPP after implementation begins. The “post problem stage” reflects the period after the project is complete and the public exists in boredom, paying little attention to the issue.

The rational model of policy formation posits that the process proceeds as follows: first a problem in need of addressing arises and the decision is made to create a policy attempting to solve this issue. Goals are specified (what attributes does a successful outcome have?), a set of alternatives for achieving these goals are developed, along with the assessment of consequences for each alternative, and the best policy which either maximizes or achieves the goals with minimal negative consequences is finally chosen (Birkland, 2010). According to this model, each of these steps is rationally completed by the decision makers who possess the comprehensive information and are not swayed by bias or emotion.

The EIS process used in the formation of the FWPP reflects the rational model of policy formation. This process requires a clearly defined end goal, a study of alternatives and prediction of the consequences for each alternative, and a final decision about which alternative will achieve the "maximum gain" (Birkland, 2010). The FWPP end goal is termed as a fuels reduction process, which aims to minimize the wildfire hazard. The DEIS and FEIS analyzed various thinning method alternatives, taking into account all perceptible planned associated costs as well as wildlife and social concerns (U.S. Forest Service, 2014 and 2015a). The FWPP is an interesting case study because the ultimate decision was a combination of all three of the action alternatives proposed in the FEIS.

Interdisciplinary collaboration played an important role in the construction of the FWPP. The Forest Service published a proposed action plan in April 2013 to gauge the interests and concerns of the public (U.S. Forest Service, 2015a). The most common and relevant themes expressed by the public include the potential damages to MSO habitat, the use of cable logging, and the possible destruction of old growth trees.The project formed a 15 member interdisciplinary (IDT) team after the creation of the proposed action plan to analyze NEPA policy for the EIS draft, and to address wildlife concern (Mottek Lucas, 2015). A communication team, consisting of experts and stakeholders, was formed to organize documents, maintain internet presence, and plan public events. The project specific website is updated with current FWPP related information and boasts a user-friendly interface.

The policy process used by the FWPP addressed differing values and incorporated ideas from several stakeholders groups to reach a decision that best represented multiple perspectives and needs effected by the project. This was most evident during the scoping and public comment periods that were part of the FWPP EIS. During these periods, members of the public contributed comments to incorporate their values and help shape the decision-making process. In addition, stakeholder groups such as The Sierra Club and the CBD were able to utilize the Project-level Objections Process in the EIS to provide input and voice their concerns (U.S. Department of Agriculture, 2013). By acknowledging values and involving stakeholders in the decision, the Forest Service utilized strategies that led to more widely accepted decisions and created less conflict between interested groups (Dietz, 2013; Voinov and Bousquet, 2010).

Finally, collaboration with and involvement of various actors, including the public, played a significant role in the formation of the FWPP policy. Initially, decades of collaborative work between the City, Flagstaff Fire Department's Wildland Fire Management program, the Forest Service, ERI, NAU, and the Greater Flagstaff Forest Partnership provided a solid base of science and support for the project (Mottek Lucas, 2015). The City of Flagstaff (2012) report,

published shortly before the 2012 campaign, helped establish the scientific foundation necessary for an overwhelming majority (73.6%) of Flagstaff voters to approve the bond needed to fund the FWPP (Mottek Lucas, 2015). The IDT established within the FWPP engaged the participation of the public, interest groups, and experts throughout the policy process by involving wildlife experts from the Center for Biological Diversity in deliberations surrounding protection of MSO habitat and seeking public comments on the Proposed Action Plan and EIS processes (Mottek Lucas, 2015). The City also engaged public participation through various actions, including presentations, public outreach events, site tours, social media, and mail flyers. The myriad of suggestions made throughout this process embody Pielke's (2007) conception of the way science-based policy formation should work, with increased policy options as a result of collaboration. This collaborative and interdisciplinary approach to the FWPP policy formation has been credited with streamlining the process by minimizing distrust and pushback from interest groups, though the CBD along with the Sierra Club did file objections to the FWPP (Mottek Lucas, 2015).

Our Assessment

It is important to evaluate wildfire risk and consequences of post-fire flooding facing the Flagstaff community that could result in damage or loss of infrastructure, property, wildlife habitat and watershed resources. The assessment of the strengths and shortcomings of the use of science throughout this project is important as well. One of the strongest aspects of the formation of the FWPP is the effective use of science communication and encouragement of participation through public outreach and education to proactively mitigate fire and flood hazard (Mottek Lucas, 2016). As mentioned above, nearly two decades of collective fuel reduction work from the City, Forest Service, ERI, NAU, the Greater Flagstaff Forest Partnership, and local interest groups encouraged public education and advocated for the approval of the FWPP (Mottek Lucas, 2015). This same approach was used to easily communicate the Best Management Practices (BMPs) that were created during the EIS process and are being used in the FWPP treatment areas (Flagstaff Watershed Protection Project, 2016). The BMPs are determined on a site level basis based on current forest conditions, surrounding wildlife, and usability of equipment. Another beneficial facet of the FWPP science-policy interface is the flexibility incorporated in the assessment of the alternative action plans, which blended the alternatives to create the BMPs (Pielke, 2007; U.S. Forest Service, 2015a). It was also paramount to work with the objecting interest groups during the EIS procedure to ensure all parties felt their concerns were sufficiently listened to and addressed in the final action plan.

This can be seen by the objection withdrawal by the CBD, and the legal inaction by the Sierra Club after the ROD, signifying how both interest groups were satisfied enough to avoid litigation. The political framework constructed through the formation of the FWPP provides structure for future forest fuels reduction projects in communities across the western United States.

While most of the science involved in creating the FWPP was used and communicated efficiently, there are examples of shortcomings in the form of monetary planning, long-term public perception, socioeconomics (Mottek Lucas, 2016), and the use of "worst-case scenarios" to influence voter support. The public perception of treatment implementation can be difficult to gauge and it is possible that the public has not realized the extent of forest thinning and how dramatically different the forest will look during and after treatment. As a result, the public perception may worsen over time due to the possible lack of understanding of fuels reduction treatment appearances in the short term, especially for those who live near or frequently recreate near the treatment areas. The socioeconomic aspect of the FWPP is a common problem in fuel treatment and restoration projects across the southwest because there is little to no market for the small diameter wood coming off the landscape. As of now, this is not a problem for the FWPP because the Forest Service has not begun treatments, but it will likely be a problem in the near future (Mottek Lucas 2016). The city is able to avoid this issue by converting the small diameter wood into wood chips and sending the product to the Coronado Generating Station, which is currently experimenting with the addition of 2-5% wood chips to coal fuel mix (Millar, 2016b). The use of "worst case scenarios" was a questionable way of framing the problem to motivate voter support for Proposition 405 approval. The information was created by scientists and dispersed to the community to show the potential flooding of downtown Flagstaff and surrounding areas (Figure 6) from possible severe wildfires followed by severe monsoon precipitation. However, this community had already seen the "worst case scenario" and effects from the then recent Schultz Fire.

The investigation of MSO habitat issues also included the questionable use of science, as well as a lack of seemingly key sources. The Sierra Club's objection largely cited sources focusing on the California spotted owl and were published by many of the same authors, most notably, Monica Bond. This may indicate 'cherry picking' for references that only support one side of an argument. Upon further investigation of the MSO management issue, it was found that the article titled "Real versus perceived conflicts between restoration of ponderosa pine forests and conservation of the Mexican spotted owl" (Prather et al., 2008) was not referenced by either side of the MSO argument. This is relevant literature, written in part by a faculty

member at NAU, that discusses the exact argument surrounding MSO, and was available for use in the formation of the FWPP.

The FWPP successfully utilized leverage points within the social and policy system to gain support for the project. Leverage points are places to intervene within a system where a small change will cause a substantial shift in the behaviour of the system (Meadows, 2009). A shift in paradigms is one of the most useful leverage points, and in the case of the FWPP, a paradigm shift occurred from the community understanding the need to shift from a fire suppression management system to fuel reduction and fire reintroduction methods because they were directly affected by the Schultz Fire. This paradigm shift increased the community's willingness to support a bond that would pay for the fuels reduction and watershed management. The significance of clearly defined goals is another vital leverage point and is also recognized as a crucial step in the rational policy model (Birkland, 2010). The FWPP explicitly states the objective of the project as fuels reduction, and the straightforward goal allowed for a focused policy process. There was an intentional framework to not discuss restoration or the language around restoration because there was a concern that the language would confuse voters or detract from the ultimate goal of the project. The utilization of public education also acts as a leverage point in the form of a reinforcing feedback loop. Another crucial facet for the FWPP is the access to information for the public and the transparency of the policy process. The collaborative element and large amounts of public outreach act as an effective information flow that reinforces public education. During the field visit, Matt Millar, an employee of the City, noted how more public involvement could help support the project. Project tours during City events are mostly attended by stakeholders and not the general public (Millar 2016). Millar expressed a desire to continue to increase the participation of members of the public by providing project tours, and despite the outreach, there has not been as much interest as they expected. The payment method for the project, which was funded through a bond replacement, was an atypical way to fund the FWPP that acted as an successful leverage point to strengthen voter support for the bond.

Conclusion

The FWPP of Flagstaff, Arizona provides a salient case study of the role of science in policy formation. As a town in the western United States prone to forest fire, the Flagstaff community came together to proactively mitigate fire and post-fire flooding risks posed by dangerous fuel loads in forests in and around the city limits. With the influence, motivation, and devastation from the Schultz Fire of 2010, the City, Forest Service, and State came together to

form and implement the FWPP. Though there were a number of shortcomings in which science was potentially misused to form FWPP policy, such as perceived “worst case scenarios” and the lack of planning for long term public perception, science ultimately played an influential and productive role for the FWPP policy formation. By addressing contrasting perspectives regarding MSO habitat, communicating scientific information to the public, drawing attention to the issue, and building a scientific foundation to capitalize on leverage points, such as a paradigm shift to facilitate policy formation, the FWPP provides the first example of a city bond funding public lands. Lessons in communication and implementation can be learned from this project and applied to future projects where there is involvement and input from numerous stakeholders under various jurisdictions.

References

Agee, J.K. and Skinner, C.N., 2005. Basic Principles of Forest Fuel Reduction Treatments. Forest Ecology and Management. 211: 83–96.

American Bird Conservancy, 2013. New Recovery Plan Raises Concern for Mexican Spotted Owl.

Beveridge & Diamond PC 2010. CEQ NEPA Guidance Documents Available for Public Comment - Client Alert. Beveridge & Diamond PC, 2010 Feb. 23. Web. 11 Dec. 2016

Birkland, T.A., 2010. An Introduction to the Policy Process: Theories, Concepts, and Models of Public Policy Making. 4th Edition. M.E. Sharpe.

Bond, M. L., Lee, D.E., Siegel, R.B. and Ward, J. P., 2009. Habitat Use and Selection by California Spotted Owls in a Postfire Landscape. The Journal of Wildlife Management, 73: 1116-1124

Bond, M.L., R.J. Gutiérrez, A.B. Franklin, W.S. LaHaye, C.A. May, and M.E. Seamans, 2002. Short-term effects of wildfires on spotted owl survival, site fidelity, mate fidelity, and reproductive success. Wildlife Society Bulletin 30:1022-1028.

Burke, K., 2012. Forest Restoration and Watershed Protection Bond [Memorandum]. Flagstaff, AZ: City of Flagstaff, City Manager's Office

Center for Biological Diversity, n.d. "Saving the Mexican Spotted Owl." http://www.biologicaldiversity.org/species/birds/Mexican_spotted_owl/

City of Flagstaff, 2012. City of Flagstaff Resiliency and Preparedness Study.

City of Flagstaff Open Space Commission, 2015. City of Flagstaff Open Space Strategic Plan.

Council on Environmental Quality Executive Office of the President (CEQ), 1969. National Environmental Policy Act (NEPA)

Combrink, T., Cothran, C., Fox, W., Peterson, J., Snider, G., 2013. A Full Cost Accounting of the 2010 Schultz Fire. Northern Arizona Ecological Restoration Institute. 48 pp.

Covington, W.W., and Moore, M.M., 1994. Postsettlement changes in natural fire regimes and forest structure: ecological restoration of old-growth ponderosa pine forests. Journal of Sustainable Forestry, 2, 153-181

Covington, W. W., Fulé, P. Z., Moore, M. M., Hart, S. C., Kolb, T. E., Mast, J. N., ... Wagner, M. R. 1997. Restoring ecosystem health in ponderosa pine forests of the Southwest. Journal of Forestry, 95(4), 23–29.

Clewell, Andre et al. 2004. The SER International Primer on Ecological Restoration. Society for Ecological Restoration International Science & Policy Working Group.

Dietz, T. 2013. Bringing values and deliberation to science communication. Proceedings of the National Academy of Sciences, 110 (Supplement 3).

Downs, A., 1972. Up and Down with Ecology- the “issue-attention cycle.” Public Interest, 28: 38-50.

“Flagstaff Watershed Protection Project: Frequently Asked Questions (FWPP FAQ)” Flagstaff Watershed Protection Project. City of Flagstaff, n.d. Web. 11 Dec. 2016

"Flagstaff Watershed Protection Project: Harvesting Methods Facts Sheets & Poster" *Flagstaff Watershed Protection Project*. City of Flagstaff, 2016 May 6. Web. 25 Oct. 2016.

“Flagstaff Watershed Protection Project: Best Management Practices Used to Minimize Impacts to Soils, Water Resources and Trails” *Flagstaff Watershed Protection Project*. City of Flagstaff, n.d. Web. 25 Oct. 2016.

Freudenburg, W. R., Gramling R., and Davidson, D.J. 2008. "Scientific Uncertainty Argumentation Methods (SCAMs): Science and the politics of doubt." *Sociological Inquiry*, 78(1):2-38.

Ganey, J. L., & Balda, R. P. (1994). Habitat selection by Mexican spotted owls in northern Arizona. The Auk, 162-169.

Gitlin, A., 2015. Objection: Flagstaff Watershed Protection Project. Sierra Club

Gucinski, H., M.J. Furniss, R.R. Ziemer and M.H. Brookes (eds.)., 2001. Forest Roads: A Synthesis of Scientific Information. USDA For. Serv. Gen. Tech. Rep. PNW-GTR-509. Portland, OR.

Hjerpe, E., J. Abrams, and D. B. Becker. 2009. Socioeconomic barriers and the role of biomass utilization in southwestern ponderosa pine restoration. Ecological Restoration 27:169–177.

Lakoff, G., 2010. Why it Matters How We Frame the Environment. Environmental Communication: A Journal of Nature and Culture, 4 (1): 70-81

Lee, D.E., Bond, M.L., Siegel, R.B., 2012. Dynamics of Breeding-Season Site Occupancy of the California Spotted Owl in Burned Forests. The Condor 114:792-802.

Lininger, J., 2015. Objection: Flagstaff Watershed Protection Project. Center for Biological Diversity

Ludwig D., Hilborn R., Walters C., 1993. Uncertainty, Resource Exploitation, and Conservation: Lessons from History. Science. 260:5104 (17-36)

Luntz, F.,1998. The Environment: A Cleaner, Safer, Healthier America. The Luntz Research Companies - Straight Talk: 131-146.

McDonald, C.B., Anderson, J., Lewis, J.C., Mesta, R., Ratzlaff, A., Tibbitts, T.J., Williams III, S.O. 1991. Mexican Spotted Owl (*Strix occidentalis lucida*) status review. U.S. Fish and Wildl. Serv. Endangered Species Rer. 20, Albuquerque.

Meadows, D., 2009, October 2. Leverage Points: Places to Intervene in a System. The Solutions Journal 1 (1): 41 - 49.

Millar, M., 2016a. Observatory Mesa Harvesting Guidelines: FWPP Planned Operations – Section 6. City of Flagstaff. Print 13p

Millar, M., 2016b. October 19; November 8. Personal communication with Brown, L.

Moore, M. M., Covington, W. W., & Fule, P. Z. 1999. Reference conditions and ecological restoration: A Southwestern ponderosa pine perspective. Ecological Applications, 9(4), 1266–1277.

Mottek Lucas, A., 2015. Flagstaff Watershed Protection Project: Creating Solutions through Community Partnerships. Flagstaff, AZ: Ecological Restoration Institute, Northern Arizona University, ERI White Paper- Issues in Forest Restoration

Mottek Lucas, A., 2016, October 6; October 19. Personal communication with Brown, L., Shin, P., and Webster C.

Murphy, D.D., Noon, B.D., 1991. Coping With Uncertainty in Wildlife Biology. October. Journal of Wildlife Management 55(4):773.

Nystrom, J., Fule, P. Z., Moore, M. M., Covington, W. W., Waltz, E. M., Applications, S. E., ...Forest, P. P. (1999). Restoration of Presettlement Age Structure of an Arizona Ponderosa Pine Forest. Ecological Applications, 9(1), 228–239

Pielke, R.A., (2007). *The Honest Broker: Making Sense of Science in Policy and Politics*. Cambridge: Cambridge University Press.

Prather, J.W., Noss, R.F. , Sisk, T.D., 2008. Real versus perceived conflicts between restoration of ponderosa pine forests and conservation of the Mexican spotted owl. Forest Policy and Economics 10: 140-150.

Roberts, S.L., J.W. van Wagtendonk, A.K. Miles, D.A. Kelt., 2011. Effects of fire on spotted owl site occupancy in a late-successional forest. Biological Conservation 144:610-619.

Reynolds, R. T., Sánchez Meador, A. J., Youtz, J. A., Nicolet, T., Matonis, M. S., Jackson, P. L., ... Andrew, D. (2013). Restoring Composition and Structure in Southwestern Frequent-Fire Forests : A science-based framework for improving ecosystem resiliency. USFS General Technical Report 310.

Schneider, E. E., Sánchez Meador, A. J., & Covington, W. W. (2016). Reference conditions and historical changes in an unharvested ponderosa pine stand on sedimentary soil. Restoration Ecology, 24(2), 212–221. http://doi.org/10.1111/rec.12296

Sullivan, P. J., Acheson, J., Angermeier, P. L., Faast, T., Flemma, J., Jones, C. M., ... & Zanetell, B. A. (2006). Defining and implementing best available science for fisheries and environmental science, policy, and management. Fisheries, 31(9), 460.

U.S. Department of Agriculture, 2013. Project-level Pre-decisional Administrative Review Process. 36 CFR Part 2018.

U.S. Fish and Wildlife Service, 1973. Endangered Species Act of 1973. Department of the Interior.

U. S. Fish and Wildlife Service, 2012. Final Recovery Plan for the Mexican Spotted Owl (*Strix occidentalis lucida*), First Revision. U.S. Fish and Wildlife Service. Albuquerque, New Mexico, USA. 413 pp.

U.S. Fish and Wildlife Service, 2015. Biological Opinion for Flagstaff Watershed Protection Project.

U.S. Forest Service, 1976. "National Forest Management Act of 1976". (16 U.S.C. 1600(note)).

U.S. Forest Service, 2010. Schultz Fire Image. http://www.fs.usda.gov/detail/coconino/landmanagement/resourcemanagement/?cid=stelprdb5348846

U.S. Forest Service, 2013. Flagstaff Watershed Protection Project Proposed Action. United States Department of Agriculture.

U.S. Forest Service, 2013b. Master Participating Agreement Between the City of Flagstaff and the USDA, Forest Service Coconino National Forest. OMB 0596-0217 FS-1500-16A. FS Agreement No. 13-PA-11030420-013.

U.S. Forest Service, 2013c. Memorandum of Understanding Between the City of Flagstaff, Arizona and the USDA, Forest Service Coconino National Forest. OMB 0596-0217 FS-1500-15. FS Agreement No. 13-MU-11030420-012.

U.S. Forest Service, 2013d. Memorandum of Understanding Between the City of Flagstaff, Arizona and the USDA, Forest Service Coconino National Forest to Grant Cooperating Agency Status. OMB-0596-0217 FS-1500-15. FS Agreement No. 13-MU-1103030408-016

U.S. Forest Service, 2014. Draft Environmental Impact Statement for the Flagstaff Watershed Protection Plan. United States Department of Agriculture.

U.S. Forest Service, 2015a. Final Environmental Impact Statement for the Flagstaff Watershed Protection Plan. United States Department of Agriculture.

U.S. Forest Service, 2015b. Record of Decision for the Flagstaff Watershed Protection Plan. United States Department of Agriculture.

Voinov, A. and Bousquet, F., 2010. Modelling with stakeholders. Environmental Modelling & Software, 25(11).

"Yes on 405." *Yes on 405*. 2012. City of Flagstaff, n.d. Web. 25 Oct. 2016.