Chapter 13

Flight of the Phoenix: Coexisting with Mixed-Severity Fires

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13.1 ECOLOGICAL PERSPECTIVES ON MIXED-SEVERITY FIRE

Throughout this book, we have presented compelling evidence of fire's beneficial ecological role mainly in western North America but with relevant case studies in other regions. Even though most people recognize the importance of maintaining fire on the landscape, few realize the myriad ecosystem benefits associated with large fires of mixed severity. Habitat heterogeneity, which may be maximized by mixed-severity fire that includes large patches of high severity, and the successional mosaic such fire creates, is one of the most dependable predictors of species diversity (Odion and Sarr 2007, Sitters et al., 2014). This ecological tenet has yet to be fully realized in management circles. If such fires are operating within historical bounds, then ecosystems will remain resilient to them; indeed, deficits of these fires relative to the natural range of variability, in places such as montane forests of western North America, are degrading to fire-dependent biodiversity (Odion et al., 2014a; Sherriff et al., 2014). This is particularly the case when reductions in fire extent and/or severity occur in combination with forest management practices, such as postfire logging, that undermine development of complex early seral forests (Chapter 11).

The Ecological Importance of Mixed-Severity Fires: Nature's Phoenix

Natural heterogeneity in vegetation types, stand structures, and successional age classes at all spatial scales and environmental settings is emerging as a strategy for enhancing forest ecosystem resilience to climate change, at least in North America (Moritz et al., 2014). This will help ensure that there will be enough habitat for species with varying postfire habitat requirements. The fire dynamic is changing in places, however, with climate change now poised in some systems to recalibrate fire behavior (Chapter 9). With the addition of ongoing pre- and postfire logging in forests and other development pressures, particularly in shrublands, this is having a combined negative impact on native biodiversity associated with both complex early seral and old-growth forest and chaparral ecosystems (e.g., Chapters 2–5).

Beneficial Fire Effects Often Take Time to Become Fully Realized

In general, for ecological acceptance of postfire landscapes to translate into improved management practices, as a prerequisite fire ecologists, land managers, and the general public all must recognize both pre- and postfire landscapes as irreplaceable habitat for fire-associated biodiversity. To a large extent, this depends on how one views the postfire landscape.

When considering the effects of fire, patience is clearly a virtue; postfire processes may take years, decades, or longer to unfold. However, land managers often rely on quick indices to assess fire effects, and this can have negative consequences. For instance, in the western United States, the US Forest Service's "burn area emergency response" (http://www.fs.fed.us/eng/rsac/baer/; accessed February 22, 2015) uses satellite images and other geospatial data in real time to classify soil "damages" immediately after fire. Similarly, the US Forest Services' Rapid Assessment of Vegetation Condition (RAVG) after Wildfire (http://www.fs.fed.us/postfirevegcondition/whatis.shtml; accessed February 22, 2015) provides estimates of "basal area losses" in forests 30-45 days following fires >400 ha. We saw in Chapter 11 that these types of rapid assessments can overestimate tree mortality given their immediate timeline compared with the delayed response of fire-affected trees. In forests, particularly pine and mixed conifer, this can lead to premature conclusions about fire "damages" and fire "catastrophes," as well as erroneous notions about high-severity fire patch size, along with a rush to "take action" at any cost and to advance "restoration" or "recovery" approaches that do far more harm than good (Box 13.1; see also DellaSala et al., 2014; Hanson, 2014).

Notably, differences in whether postfire vegetation is viewed as fuel or habitat (Haslem et al., 2011) most often are at the heart of heated conflicts between natural resource managers and conservationists. Witness these polar opposites: fire suppression (including both mechanical thinning and actions to halt active fires) versus let-burn approaches for wildlife habitat (Chapter 12); postfire logging versus a pulse of biological legacies produced by higher-severity fires (Chapter 11); thinning versus habitat for closed-canopy species; and

BOX 13.1 Rapid Assessment of Vegetation Condition after Wildfire "Treatments" as Defined by the US Forest Service

According to the US Forest Service RAVG assessments, the term *treatment* "describes any of a set of management activities that can assist the prompt recovery of forestlands. Management actions include any combination of live, dead, and dying wood removal, or disposal (with or without commercial value) by any feasible method, including but not limited to logging, piling, masticating, and burning, for site preparation. In addition, planting, seeding, and monitoring for natural regeneration without site preparation are appropriate management activities designed to foster the prompt recovery following wildfire. Treatments also include follow up activities to control vegetation that is believed to compete with desired trees during the early establishment period, usually 1 to 5 years after establishment, using any viable method that meets Land and Resource Management Plan direction."

reseeding/replanting and shrub removal versus the montane chaparral component of complex early seral forest (Chapters 3, 4, and 7). Where one stands on this debate can be a matter of principle and perspective, but can also stem from a lack of a comprehensive understanding of the effects of mixed-severity fire and successional processes after fire (see, e.g., Chapters 2–5). Further, while the public may consider fire to be a necessary change agent (see "Understanding the Public's Reaction to Fire," below), this seems to be tempered by whether fire is operating within "safe limits," constrained by prescribed (or "controlled") fire or reduced in intensity by tree thinning and shrub mastication. While prescribed fire is most appropriate for low-severity, high-frequency fire systems, it is not a replacement for the ecosystem benefits produced by large and higher-severity fire because prescribed fire does not mimic the patch mosaics or pulses of biological activity that higher-severity fires produce (Moritz and Odion 2004, DellaSala et al., 2014). Thus, understanding one's perspective is a starting point for potentially settling differences and developing ways to coexist safely and beneficially with fire. Being willing to respond competently to the cognitive dissonance created when perspectives do not align with new scientific information is also vital to the development of successful and ecologically sound fire management strategies (e.g., Chapter 7).

13.2 UNDERSTANDING THE PUBLIC'S REACTION TO FIRE

If ecologists and conservationists want a new discourse on fire that improves ecological understanding and fire management practices, then informed and sustained communications with the public, land managers, the media, and decision makers are vital. A common understanding is needed to move the public and land management agencies from a view of fire as the harbinger of death (Kauffman, 2004) to fire as nature's phoenix. Here we provide some insights from a public poll on fire attitudes in the United States that reaffirms our personal experiences about the prevailing attitudes of the public and of land managers when it comes to fire.

Attitudes Toward Fire

In 2008 The Wilderness Society and The Nature Conservancy got together to construct a 10-year fire communications framework that was informed by a large national sample of public attitudes ($n=2000$ respondents), focus groups in six regions of the United States where fire was a concern, and communications experts (Metz and Weigel, 2008). The task was to develop ecological messaging on fires that would "complement Smokey Bear's message" about being careful with fire.

Based on a summary of the survey findings, important messages on fire can be gleaned from survey data, some of which are remarkably aligned with fire ecology, whereas others are at odds with basic ecological principles. Most notably, the poll demonstrated the public's sophistication regarding the role of fire in ecosystems, but it was clearly tempered by safety concerns (Smokey Bear), notions regarding the importance of "controlled" burns, and a desire to let "some" fires burn in "natural areas." Education (higher levels) was associated with positive attitudes toward fires, and gender was a factor, with men being more risk tolerant and women more risk averse. Some of the poll's most relevant findings are displayed in Box 13.2. We

BOX 13.2 Key Findings on Public Fire Attitudes from the Study by Metz and Weigel (2008)

- Some fires can be beneficial, and a history of fire suppression has led to more large and destructive fires. (*Note that dramatic changes in fire behavior actually are associated with very few forest types in western North America* (Odion et al., 2014a)).
- Strong negative emotional reactions to fire persist based on safety issues (most view fire as "scary").
- Public understanding of fire's ecological role has increased over time.
- Public concerns about wildfire rank very low compared with other conservation issues.
- The most significant fire concerns pertain to effects on people and firefighters rather than ecosystem benefits.
- Allow fire teams to use "controlled burns" when and where doing so will safely reduce the amount of fuel for fires (*controlled burns are most relevant in low-severity rather than mixed-severity systems*).
- Cut and remove overgrown brush and trees in natural areas that act as fuel for fires (*this is largely true for low-severity systems, not higher-severity fires that are largely controlled by extreme weather*).
- Allow naturally started fires that do not threaten homes, people, or the health of natural areas to take their natural course, rather than putting them out.
- Shift some government funds from putting out practically all fires to proactively cutting and removing overgrown brush and trees and using controlled burns to reduce the amount of fuel for fires (*removing brush/trees and controlled burns are mostly ways to reduce fire severity in low-severity systems*).

also highlight in parentheses those beliefs that seem to be at odds with the ecological literature on mixed-severity fires.

Communication experts then advised the conservation groups that successful fire messaging should have the following five fundamental communication themes:

1. Protect people, property, and communities
2. Safeguard the health and regeneration of natural areas
3. Safely manage controlled burns to clear fuels (*this management is appropriate in low-severity systems only during the natural fire season*)
4. Save taxpayer money through controlled burns
5. Protect air and water by protecting the health of forests and natural areas and giving plants and wildlife the exposure to fire they need to survive

From focus groups and polling results, according to communication experts the following cogent messages are likely to reach the public:

- Safety is always the number one priority when it comes to fire. By putting out every single fire, however, we are actually creating more dangerous conditions (*in western North America, higher-severity fires are operating at an historical deficit*). Using controlled burns to thin out overgrowth and carefully managing natural fires help ensure the safety of neighborhoods in outlying areas.
- Forests and natural areas are important to our health; they act as natural filters to give us clean air and are the source of clean drinking water. We must ensure the health of forests and natural areas by allowing some fires to take their natural course.
- Taxpayer money is being wasted putting out fires that are far from people and their property. A far more cost-effective approach is to use controlled burns to prevent large, severe fires from spreading into areas where people live and to allow some fires to take their natural course (*and they are ecologically inappropriate when applied outside the natural fire season*).

For higher-severity fires, a good portion of this messaging may work to bridge the divide between science and public attitudes, whereas some of the recommendations of the communications experts in 2008 (refer to the italicized text in the parentheses above) do not incorporate the ecological importance of maintaining, and managing for, complex early seral forest created by mixed-severity fire. In particular, the poll's findings that fire safety matters most is still very much relevant; thus putting out fires that are dangerous to human communities is clearly of primary importance. From a safety standpoint, Smokey Bear's cautionary fire safety tale needs to be updated so that the focus of fire management is on creating "defensible space" around homes, the home ignition zone (HIZ), and introducing land use zoning to allow fire to run its course unimpeded in natural areas under safe conditions ("Making Homes Fire Safe", see below). And, while the poll found the public generally agreed that fire is necessary in natural areas, how far this tolerance would go in relation to large or higher-severity fires is unclear given that the poll's questions were geared toward low-severity fires that can be either "controlled" or suppressed (through thinning or the use of fire retardants). Notably, in Chapter 12 we discussed how runaway expenditures in fire suppression have been ecologically damaging and fiscally irresponsible, and the public seems to agree with these fiscal concerns. In combination with economics, whether public attitudes will change, or are changing, regarding large or higher-severity fires is still unknown; this will require polling that is more specific to these kinds of fires along with enhanced public education (e.g., the videos referenced in the preface) regarding ways to coexist with large fires.

A core message—and one that will most certainly be difficult for much of the public to accept despite being fact based—is that large fires in any given location each year, at least in western North America, cannot be stopped no matter what we do. We at least need to be honest about that and clearly state the damages that can ensue from large-scale pre- and postfire management that attempts to control large, mainly climate-driven fires that are uncontrollable. We also need to clearly communicate to the public the current state of scientific knowledge regarding the ecological benefits and values of the habitats created by mixed-severity fire. This is especially so given the still all-too-common notions that such areas have been categorically damaged by fire, which in turn leads to misguided assumptions that they are in need of "restoration" or "recovery" management actions.

13.3 SAFE LIVING IN FIRESHEDS

Based on public attitudes toward fire there are important challenges to coexistence with fire. These can be overcome, however, if we not only increase public education about current fire ecology but also act responsibly in reducing risks where they matter most. We note that by far the biggest challenge to coexistence with fire is the explosion of exurban sprawl in many rural communities triggered by those moving out of congested cities.

A case in point is Kalispell, Montana, the gateway to Glacier National Park. A November 17, 2014, article in *Greenwire*, the online source of information on the environment ("Where property rights are king, development continues despite growing wildfire threat"), reported that during the 1990s the county's population grew at twice the state's average as more and more people seeking a rural quality of life purchased 16-ha "ranchettes" scattered across Big Sky fire country. They were able to do so as a result of lax and often resisted land use zoning standards. Based on data provided by Headwaters Economics (2014), 11,000 houses in this Montana county lie within the wildland-urban interface (where towns, homes, and other built structures abut fire-prone wildlands)—more than any other county in Montana—and this number is growing at a phenomenal rate. As reported in the online article, public attitudes included the notion that fire will not directly affect them and strong views about private property rights (i.e., "don't tell me what to do on my land"). Some of the same people vocally oppose government actions in general then demand that public money be spent to remove "fuels" from wildlands. In essence, the lack of homeowner fire risk reductions and inappropriate fuel treatments is setting in motion the perfect storm of land use and fire conflicts.

To minimize these kinds of conflicts, landowners need to practice fire-safe (also known as "fire-wise" in the United States) planning to protect home structures. We suggest that landowners first declare a common "fireshed" boundary, as they do for watersheds. Firesheds are multidimensional spaces. They begin at the scale of a watershed and encompass the residential community with similar fire risks (Figure 13.1a). Within a fireshed, homeowners can take fire risk reduction measures together (preferably) or on their own (Figure 13.1b).

Making Homes Fire-Safe

Probably no research results are as relevant to fire safety science than those of Dr. Jack Cohen (e.g., Cohen 2000, 2004), whose seminal fire safe research recommendations are now standard risk reduction measures taken by many homeowners[1] and have caught on with risk-averse insurance companies[2]. The work of Syphard et al. (2012, 2014) on home loss in chaparral systems of southern California is strikingly similar.

According to Dr. Cohen, fire planning within an HIZ begins with defensible space nearest the home. Notably, research on HIZ risks shows that homes whose owners reduced vegetation and flammables within 10-18 m of the structure and built with nonflammable roof materials had an 86% (Foote, 1996) to 95% (Howard et al., 1973) "survival" rate when fires swept through an area (cf. Syphard et al. (2014) for more recent and similar home structure protection distances). Combined with home fire simulations by the insurance industry (http://www.extension.org/pages/63495/vulnerabilities-of-buildings-to-wildfire-exposures#.VHUr00snRNs; accessed February 15, 2015), Box 13.3 provides measures that are most critical for living safely in firesheds.

An example from a town in Idaho during an intense 2007 fire is instructive regarding the importance of the HIZ and fireshed management. As the *Idaho Statesman* newspaper reported (Druzin and Barker, 2008):

> *We spend billions attacking almost every wildfire, but scientists say that's bad for the forest, can put firefighters in unnecessary danger and doesn't protect communities as well—or as cheaply—as we now know how to do. A wall of fire barreled through the forest with a jet-engine roar near Secesh Meadows last August, and local fire chief Chris Bent knew his work was about to be tested.*

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1. http://www.firewise.org/wildfire-preparedness/firewise-toolkit.aspx?sso=0; accessed November 25, 2014.

2. http://www.extension.org/pages/63495/vulnerabilities-of-buildings-to-wildfire-exposures#.VHUr00snRNs; active November 26, 2014.

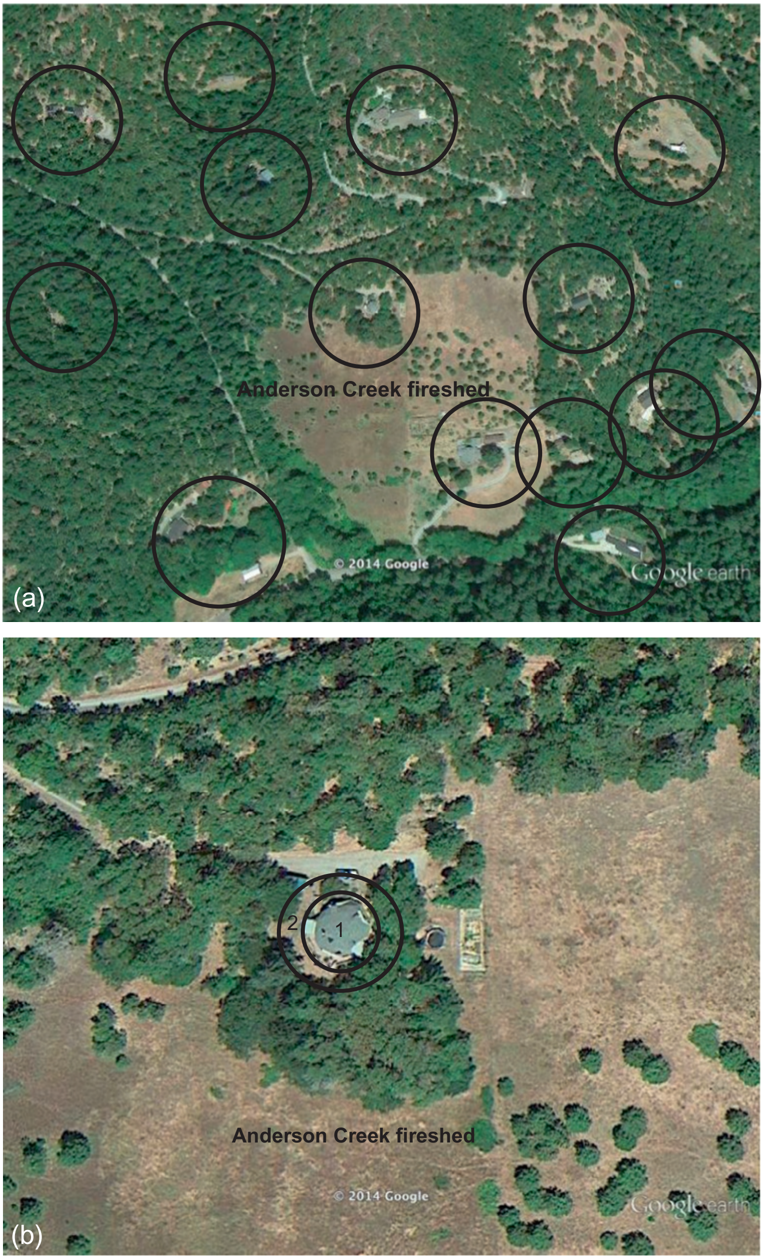

FIGURE 13.1 (a) Google Earth image of the Anderson Creek watershed and community fireshed in Talent, Oregon, showing a housing development (circled; the center house is depicted in b). Most members of this community reduced lower-strata fuels via thinning small trees in the surroundings, although tree densities are beginning to fill in and require repeat treatments. (b) Two fire-safety zones where the landowner built with fire-resistant material in the inner most zone (home ignition zone 1) and cleared most vegetation within a 10 m radius around the structure (zone 2). Tree crowns are touching in zone 2; however, lower branches were pruned to 3 m, and there are few ladder fuels to carry fire from the ground into tree crowns. Downslope grasses may pose a fire hazard but may not crown out given the precautions taken in zones 1 and 2.

BOX 13.3 Prudent Fire Risk Reduction Measures for Homeowners

- Build homes with noncombustible roof covering and siding; keep roof and gutters clear of leaves/needles; keep firewood away; keep vegetation adjacent to homes to a minimum; cut overhanging limbs of trees closest to the home; and install ember-resistant attic vents.
- Clearing vegetation within 5-20 m of a home is the most effective treatment: Carefully space plants, reduce wood plant cover to <40% around the structure, and use varieties that grow low and are free of resins, oils, and waxes that burn easily; mow the lawn regularly and prune trees up to 3 m from ground; space conifer crowns ~3 m apart and remove lower limbs; trim back trees overhanging the house; create a "fire-free" area within 1.5 m of the house using noncombustible landscaping; remove dead vegetation; use fire-resistant furniture; remove firewood and propane tanks; and water plants or use xeriscaping.
- Additional measures include low-growing, well-irrigated, and relatively noncombustible vegetation in low planting densities; a mix of deciduous and conifer trees; fuel breaks like driveways and gravel walkways and lawns.
- Treatments >30 m from the home structures offer no additional protection (Syphard et al., 2014).

> *Flames danced atop lodgepole pines, smoke darkened the sky, and residents of the tiny mountain hamlet north of McCall prepared for the worst. Just a month earlier, a forest fire had burned 254 homes near Lake Tahoe and the 2007 fire season appeared ready to claim its next community. But as the raging East Zone Complex fire reached the cluster of loosely-spaced homes, the flames dropped to the ground, crackling and smoldering. The fire crept right up to doorsteps. But without the intense flames that spurred the fire just moments before, no homes burned—a feat fire managers attributed largely to Bent's push to clear flammable brush from around houses in the community. "It just blew through the area," Bent said. "We were well prepared." The town's ability to withstand a frontal assault by a major wildfire demonstrates what fire behavior experts have been saying for more than a decade. Clearing brush and other flammables and requiring fireproof roofs will protect houses even in an intense wildfire—without risking firefighters' lives. More provocatively, the research suggests that fighting fires on public lands to protect homes is ineffective and, in the long run, counter-productive. It is also far more expensive.*

Importantly, clearing vegetation nearest a home is not enough, as fire risk reduction also needs to include the home structure itself (Figure 13.2). This is often missed in discussions about homeowner fire safety, and it is a crucial step in responsible fire risk reduction, as we illustrate in the following examples.

In a recent research paper concerning why homes burn in wildfires, Syphard et al. (2014) concluded that geography is key: where the house is located and where houses are placed on the landscape. Syphard and her coauthors gathered data on 700,000 addresses in the Santa Monica Mountains and part of San Diego

FIGURE 13.2 Homes burn because they are flammable. Many homes with adequate defensible space still burn in wildland fires because embers land on flammable materials around the home or enter through openings such as attic vents. These two homes burned during the 2014 Poinsettia Fire in Carlsbad, California, despite fire-safe landscaping, a firewall, and thinned wildland vegetation. Focusing exclusively on wildland vegetation clearing ignores the main reasons homes burn: they are flammable. *(Photo credit: Richard W. Halsey.)*

County. They then mapped the structures that had burned in those areas from 2001 to 2010, a time of significant wildfire activity in the region. Buildings on steep slopes, in Santa Ana wind corridors, and in low-density developments intermingled with wildlands were the most likely to have burned. Nearby vegetation was not a major factor in home destruction.

Looking at vegetation growing within roughly 800 m of structures, Syphard et al. (2014) concluded that the exotic grasses that often sprout in areas cleared of native habitat like chaparral could be more of a fire hazard than shrubs. Interestingly, they found that homes that were surrounded mostly by grass actually ended up burning more than homes with higher fuel volumes such as shrubs.

Similarly, during the 2007 Witch Creek Fire (San Diego County, CA), houses in Rancho Bernardo started burning by ember contact when the fire front was nearly 6 km away. Two-thirds of the burning homes were set on fire by embers (Maranghides and Mell, 2009).

During the 2007 Grass Valley Fire near Lake Arrowhead in California's San Bernardino Mountains, approximately 199 homes were destroyed or damaged. This happened despite the fact that the US Forest Service had thinned the surrounding forest. The main cause of the losses was that individual homeowners failed to understand that vegetation management is only one part of the fire risk reduction equation. Fire will exploit the weakest link—and it did so in Grass Valley. In the detailed report of the fire, Forest Service researchers (Rogers et al., 2008) concluded: "Post-fire visual examination indicated a lack of substantial fire effects on the vegetation and surface fuels between burned homes. Lack of surface fire evidence in surrounding vegetation provides strong evidence that house-to-house ignitions by airborne firebrands were responsible for many of the destroyed homes."

Investments in making homes and communities fire safe are clearly fiscally prudent and responsible homeownership that can save lives and homes by reducing risks to all, especially firefighters. Moreover, proper land use zoning that reduces housing development in firesheds is key to the survival of home structures over the larger area (Syphard et al., 2014).

In sum, these recent studies show that overcoming misperceptions about homeowner losses is urgently needed because those misconceptions are a driving factor in many inappropriate fuel reduction projects in wild areas. We hypothesize that with stepped-up planning directed at proper homeowner safety (as demonstrated in the above studies), public attitudes about large and intense fires may begin to shift from fear-based primal responses to more of a neocortex-like awareness of fire as nature's phoenix. This could be tested using before-and-after polling about large, higher-severity fires with and without proper public safety measures in places.

13.4 TO THIN OR NOT TO THIN?

One of the most significant challenges involved in changing the way land managers think about fire in the forests is how the US Forest Service views forest fires. The agency is deeply invested in continuing the fire management trajectory of the past—a situation compounded by the budgetary issues associated with the agency's direction of much, and often most, of their tax-based support to selling timber from public lands, and the agency's retention of most of the revenue from such timber sales to fund staff salaries and operations. Though in recent years we have learned much about the ecological benefits of higher-severity fire and the risks to fire-dependent wildlife species from further suppressing these fires, which are deficient in most western US conifer forests (Chapters 1–5), the Forest Service continues to aggressively promote landscape-level mechanical thinning (North, 2012; Stine et al., 2014) and postfire logging (Collins and Roller, 2013) ostensibly to reduce fuels and prevent and mitigate future fire. These forest management policies are promoted based on the assumption that decades of fire suppression have created forests "overloaded with fuel, priming them for unusually severe and extensive wildfires" (Stine et al., 2014; see also North, 2012). The basic concept being articulated by the Forest Service is that, because of decades of fire suppression and "fuel accumulations," we cannot simply allow wildland fires to burn because long-unburned forests will "uncharacteristically" burn almost exclusively at higher severities (North, 2012; Stine et al., 2014). Under this premise, recommendations focus on how to manage forests through logging and fire suppression to further reduce and prevent the significant occurrence of mixed-severity fire (North et al., 2009; North, 2012; Stine et al., 2014). Yet these sources do not include a discussion of the current deficit of these fires in most forests of western North America (Odion et al. 2014a; see also Chapters 1, 2, and 9) or meaningful content on the ecological importance of mixed-severity fire for many rare and imperiled wildlife species (Chapters 2–5). Nor do they explore the validity of the basic premise that long-unburned forests will burn much more severely.

Studies that empirically investigated the "time-since-fire" issue in the Sierra region of northern California and the Klamath Mountains of Oregon and California tended to find that, contrary to popular assumptions, the most long-unburned forests experience mostly low- and moderate-severity fire and do not have significantly higher levels of higher-severity fire than more recently burned forests (Odion et al., 2004, 2010; Odion and Hanson, 2006, 2008; Miller et al., 2012; van Wagtendonk et al., 2012). One modeling study predicted a modest increase in fire severity with increasing time since fire, but the strength of inference was limited by a lack of data for all but long-unburned stands, especially in the largest forest types, such as mixed-conifer forest. Even the most long-unburned forests were predicted to have ~70-80% low/moderate-severity effects (Steel et al., 2015), well within the range of natural variability (see Chapter 1). In fact, long-unburned forests sometimes have the lowest levels of higher-severity fire; understory vegetation and the lower limbs of conifers self-thin as canopy cover increases and available sunlight in the understory decreases with increasing time since fire (Odion et al., 2010). Therefore the argument that we cannot allow more wildland fires to burn without suppression in natural areas is not valid for many dry montane forests in western North America (Odion et al., 2010).

Problems with Fuel Models and Fire Liabilities

Government programs that aim to make forests safe places for people to live are based on theory rather than actual evidence about historical forests. As discussed above, the common argument has been that fuels have unnaturally accumulated from fire exclusion and land uses, and if fuels are restored to low levels, fires will burn primarily at low intensity rather than as high-intensity crown fires (e.g., Agee and Skinner, 2005). Thus forests can be restored while also making them safe places to live—a win-win solution that is appealing to the public. Little evidence about actual historical fuel amounts in forests to support this argument was available, however; instead, evidence is mostly based on the idea that frequent fires would have kept fuels at low levels. When records from land surveys before fire exclusion were examined (Baker, 2012, 2014; Baker and Williams, 2015; Hanson and Odion, in press), understory fuels (shrubs, small trees) that would naturally have promoted intense fires were found to have been common and often abundant in many areas, and small trees were dominant, not rare. This direct evidence suggests that fuel treatments would typically have to artificially remove natural shrubs and small trees and adversely alter habitat for native species in a quest to make forests safer places for people to live.

Fuel reduction also has been overpromised to be effective, using questionable logic and unvalidated models. First, fire intensity in most forest types is much more strongly affected by wind than by fuel. High fire-line intensity, the primary fire characteristic that promotes crown fires, is the product of the energy released by burning fuel and the rate of spread of fire (Alexander, 1982). Energy release by fuel varies over perhaps a 10-fold range, however, whereas rate of spread can vary over more than a 100-fold range; thus a high rate of spread caused by strong winds can easily overcome the limited reductions in fuel that are feasible (Baker, 2009). This was confirmed by a recent analysis of the 2013 Rim Fire in California, which concludes: "Our results suggest that even in forests with a restored fire regime, wildfires can produce large-scale, high-severity fire effects under the type of weather conditions that often prevail when wildfire escapes initial suppression efforts.... During the period when the Rim fire had heightened plume activity... no low severity was observed [in thinned areas], regardless of fuel load, forest type, or topographic position" (Lydersen et al., 2014, p. 333). Second, common fire models used to show that forests would be fire-safe after fuel reductions have an underprediction bias and are not validated. These flawed models include NEXUS, FlamMap, FARSITE, FFE-FVS, FMAPlus, and BehavePlus (Cruz and Alexander, 2010; Alexander and Cruz, 2013; Cruz et al., 2014). The underprediction bias means that these models often predict that fuel reductions would reduce or eliminate the potential for crown fires in forests, when in fact fuel reductions do not achieve this effect. Fixing these models would be difficult and has not yet occurred (Alexander and Cruz, 2013). Also, these models have not been sufficiently tested and validated using a suite of actual fires, in which case they would likely be shown to fail (Cruz and Alexander, 2010). Alternative validated models are available and could be further developed, but they are not being used (Cruz and Alexander, 2010). Further, studies of tree mortality in thinned areas following fire do not typically take into account the mortality caused by the logging itself before the fire, leading to further biased results.

These concerns should raise red flags about the effectiveness of fuel treatments, as well as issues regarding liability and responsibility. Imagine if a company sold airplanes with identified flawed designs and without adequate test flights, which then crashed. There are thus sound scientific reasons to closely scrutinize government wildland fuel-reduction programs. Meanwhile, we need to be honest and warn the public that living within or adjacent to natural forests prone to burn is inherently hazardous. Only treating fuels in the immediate vicinity of the homes themselves can reduce risk to homes, not backcountry fuel reduction projects that divert scarce resources away from true home protection (Cohen, 2000; Gibbons et al., 2012; Calkin et al., 2013; Syphard et al., 2014).

Finally, another land management liability that is frequently overlooked when assessing fire-related economic losses is the role of silviculture. For instance, before the 2013 Rim Fire, a significant portion of the Stanislaus National Forest in central California's Sierra Nevada Mountains consisted of even-aged monoculture tree plantations (following past clearcuts) distributed across large landscapes (Figure 13.3). Land managers often claim that clearcutting over large landscapes

FIGURE 13.3 Google image of the Stanislaus National Forest, central Sierra Nevada, taken on July 8, 2012, before the August 25, 2013, Rim Fire. The red boundary is where the Rim fire burned. Note numerous clearcuts within the burn area, where the fire later burned intensely. Figure provided by J. Keeley.

like this reduces fire spread, yet based on preliminary findings from the Rim Fire, clearcutting did nothing to stop the fire. In fact, the area with the most clearcutting had the largest contiguous area of high-severity fire of any portion of the Rim Fire (see Figure 13.3 and compare with Figure 11.11). In other areas with large portions of the landscape in tree plantations from past clearcutting, fires have a tendency to burn uncharacteristically severe, presumably because of homogenized fuel loads (e.g., Odion et al., 2004). Despite these observations, in postfire assessments land managers rarely discuss this effect or the liabilities it creates for economic losses related to intense burns.

13.5 FIRE SAFETY AND ECOLOGICAL USE OF WILDLAND FIRE RECOMMENDATIONS

Based on the ecological importance of higher-severity forest fires (e.g., Reinhardt et al., 2008; DellaSala et al., 2014; Hanson, 2014; Moritz et al., 2014) and home safety concerns (e.g., Cohen, 2000; Headwaters Economics, 2014), there are ways for people to live safely in firesheds and still allow fire to perform its vital ecosystem service. Below we provide some summary recommendations that, if widely implemented, would allow fire to take its natural course (i.e., ecological use of wildland fire) while reducing risks to people.

Fire Safety Recommendations (mainly summarized from Headwaters Economics, 2014)

- Prepare to live safely with fire so that it can perform its ecologically beneficial functions. (The bulk of fire risk reduction should occur immediately adjacent to homes.)

- Develop negative financial consequences for landowners who increase fire risk within firesheds by not taking precautionary measures versus providing financial incentives for those who reduce risks (e.g., cost sharing for fire safety). As an example, mortgage and/or insurance rates could be increased for high risks from lack of fire safety and discounted for those who practice fire risk management principles. In this manner, planning for home fire safety would become as routine as taking out a mortgage to buy a home.
- Include HIZ and fire-safe principles in rural land use planning, including zoning restrictions that limit housing densities in firesheds deemed too risky for development.
- Require mandatory disclosure of fire risks to homebuyers.
- Have local and state governments contribute to firefighting costs to create a powerful incentive for improved land use planning, including zoning restrictions, which reduce fire suppression needs.
- Offer technology transfer to local governments and financial assistance to plan communities that are fire safe.
- Map high-risk areas where fire-safe standards are most prudent within a local county or other land use unit.
- Discourage rebuilding in the same high-risk place or require that building occurs with risk management conditions.
- Redirect funding away from backcountry fire suppression and fuel reduction programs and toward aiding willing homeowners in creating defensible space and reducing the ability of homes to ignite.
- Initiate strategies to reduce human-caused fire ignitions, especially along roadsides. Many wildland fires start along highways and streets.

Wildland Fire Recommendations

- Postfire "salvage" logging is especially damaging to complex early seral forests. If such forests were ecologically valuable or protected before fire, then they should also be recognized as uniquely valuable and protected after fire.
- Wildlands cannot be fireproofed by suppression (mechanical thinning or aerial retardants) or clearcutting; fuel treatments (thinning) are more likely to work in low-severity frequent fire systems and much less so in mixed- and higher-severity fire systems that tend to burn under extreme conditions, when suppression is least effective.
- Large fires, including high-severity patches, are the most efficient means of restoring fire-dependent ecosystems and natural heterogeneity where fire has been excluded for decades. When a fire burns under these conditions, fire-dependent communities are therefore restored. This should be encouraged, with public safety assured.
- The best way to buffer fire-dependent ecosystems from climate change is to increase ecological resilience, particularly in areas where a fire deficit

exists, by allowing fires to burn naturally under safe conditions. This will require relatively large protected landscapes with proper land use zoning and logging restrictions.

- Implement strategies to reduce human-caused fires in ecosystems with excessive fire frequencies, such as the chaparral in southern California.

13.6 LESSONS FROM AROUND THE GLOBE

Africa

Of the five communication themes that arose from the polling in North America, the one most applicable to attitudes in sub-Saharan Africa is number 5 (as mentioned in the above “Attitudes Toward Fire”), a broad statement to protect natural resources for the ecosystems services they provide (see Chapter 8). The public in South Africa, for example, assumes number 3, safety in controlled burns, because the public is already attuned to the widespread use of fire for habitat management, and when accessible, fuel wood is collected for heat and cooking. Of course, the South African public is not deluged by media reports of catastrophic losses caused by wildfire, so items 1, 2 and 4 are not part of a daily discourse in countries where wildfires in large forests are rare and most of the managed habitat is the much thinner type of woodland associated with savanna (see Chapter 8).

In terms of such issues as woodland thinning (directed silviculture or ad hoc management), in African savanna the public and policy makers are more concerned with maintaining herbivore populations as part of ecotourism and for the love of Africa’s “big five” megafauna wildlife species. South Africa practices extensive silviculture, and it often is blended into wilderness areas (Tsitsikama National Forest lies adjacent to extensive tracts of forest plantation, where fire suppression is practiced because of economics of the wood industry). It seems the “fear” of fire so prevalent in North America is absent from rural areas of Africa for multiple reasons, but this results in a more sane approach to fire ecology. In Kruger Park managers learned over time that allowing wildfire is acceptable, and it is now a tool (although not frequent) integrated with controlled burns. They even seek to achieve as hot a fire as they can in certain habitat conditions to clear the invasive vegetation or just to suppress woody growth. The lesson learned in South Africa over 50 years of “experimenting,” and from many decades of following the Serengeti system, is that monitoring is critical, and adapting to those results (adaptive management) is imperative.

Australia

In Australia prescribed burning is considered a staple part of the land management tool kit and is routinely applied with the aim of reducing the risk of large, unplanned wildfires to property and infrastructure (Clarke, 2008). In some cases fire is applied to the landscape in efforts to “restore” ecosystems or to create fine-scaled fire mosaics of mixed successional stages to encourage greater faunal and floral diversity (Bradstock et al., 2005). In response to the perceived need to apply fuel-reduction burns, the Victorian state government implemented a policy that mandated that 5% of the total land area under state jurisdiction be burned each year. This policy did not discriminate fire prescriptions between ecosystems and has been subject to widespread criticism from fire ecologists in Australia; it is currently under review (DELWP, 2015a). Although appropriate fire regimes have positive ecological outcomes in many systems, application of prescribed burning can lead to species declines and in some cases can cause irreversible changes in ecosystem state (Pardon et al., 2003, Pennman et al. 2011, Pastro et al., 2011).

Recent large wildfires in Australia have spurred new policies to address the growing public concern over the dangers presented by these fires (McLennan and Handmer, 2012; Whittaker et al., 2013). The royal commission that followed the 2009 "Black Saturday" fires suggested the implementation of new policies to encourage clearing around homes and to shift public perceptions toward recognition of bushfires as defensible events (i.e., homes can be effectively protected) that require early planning and avoidance actions (Teague et al., 2010). Residents in areas of high fire risk are now able to clear all vegetation within 50 m of their homes. These new measures, coupled with the 5% burn target, aim to reduce the potential of a repeat of the 2009 fires. This home protection approach is partially supported by science. Gibbons et al. (2012) highlighted that houses with vegetation cleared within 50 m were 70% more likely to survive a fire than those with no clearing. They revealed, however, that there was no effect of fuel reduction burning in nearby state forest or ecological reserves on house preservation following the 2009 fires in Victoria, Australia. Furthermore, in some of the most potentially pyrogenic systems, such as mountain ash (*Eucalyptus regnans*) forests, fuel reduction burns are rarely applied because moisture levels are normally high, and risk of fire spread is considered unacceptable when conditions are dry (DELWP, 2015b). A growing body of literature indicates that inappropriate fire regimes are contributing to species declines globally (Driscoll et al., 2010). In response to the increased fire risk caused by climate change, policy makers should seek to implement strategies with a proven ability to protect homes, while avoiding ineffective actions that detrimentally impact biodiversity.

Central Europe

In central Europe forest fires are relatively infrequent and mainly limited to regions with pine forest plantations growing on sands, gravel-sands and sandstone rocks. Any burned areas are mandatorily reclaimed within just 2 years of their formation; exceptions are possible in forests protected as national parks or nature reserves. The option to request avoidance of logging and replanting is used only rarely, however, and nearly all forests affected by fires are quickly logged and replanted.

Available evidence suggests that fire-induced bare soil patches, charred trunks, and dead wood resulting from the postfire dieback represent unique nesting resources for numerous species. The areas subject to mixed- and high-severity fires are associated with dynamic assemblages of plant and animal species, many of which are rare or even absent in the surrounding landscape. The burned forests serve as key habitats, particularly for aculeate Hymenoptera associated with cavities in dead wood (such as *Dipogon vechti*). Such cavities are considered limiting nesting resources, and their absence (and targeted removal of any newly emerging snags, which is mandatory by law) causes numerous specialized cavity adopters to be red-listed or extinct. Mounting evidence suggests that specific groups of organisms are strictly dependent on the occurrence of repeated fires. As long as sites of natural disturbances become extremely rare in the intensively cultivated landscape of central Europe, bare soil specialists and species that specialize in cavities of decaying wood will be completely absent where forests are subject to intense cultivation and rigorous dead wood removal. Dead wood thus should be considered an important habitat resource deserving conservation measures. Mosaic management of burned forest sites and retaining charred trunks are suggested as management measures supporting biodiversity at the sites of recent forest fires (Bogusch et al., 2015).

Canadian Boreal

There is emerging a new paradigm about the role of fire in the Canadian boreal forest. Historically, it was perceived as a simple system where "catastrophic" fire created landscapes of young, even-aged stands and where species diversity was poor. The reality is much more complex. There is an impressive range of fire cycle estimates—some as long as several centuries—suggesting that for at least part of the boreal forest region the abundance of old-growth forests in preindustrial times was much greater than expected (see Chapter 8). Associated with these old-growth forests is high understory diversity in black spruce (*Picea mariana*) stands and a number of rare species of nonvascular plants associated with balsam fir (*Abies balsamea*) stands. Similar findings have been made in boreal forests of Europe and Asia.

At the other end of the disturbance spectrum, there is now compelling evidence showing the importance of early seral burned habitats for the pyrocommunity, led by saproxylic insects (dependent on dead or decaying wood) and followed by primary cavity nesting birds (see Chapter 8). The retention of a wide range of burn conditions enhances saproxylic insect diversity. A link between this saproxylic community and nutrient cycling has been found, indicating a connection between biodiversity and ecosystem function in Canadian boreal forests. Large fires produce significant pulses of dead wood, which drive biodiversity and ecosystem processes through natural succession over time. Fire skips, or remnants left after large burns, also are critically important for biodiversity, species persistence, and recolonization and ecosystem recovery.

For a long time, forest management was driven with a strong focus on timber extraction and developed a jargon that infiltrated the dialect of forestry, with words like "decadent" for old-growth forests, "waste wood" for trees that had been killed by natural disturbances, and "salvage" as the practice used to recover that "wasted" timber. Today, management in the boreal forest is increasingly driven by themes like ecosystem-based management and sustainable development. The new era will require conservation of boreal forests at different ends of the disturbance spectrum from newly created, postfire habitat to multicentury, old-growth forests.

13.7 ADDRESSING UNCERTAINTIES

Even though most people recognize the importance of maintaining fire on the landscape, there remain important questions about what might be the optimal postfire conditions for the broad suite of species with varying fire tolerances. For instance, we do not know whether there is a certain amount of burned forest or spatial distribution of burned forest patches, patch sizes, and fire frequencies necessary to maintain species at polar ends of the successional gradient. However, we hypothesize that in large, intact forested landscapes where fire is allowed to burn and logging is restricted (e.g., wilderness areas, large national parks, and other protected ecosystems) there should be ample habitat for all seral species over the long term and the best opportunities for coexistence with fire as a process (see Chapters 3–5). By contrast, in highly degraded landscapes, particularly those close to towns and homes, an optimal condition of recently burned and long-unburned patches is more difficult to ascertain because it may involve tradeoffs for public safety reasons (DellaSala et al. 2004).

Currently, megafires in western North American forested landscapes burn in mixed-severity patterns and seem to provide the necessary patch mosaics for a broad array of species (Chapters 2–6). Fire-related change of late seral habitat to complex early seral forest (Swanson et al., 2011; DellaSala et al., 2014; Hanson, 2014) has not been a threat to species dependent on such mature forest habitat, particularly given that there is generally much less high-severity fire in mixed-conifer and pine forests of western North America than there was historically (Odion et al., 2014a). Rates of old forest recruitment, as a result of growth, also outpace rates of high-severity fire in old forest by several times (Hanson et al., 2009; Odion and Hanson, 2013; Odion et al., 2014b). The situation is less clear in portions of Australia, however, where fewer vertebrate species have thus far been found to be fire dependent (see Chapters 3 and 4) and there are more species associated with late seral conditions that are especially at risk (Kelly et al., 2015). By contrast, other Australian research found bird species richness to be highest where there is the most successional diversity from higher-severity fire (Sitters et al., 2014) (see Chapter 8). Human-caused fires in North American chaparral, the Great Basin, and many desert ecosystems, which mostly replace stands, have exceeded historical bounds, adversely affecting this diverse shrubland community (Chapter 7). Thus, whether or not fire mosaics are correlated with high levels of biodiversity (cf. Martin and Sapsis, 1991 versus Parr and Andersen, 2006; Taylor et al., 2012; Kelly et al., 2015) depends on differences in biogeography, fire histories, land use histories, and life history requirements (including fire tolerances and dependencies) of species over long time lines and large landscapes (e.g., Scott et al., 2014; see Chapters 3–5).

In addition, climate change introduces uncertainty in how forests will respond to changes in fire extent, longer fire seasons, and higher severities in places, how soon the current fire deficit in places will remain that way before exceeding historical bounds, and whether existing deficits will be exacerbated in some forests with increasing precipitation driven by climate change (see Chapter 9). Nonetheless, at least for mixed-severity fire systems there is no magic thinning or suppression bullet to forestall climate-mediated fire changes. Changes in fire behavior are a consequence of human-caused climate change. It is best to treat the cause—climate change—rather than the symptom (fire behavior) if we are truly concerned about climate effects on ecosystems and people.

13.8 CLOSING REMARKS

When viewing the natural world, as a matter of perspective, we are reminded of discussions we have often had with foresters regarding how we each see the value of postfire landscapes. Clearly, we see the world differently depending on our professional judgment and value system.

A professional forester views the fruits of his or her labor, imagining what the future "production" forest will look like after decades of growing wood fiber, and then being frustrated by nature run amuck when the forest goes up in flames.

For the fire-trained ecologist, the initiating fire is but a glimpse into a vibrant community that begins with a pulse of biological activity and ensures successional events, just one of the many important links to follow in a long chain of ecosystem changes. Even the most charred forest is transformed by fire on one of nature's grandest stages. Among the first actors to arrive on the postfire stage are the biological legacies that provide the supporting foundation for other postfire actors to enter with the passage of time. If we imagine what the stage will look like years after a severe burn (often only 1 year), we see a floral phoenix arising from the ashes, we hear a cacophony of songbirds and drumming woodpeckers, and the rhythmic buzzing of bees and other insects as they go about their business of pollinating the next explosion of flowering plants. Up close and personal, we see tiny native beetle larvae tucked neatly into galleries beneath the outer charred tree bark, wood-boring scorpion wasps recoiling long abdomens after depositing eggs into open crevices in tree bark, centipedes and millipedes working charred humus, and ravenous insect-loving bats and fly-catching birds feasting on all the buzz.

The postfire landscape is indeed a transformative place if we humans are willing to have the patience to look beyond the brief snapshot in time right after the initiating event. Only then will the postfire esthetic become apparent. Our human world of instant gratification pales in comparison to nature's seemingly infinite horizon. Meticulous observations by trained ecologists too often are drowned out by the noise of a fast-paced society preoccupied with one-size-fits-all solutions, impulses to do something at any cost, myopic economic benefits, and a fear-based media blitz of fire catastrophe reporting. But if we wait for the ecosystem actors to emerge in synchronicity, the postfire habitat unveiled is remarkably resilient, brilliant like the mythical phoenix, and even musical if we know how to listen. We hope that we have sufficiently portrayed an ecological awareness for this postfire symphony in the chapters of this book.

In this closing chapter we also have discussed the importance of education and outreach for a communications framework and improved ecological understanding of fire that follows fundamental ecological and safety principles.

From a communications standpoint, fire operates very much like an apex predator, thinning out and culling its prey, sometimes in large numbers, sometimes not. Apex predators are indeed vital to fully functioning ecosystems, yet they are either loved or hated based on one's perspective, which simply boils down to either an appreciation for wild things or a fear of being attacked or of losing a commodity. People view fire in much the same way. Decades of public outreach and campaigns in many places (most notably Europe and North America) have shifted public opinion to be more accepting of predators, and even to relish them in national parks and other protected landscapes where predators roam free and tourists flock to witness nature primeval. Clearly, fires, like apex predators, cannot be restricted to inside national parks, as the parks are not big enough to sustain them.

There is a lesson to be learned regarding the message of fear in both instances: As with predators, the risks of losses to people and property can be successfully mitigated by taking precautionary measures (e.g., just don't feed the bears, and remember to make loud noises while hiking in grizzly bear country!). In the case of fire, public safety of those living in firesheds is based on prudent fire risk reduction that with stepped-up outreach one day may become common knowledge. With a shift in this direction, we envision a move toward fire tolerance, and eventually coexistence, so that fire, in all its severities and forms, can continue to shape ecosystems into the next millennium. This will take a concerted effort of sophisticated and sustained message framing, an infusion of funds for stepped-up education that at least rivals predator-friendly campaigns, a commitment from land management agencies and the media to become more ecologically literate (including replacing Smokey Bear with nature's phoenix), conservation groups to see the value in mixed-severity and not just low-severity fire, and politicians to see the big picture that the postfire landscape has irreplaceable ecological value and is not just a money tree to be ravaged for short-term profit. Then nature's phoenix will truly take flight, reborn out of the ashes of a postfire landscape mosaic that is alive and well!

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