Joint Fire Science Program
Fire Science Brief
RESEARCH SUPPORTING SOUND DECISIONS

Baker cypress cones opening after the 2006 Titus Fire. Credit: Erin Rentz.

Saving the Cypress: Restoring Fire to Rare, At-risk Species

Summary

Many populations of Baker and Macnab cypress are dying without signs of regeneration. The Forest Service is currently implementing controlled burning across a range of vegetation types in northern California, but because there is little information about how such treatments will affect rare, endemic plant communities, cypress stands have been excluded from such treatments. However, these fire-adapted species cannot survive extended periods of fire exclusion. To effectively manage the cypress and prevent further decline of the species, land managers need information on factors that promote cypress regeneration. The objectives of this study were to (1) determine if fire is indeed necessary to restore cypress, (2) determine if prescribed burning can successfully promote cypress regeneration and, if so, (3) determine what fire severity and fire return interval promote cypress regeneration. The data confirm that fire is critical to regeneration of both Baker and Macnab cypress stands. It is therefore important to return fire to the stands—either through wildfires or through controlled burning. Because of hesitation to allow wildfires to burn, encroachment of other conifer species has resulted in the deterioration of adult trees presently seen in many of the stands. Thus, a reconsideration of wildland fire use and controlled burning are needed. Typical controlled burns are generally carried out at low intensity, yet high intensity is needed to achieve sufficient Macnab and Baker cypress regeneration rates, so experimental forms of prescribed burning will likely be necessary to promote sufficient regeneration to restore cypress populations. Regarding fire return interval, the results show that if fires occur too frequently, stands may not have matured enough to produce a sufficient amount of seeds to regenerate and are thus subject to risk of "immaturity." On the other hand, results show no evidence of risk for either cypress species growing too old and thereby outliving the possibility of regeneration. So as long as the stand remains healthy, it should be allowed to live longer to achieve greater seedbank potential. But for mature stands that face risk of death due to unfavorable site conditions, it is recommended that fire be introduced as soon as possible.

Key Findings

- Cypress seedlings are found primarily after wildfires.
- High-severity fire promotes cypress regeneration.
- The minimum age at which a stand could be burned and still have good regeneration potential is 30 to 50 years.
- For mature stands that face risk of death due to unfavorable site conditions, it is recommended that fire be introduced as soon as possible.

Cypress, then and now

The cypress has, in many cultures, often been associated with death. The Greeks and Romans used the wood for coffins. The Egyptians used it to protect mummies. Christians and Muslims placed cypress trees in cemeteries. Unfortunately, the few populations of Baker and Macnab cypress, which are rare, fire-adapted conifers found exclusively in California and southern Oregon, are feared to be heading towards that which they symbolize. These species are currently found in disjunct and isolated populations, which likely represent relics from an earlier period in which cypress grew abundantly and more continuously on the landscape. They are now, however, mainly confined to areas such as lava flows, with thin, nutrient poor soils where it's harder for other species to grow.

Macnab cypress (*Hesperocyparis macnabiana*) has approximately 30 populations across 12 counties in California and grows at elevations from 1,000 to 2,800 feet. Baker cypress (*Hesperocyparis bakeri*) occurs in 11 widely scattered locations across the northern Sierra Nevada, Cascade, and Siskiyou mountain ranges at elevations from approximately 3,700 to 7,000 feet. Although Baker cypress does not have state or federal listing as an endangered species, it is classified as a California Native Plant Society list-4 species (species of limited distribution) and a Special Target Element in Forest Service Region 5, meaning that its uncertain future calls for special attention in management planning. So, we know that we need to carefully plan the management of these rare cypress populations, but what is it specifically that we need to be doing to preserve the species?

(Left) Baker cypress and (right) Macnab cypress. The Baker cypress is 140 years old and the Macnab is an impressive 289 years old. Credit: Kyle Merriam.

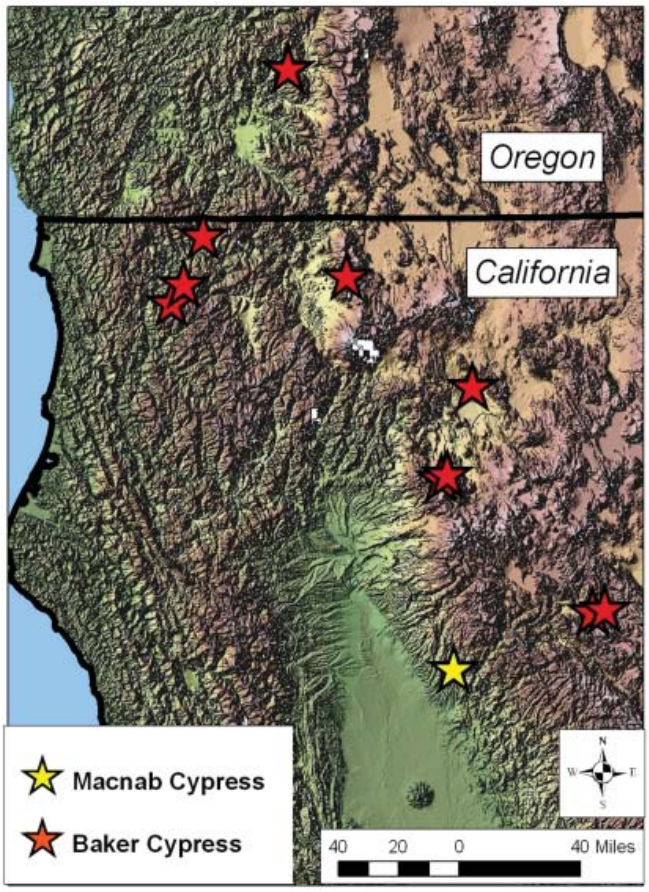
Asking the right questions

For over 20 years, land managers and others who have come across cypress groves in the woods have reported that many of the trees are dying—and without signs of regeneration. Although the cypress is a fire-adapted species, fire has been excluded from many Baker and Macnab populations for almost a century. The Forest Service is currently implementing fuel treatments, including controlled burning, across a range of vegetation types in northern California; however, there is very little information about how these treatments will affect rare, endemic plant communities, such as Baker and Macnab cypress. Moreover, managers are hesitant in general to use fire to manage rare species.

So, across the board, cypress stands have been excluded from prescribed burning programs, yet these species simply cannot survive extended periods of fire exclusion. Both Baker and Macnab cypress have closed (serotinous) cones that open in response to fire. Furthermore, to germinate, their seeds require high light and exposed mineral soil—characteristic of burned areas. In short, these species depend on fire to regenerate. In addition, fire exclusion has allowed the encroachment of other conifer species, such as white fir and Douglas-fir, which would have been kept at low densities because their seedlings can't tolerate fire. Cypresses need light and open stands to thrive, but adult trees are being crowded and shaded out, resulting in an overall decline in the health of existing cypresses.

Project team members Kyle Merriam (on the Sierra Cascade Province, which includes the Plumas, Modoc, and Lassen national forests) and Max Creasy (on the Klamath National Forest) were asked repeatedly by local land managers for information on managing Baker and Macnab stands. Merriam relates the account: "We realized that between the two of us, we had most of the known occurrences of Baker cypress on the forests where we worked. We saw a great opportunity for a study. It's such a rare species, and managers were starting to consider using active management strategies. But they just didn't know how to go about it." So, the researchers decided to put together a study, and the research objectives were to: (1) determine if fire is indeed necessary to restore cypress, (2) determine if prescribed burning can successfully promote cypress regeneration and, if so, (3) determine what fire severity and fire return interval promote cypress regeneration. The team established plots at each site, and regeneration was measured as the number of cypress seedlings present within the plots. And at the three sites

recently burned by wildfire (one in 2006, one in 2007, and one in 2008) they collected additional data on fire severity. The overarching goal of this research was to gather information on the current status of each population and to develop management guidelines—both general and for the individual cypress stands—to help prevent further decline of the species.



Cypress project study sites in California and southern Oregon.

Fire: The essential element

The first study site at which the research team decided to test controlled burning was Mud Lake on the Plumas National Forest. But because of environmental regulations and logistical constraints, the team would be allowed to burn only about 15 to 20 acres, even though the population covered roughly 300 acres. They felt that this wasn't going to necessarily help the site much, but they could at least conduct an experiment and hopefully create some guidelines for other sites. Then something remarkable happened. Merriam tells the story: "We got *really* lucky. We had already set up a group of plots, but we were only going to be able to treat a tiny portion of the stand. And then—amazingly—a wildfire burned through most of the stand, and it burned at a range of different severities. So, we were able to compare pre-burn data to post-burn and get a lot of valuable information." She continues, "The wildfire was incredibly beneficial for that population. We saw great regeneration rates—the seedlings came back the very next year. And we didn't see one single white fir seedling. But there were hundreds of thousands of Baker cypress seedlings. Just a carpet of them." In contrast, across all study sites that had not experienced a recent fire, the team found a mere 34 Baker cypress seedlings *total* in all areas. Only stands with recent fire history contained a high number of new progeny. The fire at the Mud Lake site, for example, resulted in regeneration to the tune of 85 seedlings per square meter. Macnab cypress also exhibited very low regeneration and high seedling mortality rates at sites without recent fire. Although the researchers did find some Macnab seedlings on sites that hadn't burned, the density was less than one seedling per square meter, compared to areas that had burned, which regenerated to an average density of 16 seedlings per square meter.

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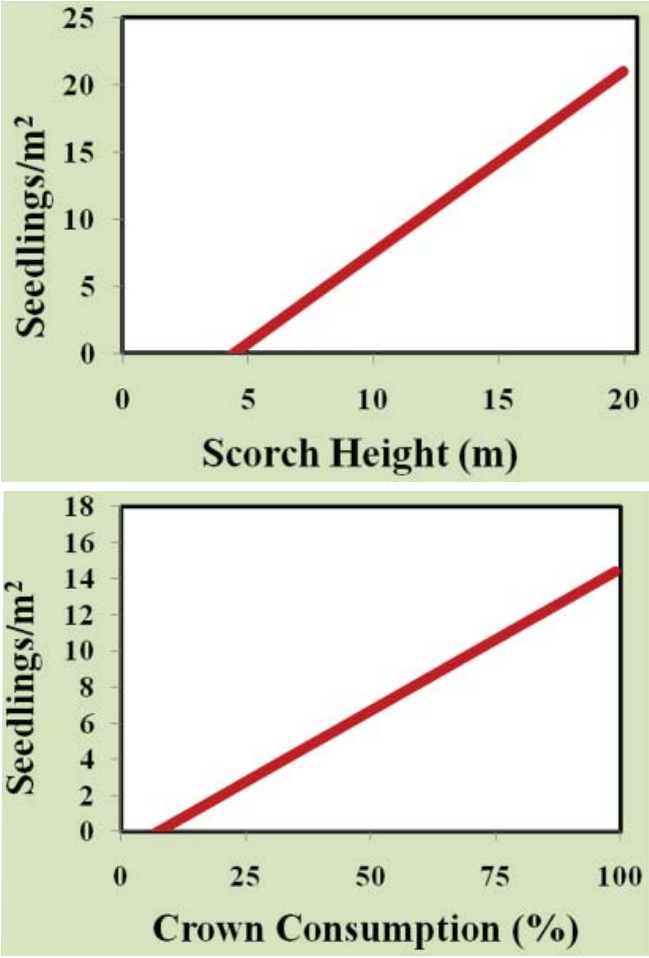
Baker cypress regeneration after the 2007 Moonlight Fire on the Plumas National Forest. Credit: Kyle Merriam.

The data confirm that fire is critical to regeneration of both Baker and Macnab cypress stands, and it is therefore important to return fire to the stands—either through wildfires or through prescribed burning. Which brings us to the next question: *Can* prescribed fires successfully promote cypress regeneration?

Turn up the heat

Before we can determine whether prescribed fires can achieve regeneration results similar to those seen after wildfire, we first need to identify what kind of fire intensity is needed to achieve successful regeneration. Under natural fire regimes, cypress stands were likely subject to high intensity crown fires. Cypresses have basically evolved to burn. They retain numerous dead lower branches and often

grow in dense thickets, creating continuous ladder fuel that is conducive to crown fires. As mentioned, high-severity fire produces favorable conditions for cypress germination and seedling survival, such as removing above-ground vegetation and exposing bare mineral soil so that dropped seeds have a place to germinate in high light. And results from this particular study found that higher fire severity increased both Macnab and Baker cypress regeneration rates. For example, after the 2008 Concow Fire, Macnab cypress seedling density increased proportionally with higher amounts of crown consumption and crown scorch. Similarly, after the 2007 Moonlight Fire at the Mud Lake study site, Baker cypress in plots with higher scorch and char heights and more severe soil fire effects had significantly higher densities of seedlings (see figure below). In addition, because most species of cypress are poor competitors, seedling survival is highest on sites where competition is limited—and post-fire recruitment depends on high fire intensity to reduce encroachment by killing cypresses' competitor species.



Scorch height increased Baker cypress regeneration after the 2007 Moonlight Fire (top), and crown consumption increased Macnab cypress regeneration after the 2008 Concow fire (bottom).

So, cypresses require high fire severity for successful regeneration, but typical controlled burns are generally carried out at low intensity. The project team realized that the controlled burn they had been planning for the Mud Lake site would likely not have been hot enough to promote regeneration. In general, land managers risk extirpating cypress occurrences by conducting prescribed burning programs that do not adequately promote cypress regeneration. That is, the trees will likely be killed, but the fire might not be of high enough intensity to fully open the cones and create favorable site conditions to initiate regeneration. The current frequency of wildfires in these stands is too low to prevent the encroachment of other conifer species and the resulting deterioration of adult trees presently seen in many of the stands. Controlled burning is needed. This is particularly the case where wildfires cannot be allowed to burn, or where a population is in such decline that immediate action is needed.

But because fire intensity needs to be high—including scorching and/or consuming the entire crown and exposing bare mineral soil—experimental forms of prescribed burning will likely be necessary to promote sufficient regeneration to restore cypress populations. Careful planning will be required for such burns. First, managers need to plan how to achieve high enough temperatures. The researchers have also been considering ideas such as burning piles right under individual or small groups of trees, or conducting burn out operations beforehand to create a wide black line around the stand. High-severity controlled burning presents challenges, but fortunately, many of these populations have natural fuel breaks around them since they often grow on lava flows or rocky outcrops.

Not too soon, not too late

And so we come to the next question: What is the appropriate fire return interval for achieving successful cypress regeneration? This is an important issue regarding regeneration potential as the fire return interval largely determines the size of the canopy seedbank for these fire-dependent seeding species. If fires occur too frequently, stands may not have matured enough to produce a sufficient amount of seeds to regenerate and are thus subject to risk of "immaturity." Both Macnab and Baker cypress do not begin producing ovulate cones until the trees are at least 14 years of age or older, and these cones then require two more years to mature. And even when sexually mature, at this young stage, the tree is still small and has not yet accumulated many cones. Cypresses, in fact, produce and retain seeds over the whole course of their lives. As they get older, they get bigger and produce more branches with more foliage exposed to the sun. Astoundingly, Baker cypress can accumulate up to 10,000 cones on one tree. This study found that, in general, trees younger than 50 years had lower seed storage than those over 50. There was, however, variation depending on vigor due to site conditions; the high end threshold for ample seed storage was 50 years, but the median was 30 years. The research thus indicates that the minimum age at which a stand could be burned and still have good regeneration potential is 30 to 50 years.

So, Baker and Macnab cypress populations can face risk of immaturity, but what about the flipside? Can they outlive their seedbank potential, necessitating that they burn before a certain point in order to successfully regenerate? In the literature, it has until now been assumed that the older the tree, the lower the seed viability. This has been the dogma for a long time, but no one had actually tested this idea. Results from this study found no evidence of risk to either cypress species of growing too old to remain viable. Baker cypress cone production remained constant across older age classes, and Macnab cypress cone production increased linearly with age. In fact, the project team found that there were very old cypress populations—even up to 150 years old—that still had tens of thousands of viable seeds per tree. Merriam illustrates, "If the trees are healthy and exposed to the sun and not experiencing a lot of competition, they can live quite a long time and continue to remain vigorous and produce high viability seeds. I don't think anyone really knew that, and we didn't expect it." So the research indicates that as long as the stand remains healthy, it should be allowed to live longer to achieve greater seedbank potential. However, a wildfire would still likely result in a good amount of regeneration, so fire exclusion is not recommended.

On the other hand, if the fire return interval is longer than the life span of the cypress stand and thus its seedbank, the population will die without reproducing. It's not the age of the stand that matters—stands can be very old yet remain vigorous with the right site conditions, or relatively young and dying from poor site conditions. The risk they face is of dying, most likely from being out-competed, before a fire can release all of the seeds and regenerate the stand. So, for mature stands that face risk of death due to unfavorable site conditions, it's recommended that fire be introduced as soon as possible.

Taking action

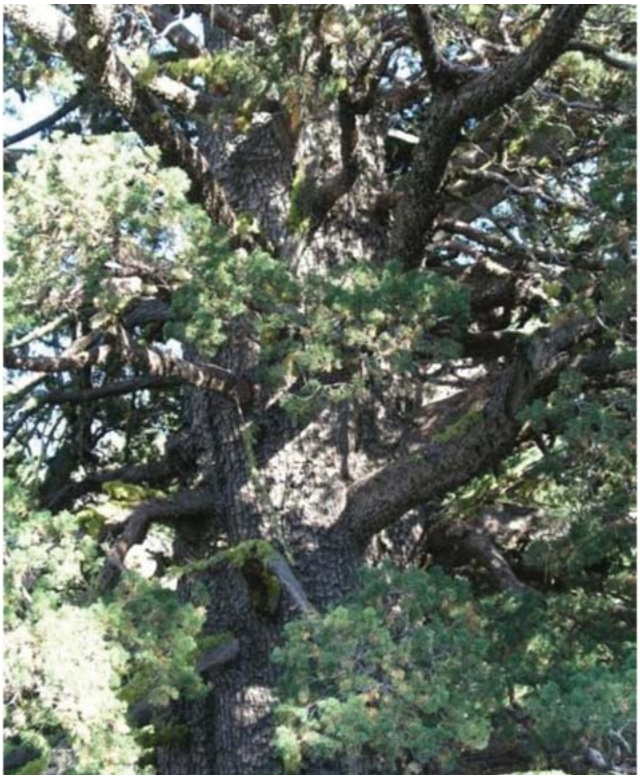
The research is clear. Deteriorating cypress populations need active management—and soon.

The research is clear. Deteriorating cypress populations need active management—and soon. The first step is determining the appropriate burn prescription. What temperature, relative humidity, fuel loading, and season (among other factors) are best for controlled burning to achieve the required fire intensity for successful cypress regeneration? In addition, the project's final report provides specific management recommendations for each Baker cypress population and is available through the Joint Fire Science Program's (JFSP's) website at www.firescience.gov (JFSP Project Number 06-2-1-17).

So, although concern over dying cypress occurrences is certainly warranted, we now have sound answers on which to base management decisions. And coincidentally, not only does the cypress symbolize death, but because it's an evergreen, it's also seen as a symbol of immortality. With timely, appropriate management of the Baker and Macnab populations, they can live on and thrive.

Management Implications

- Cypress requires fire, whether wildfire or controlled burning, both to mitigate encroachment by competitor species and to regenerate.
- Fire severity must be high to fully open cones for seed dispersal and to create open site conditions that allow for germination.
- To avoid immaturity risk, fire should not be introduced into Baker cypress stands that are younger than 30 to 50 years.
- Healthy Baker and Macnab populations do not require controlled burning; however, when a stand displays signs of decline, fire should be introduced to promote regeneration.
- Certain Baker and Macnab cypress occurrences face the risk of dying without regeneration unless fire is introduced as soon as possible.



Baker cypress champion tree, Wheeler Peak. Credit: Kyle Merriam.

Further Information: Publications and Web Resources

The final project report and associated documents are available at: http://www.firescience.gov/JFSP_Search_ProjectID_Results.cfm.

Additional resources are located at: http://fsweb.lassen.r5.fs.fed.us/scp/ecology-program/ (not yet available outside Forest Service network).

Scientist Profile

Kyle Merriam is the Province Ecologist for the Sierra Cascade Province of the USDA Forest Service, which includes the Lassen, Modoc, and Plumas National Forests. The Forest Service Ecology Program provides products and expertise fundamental to sustainable, science-based, multiple-use land management in the Pacific Southwest. The Program's principal purpose is to ensure and enable the application of current ecological science to land and resource management on the national forests in California.

Kyle Merriam can be reached at:
Region 5, Plumas National Forest
159 Lawrence Street
Quincy, CA 95971
Phone: 530-283-7777
Email: kmerriam@fs.fed.us

Collaborators

Hugh Safford, Pacific Southwest Region

Max Creasy, Northern Province Ecologist, California

Linnea Hanson, Plumas National Forest

Allison Sanger, Lassen National Forest

Ryan Tompkins, Plumas National Forest

John Colby, Lassen National Forest

Chris Christofferson, Plumas National Forest

Michelle Coppoletta, Plumas National Forest

Jason Moghaddas, Plumas National Forest

Kit Jacoby, Klamath National Forest

Julie Knorr, Klamath National Forest

Sue Daniels, Klamath National Forest

Michael Dolan, Bureau of Land Management, Alturas Field Office

Clint Isbell, Klamath National Forest

Results presented in JFSP Final Reports may not have been peer-reviewed and should be interpreted as tentative until published in a peer-reviewed source.

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John Cissel
Program Manager
208-387-5349
National Interagency Fire Center
3833 S. Development Ave.
Boise, ID 83705-5354

Tim Swedberg
Communication Director
Timothy_Swedberg@nifc.blm.gov
208-387-5865

Writer
Christine Frame
cframe@landfire.org

Design and Layout
RED, Inc. Communications
red@redinc.com
208-528-0051