



Piñon-Juniper Restoration Protocols

NM Forest & Watershed Restoration Institute

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Foreword

Rather than an Introduction, I am leading off with a Foreword, a more personal set of observations. These observations are associated with three ideas:

- Our information is incomplete.
- We can not remain paralyzed by our ignorance.
- What do you want?

I will start with the last idea, the question. The approach that I took in compiling these protocols is based on my years of consulting, both with individual landowners in the US and with limited-resource communities in developing countries. The main question for these folks is “What do you want?” What do you want the landscape to look like in X years? Because tradeoffs are always present – an off-the-grid house on private land in the middle of an otherwise wild area may be desired, but wildlife populations will be changed as a result – you need to decide for yourself what you want. As a responsible land manager, you try to think of everything, weigh your options, and move forward. Good land management can give positive results for several things at once, but we may not be “restoring” historic reference conditions in the process.

We are going to need to take a similar approach with areas where no clear consensus exists on what constitutes restoration of piñon-juniper (PJ) woodland. We will have to answer “What do we want?”, and then implement treatments that we think will get us there. Tausch and others[2009] do an excellent job of expanding the one question into multiple questions to be addressed, albeit for Great Basin PJ).

This willingness to proceed provides an opportunity to move forward to a consensus. It also demonstrates how the other two statements – incomplete information and not being paralyzed – are intertwined. If our questions were easy, they already would have been answered. If, for instance, treatment does restore function to a summer-dominated-precipitation site (one of the six PJ types—see below), does the same prescription also restore function on a winter-dominated-precipitation site? Does restoring what we think was a historic open woodland really bring back the full ecological function of a PJ-dominated landscape? And what do we mean by “full ecological function?”

We won't know the answers unless we monitor; even then, because PJ is so elastic, we won't know the answer for all PJ types by looking at just one project in just one type. And we won't be even reasonably sure of the answer until we compile the monitoring from many different treatments in many different projects within the same type. This means that as you implement treatments, pay attention to your results, and share them with your peers. Formal presentations to groups will deliver a message to a lot of people very quickly, but conversations with neighbors over a pickup bed are less stressful.

R Kent Reid



Thinning in Piñon-Juniper

Limits to Our Knowledge

The published research on PJ is extensive. A major caution before diving into the literature is to pay attention to the area and the PJ type where the research was conducted. The work on PJ in the Great Basin (Monson and Stevens 1999, Miller et al 2014) is excellent and deep, but should be applied to New Mexico woodlands with caution. Forest Service research often publishes proceedings of PJ conferences; these collections of presentations (Aldon and Shaw 1993, Shaw et al 1995, Gottfried et al 2008, Board et al 2018) provide good snapshots of a broad range of results and opinions, often with NM-specific examples. A bibliography of the literature reviewed for these Protocols is listed below under Recommended Readings.

One of the best discussions of PJ in New Mexico is in Gottfried et al (1995), and it is highly recommended as background reading. It contains a good section on management outcomes, but the authors recognize the lack of enough specific research to give focused recommendations for different PJ types. They differentiate between high and low productivity sites, and recommend leaving the low productivity sites alone. They lament that certain PJ woodland can turn into “PJ rockland” without treatment. The paper contains an extensive list of research needs, which could be incorporated into these Protocols almost without editing, despite 30 years having passed.

Our unrequited desire to know more goes back even further. In 1956's “The Vegetation of New Mexico” (Castetter), the expansion of juniper savanna and woodland since 1880 is linked to “drought, grazing misuse, and the scattering of juniper seeds by sheep and birds”. The roles of precipitation and differences in rooting depth are discussed as reasons for this expansion, but frequent fire is not mentioned. This publication was written during a time when all fires were considered bad and were to be excluded. Thinking during the last 25 years has changed, and exclusion of all fire is now considered a problem. These PJ Restoration Protocols are written with the idea that restoration of a PJ type means being able to reintroduce that historic, appropriate fire regime.

The author of The Vegetation of New Mexico repeats what he attributes to an old Southwestern saying: “The cattle are the best friends that forests have.” He said the explanations of the time regarding woody plant increase didn’t satisfy. Coming forward to the present day, this cattle-to-forests connection has been embedded in the thinking of the NMFWR and its sister restoration institutes since their establishment. With the coming of the railroad, cattle herds increased, leading to fine fuel removal, frequent fire exclusion, and eventual increases in woody plant numbers. Since our observation was boiled down into something that could be called an old saying in 1956, we obviously can’t take credit for a new idea, but we will use it as a basis for our work.

Diversity in Piñon-Juniper

One of the big challenges with managing PJ is the need to define what is meant by PJ. The first reaction when someone says “PJ” is to think of the PJ where you spend most of your time. The key accompanying this report breaks PJ into six different types, and this key was developed by a lumpers, not a splitter. It can easily be divided further to separate both PJ-savanna and Juniper-savanna, and both PJ-sagebrush and PJ-oak. And to be clear, this document is intended for use in New Mexico, and does not include PJ-dominated plant communities in other areas, such as in Texas or the Great Basin.

Various government agencies and other conservation organizations have produced their own descriptions of PJ ecological types. All are useful tools, and as we learn more about the way PJ reacts to restoration treatments, they may help to fine-tune restoration treatments. A non-exhaustive list includes:

- Habitat Types / Plant Associations (USDA Forest Service)
- Terrestrial Ecosystem Unit Survey (USDA Forest Service)
- Ecological Sites (NPS and BLM of the Department of the Interior)
- Biophysical Settings (LandFire)
- Ecological Systems (NatureServe)

How to Use These Protocols

These Protocols are built on earlier collaborative work in New Mexico. Specifically, Public Service Company of New Mexico (PNM) assembled a stakeholder group in about 2005 to develop a consensus on NM forest restoration principles. That group agreed on principles for ponderosa pine and mixed conifer, but the principles for PJ never got beyond the draft stage. The draft contained an excellent review of what was known about thinning treatments in PJ. It also identified five of the six distinct PJ types that are used here, although the key in that draft did not match their five types. The foundation document (the DRAFT Piñon-Juniper Framework – New Mexico Forest Restoration Principles from 2007) and an updated Key to 6 PJ Types are both available at the NMFWR website. (See below, Recommended Reading.)

The first step for a NM land manager interested in restoring PJ is to review the 2007 Draft Framework, to become familiar with how elastic PJ can be. That review, along with the key, will lead to the identification of the PJ type occupying the area under consideration. Finally, selection of the appropriate restoration options for a project can be made from the sections below.

Any plant community as elastic and as diverse as “PJ” defies easy categorization, which is what this key attempts to do. In particular, the differences between Savanna and Grassland, and among Persistent, Shrub, and Open Woodlands, are subject to nuance and gradations that are not easily captured in a dichotomous key. Note that tree height and canopy cover are so variable that they are not used here as diagnostic factors. Despite these difficulties, a land manager should be able to use this key and the descriptions to make informed decisions about actions toward restoration, desired conditions, and land health.

The underlying driver of the key and of the following restoration recommendations is soil depth, the related soil fertility, and how they relate to fire. When soils are deep, grass cover should be sufficient to carry a fire that kills most woody regeneration. On rocky soils, grass is not sufficient to carry fire, and PJ can survive and thrive.

Key for the Six Piñon-Juniper types

- 1a. Deep soils (>14 inches deep), surface generally free of large rock fragments or large amounts of gravel, and capable of producing continuous fine fuels under normal precipitation – **2**
- 1b. Shallow or transitional soils, surface may be eroded and often is rocky or droughty, and may or may not be capable of producing continuous fine fuels under normal precipitation – **3**
- 2a. Most precipitation falls during summer. The oldest trees (possibly >150 years) are older and usually taller than those found in Grasslands – **PJ Savanna or Juniper Savanna**
- 2b. Season of greatest precipitation can vary. Old trees are very rare and found on microsites that historically would have allowed escape from fire – **Grassland**
- 3a. Soils transitional between deep Savanna soils and shallow hillside soils. Usually not capable of producing continuous fine fuels under normal precipitation – **4**
- 3b. Generally on shallow, coarse-textured soils. Most precipitation falls during winter – **5**
- 4a. Bi-modal precipitation pattern. Uneven-aged stands on rolling uplands with persistent, taller trees. Probably common historically, but rare under current conditions – **PJ Open Woodland**
- 4b. Most precipitation falls during winter. Sagebrush or oak co-dominate with the PJ, but the shrub species may be crowded out under current conditions. This type often found in small patches that can be difficult to map on a statewide scale – **PJ Shrub Woodland**

- 5a. Piñon and juniper are the dominant species. Usually not capable of producing continuous fine fuels under normal precipitation – **PJ Persistent Woodland**
- 5b. Older ponderosa pine overstory, with mostly piñon and juniper understory. May be capable of producing continuous fine fuels under normal precipitation, but herbaceous layer is usually shaded out – **PJ-Ponderosa Transition**

Guidelines from the PJ Restoration Framework 2007

- Develop site-specific knowledge.
 - Develop a comprehensive understanding of historical and current conditions.
- Look for evidence, which may be difficult to see, that restoration is necessary.
 - For example, trees too dense to easily walk through, or active erosion.
- Don't do restoration just because you need to do something.
 - Use resources on areas that are truly degraded and in need.
- If you can't clearly identify a restoration need, but you want to reverse ongoing degradation, use best management practices.
 - All restoration is good, but not all good practices are restoration.
- Don't be too quick to burn the project area
 - You may need to scatter-and-leave a substantial portion of the woody biomass to help site recovery, especially if it can't be rested from grazing.

Summary of Logical Possibilities

For the time being, skip Persistent Woodland.

Treat Shrubland and Open Woodland with caution, with the understanding that we don't know a lot about it.

- After treating, monitor the project area;
- Re-introduce fire, or rather, manage so that fire can be re-introduced;
- And continue to monitor.

Go ahead and restore Grassland or Savanna.

Only by getting a lot of data points are we going to be sure about our treatments.

Treatment Protocols by PJ Type

The type descriptions in this section are taken from the Draft PJ Restoration Framework 2007. The numbers identifying the types correspond to numbers in the Key for the Six Piñon-Juniper types.

Key 2a. PJ savanna or Juniper savanna

Examples: north of the Sandias, top of Rowe Mesa

Savannas are typically found on moderately deep, coarse to fine-textured soils that readily support a variety of growth forms including trees, grasses, and other herbaceous plants. A large portion of annual precipitation comes in summer via monsoon rain. Historically, frequent, low-severity surface fires were carried by grasses. Livestock grazing and fire exclusion are important mechanisms driving the conversion of PJ savanna to PJ woodland in at least some areas.

The difference between this type and Grassland can be subtle, since the main historic difference is a very few trees vs no trees. Thus, it can be very easy to remove all the PJ in a project area and call the result a grassland, when historically the site was a savanna. This mistake can be avoided by leaving the trees on areas of rocky soils, or leaving trees that stand out as being older than the rest of the stand. At the other end of the spectrum, groups of PJ could be left as thermal cover in areas that historically were grassland and devoid of trees.

Stringers of PJ or of pure juniper are common along arroyos and other minor drainages within a savanna landscape. In most cases, restoration would not be called for, since the soils on the edge of the arroyo are mostly eroded, rocky, and thin, and PJ would have been there during the time of pre-settlement frequent fire.

What do you want?

Assume you want to restore the grass component and leave an area that is mostly free of trees. Any method of tree removal is acceptable, assuming wildlife, soil, surface water, and other factors are considered. These removal methods include fire, bulldozing, chaining, mastication, and herbicides. However, leaving individual trees and small groups would be difficult when implementing some of these methods. With chaining, for instance, the cost of moving two bulldozers to a remote site might lead to a decision to "take everything while we are at it".

In almost all cases, restoration of this type involves removing trees on large expanses, and an operator can easily get carried away and take the trees that were meant to be left. The residual trees or groups will need to be marked clearly, and probably extravagantly. For savanna restoration, leave all trees that are growing on thin soils and rocky outcrops, and occasionally leave one of the largest trees growing on deep soils. If selecting for thermal cover, base the selection on what is most useful for the animals.

For stringers, rare exceptions may be found where they are dense enough and wide enough that they would burn as a stand-replacing fire if they ignited. In that case, don't thin the stringer, but cut gaps in it wide enough to stop the continuous fuel path.

Erosion is a potential problem. On sites with heavy pre-treatment PJ cover, the herbaceous layer may be almost non-existent, and removing the PJ will expose large expanses of bare ground. This potential should be evident during pre-treatment surveys, and the decision made then to lop-and-scatter much of the woody debris from the PJ removal. In extreme cases, seeding of a native grass/herb mix may be needed.

Understand that as long as a seed source is in the area, PJ, and especially juniper, will come back. The regeneration will need to be managed. Understand the snow will melt faster from treated areas, and wind may take snow off of treated areas. The reduced transpiration and sublimation from removing trees may balance the snow loss, at least in the short term, but this appears to have never been measured.

Monitor: erosion, grass regeneration, PJ seedling appearance, encroachment of invasive grasses. We need a good index of minimum grass needed to carry sufficient fire to control PJ regeneration.

Key 2b. Grasslands

Example: Fort Stanton area, and throughout the state.

New Mexico's diverse and variable native grasslands are shaped primarily by climatic fluctuation, herbivory, fire, and soil processes. Non-native invasive species have changed the dynamics and structure of some grasslands in ways that are diverse and complex. Shrubs and trees have encroached upon some grasslands, thereby decreasing herbaceous biomass. Fire exclusion is at least a contributor to, if not the main cause of, this encroachment.

See savanna discussion for restoration recommendations.



Key 2b. Grasslands

Key 4a. PJ Open Woodland

Example: Along 1-25 east of Glorieta Pass

PJ Open Woodland typically is found on productive upland sites. Soils are transitional between deep, well-drained soils that support PJ savanna and shallow, coarse soils that support persistent woodland or ponderosa pine forests. Historically, stands were all-aged, open to moderately dense, with an understory of sparse to moderately dense shrubs, and moderately dense to dense herbaceous cover, all maintained by frequent fire. Cool season grasses frequently occur under tree canopies and warm-season species occur in tree interspaces. The 20th century saw an increase in tree density and canopy cover, resulting in loss of stand openings and inter-group spaces, with fire exclusion and livestock grazing as major contributors.

The restoration here is not back to grassland, but reducing density back to what might have been historically present.

What do you want?

To restore open woodland: Assume deeper soil grew better grass and thus carried fire, so those areas would have been relatively free of woody plants. Thus, cut the trees in areas with deeper soils. This implies a need for a minimal soil survey pre-treatment. If an herbaceous layer is absent, leave activity fuel.



Key 4a. PJ Open Woodland

On the remainder of the stand: in areas with rocky and/or coarse silts that don't support continuous grass that could carry fire, thin from below, leaving more trees in rockier soil. Single-tree selection is considered the best method to fit most natural PJ stand conditions (Ellenwood 1995.) Page (2008) thoroughly explains a technical approach to thinning PJ, and presents spacing guidelines for the residual stand. In any case, attempt to keep the same species mix, in the same proportions, on the site.



Key 4a. PJ Open Woodland

“If the area is grazed, the animals are going to reduce grass and fine fuel levels and work against maintaining openings.

Monitor: herbaceous layer, tree seedling recruitment, fine fuel distribution, and fire behavior. Share your monitoring results.

Key 4b. PJ Shrub woodland

Examples: oak – southern slopes of the Gila; sage – south of Tres Piedras

The Framework concluded that this type was a transition from herb-dominant to tree-dominant, and, more importantly, that a high-severity fuel component was always present. In one sense, this means the correct restoration treatment can be very broad and still fall within the historic range of variability. In another sense, it could allow management for a dense, woody stand that would burn in a stand replacement fire, and therefore might not be desirable on a municipal watershed.

For our purposes, this type will be considered to be “restored” when the system is stable, when the fire can burn and the landscape can recover without human intervention. The restored area will burn in a mosaic, and some limited areas may be high severity. This implies some areas need to burn at low intensity, and these areas are what we ought to be creating.

What do you want?

First, assume that a land manager wants to maintain all the native plants on the site: PJ, oak or sage, plus a diverse herbaceous layer. (Total removal of the oak or sage may be desired by the land owner, but that choice is not a part of these protocols, since NMFWR I does not consider that to be strict-sense restoration.)

On the other hand, strong social pressure to not change certain landscapes may be present. The unique piñon-sage association between Ojo Caliente and Tres Piedras may be one of these



Key 4b. PJ Shrub woodland

landscapes. The herbaceous layer that would be expected to be maintained in a frequent fire system is currently excluded from much of this area. A large-scale mosaic with grass does exist, but piñon and sage density is typically so great that grass is not present in sufficient amounts to prevent soil erosion, much less carry a ground fire. That said, this is such an iconic landscape for visitors and non-ranching residents that any large-scale woody vegetation manipulation may be challenged.

This attraction to a sage-dominated landscape may not hold true for scrub oak. But, like with sage, oak size and density may be great enough that the grass-herb layer is absent. In both sage and oak, the main objective of restoration will be to bring back more grass.



Key 4b. PJ Shrub woodland

Maintaining pre-treatment diversity, including the age ranges of all the species, means considering alternatives and combinations of alternatives. Depending on ownership and organizational restrictions, it could also mean a pre-treatment inventory of the project area that looks at soil depths and/or age distribution of the PJ and the oak/sage. The manager may decide to remove just PJ, or just oak/sage, or most likely for most circumstances, a combination of both. Fire should be reintroduced as a system

component, but we have little empirical knowledge of proper fire regime. Finally, the alternatives presented here could lead to the PJ and the oak/sage groups moving throughout the area over time, which is how we think the system functioned historically.

Alternative 1: Restore by removing PJ where it has encroached onto deeper soil. This alternative assumes PJ grew only in rockier soil historically, and mostly older trees would be on those sites. Sage or oak would have been interspersed among the grass in deeper soils.

- Assumes grass present to be able to occupy the created opening.
- This alternative might remove younger PJ:
 - If PJ has encroached from shallow into deeper soil, those PJ would be younger.
 - Post-treatment, with an insect attack or with just aging, residual, older trees might completely disappear, leading to a severe reduction on piñon presence.

Alternative 2: Restore by removing individuals and groups of PJ, of a range of ages, without paying attention to soil depth. This alternative assumes PJ regeneration is occurring throughout the treatment area.

- Both the shrub and grass layers would be released
- Doesn't rely on a soil survey
- This alternative might remove too much younger PJ:
 - If PJ is encroaching from older PJ into oak/sage areas, those PJ would be younger.

Alternative 3: Restore by removing patches of oak/sage and leaving PJ. This alternative could be applied when fewer PJ individuals are present. It assumes the herbaceous layer is excluded by the oak/sage.

- Can be applied when less PJ is present, either in groups or as individuals.
- Doesn't rely on a soil survey
- Appropriate for improving habitat of grazers:
 - Increases grass availability
 - Maintains thermal and visual cover
- In oak scrub:
 - Openings may be difficult to maintain due to root sprouting
 - Openings may present an opportunity to reintroduce frequent fire
 - So as to not degrade wildlife populations, keep total openings to less than half of area.

Monitor: herbaceous growth, woody regeneration, fine fuels and fire behavior, oak/sage response, and share the monitoring results.

Key 5a. PJ Persistent Woodland

Example: Mesa Verde National Park

PJ Persistent Woodland historically was found on shallow, coarse-textured soils that support sparse herbaceous cover. The fire regime was infrequent and high-severity crown fire. Stand structure was variable, ranging from sparse stands of scattered small trees growing on poor substrates to dense stands of large trees on productive sites. Tree, shrub, and herbaceous layers changed little during the long intervals without fire. Stand dynamics sometimes were driven more by climatic fluctuation, insects, and disease than by fire.

Generally, the recommendation is that this type be left alone. It is a low priority for treatment, and money is better spent elsewhere.

What do you want?

If fire is a worry, in this order:

- Cut some openings in it, locating the openings on deeper soils within the stand. Gottfried (2008) suggests openings of about 2 acres, distributed across the landscape, break up a large homogeneous landscape, providing food and adjacent thermal cover.
- Thin from below in the rest of the stand.

Beyond and possibly including these two steps, any work would be considered something other than restoration.

NMFWRI takes the position that the best possible land management is restoration, but we recognize that good land management can prioritize other objectives.

Key 5b. Transition to ponderosa pine

This type was not discussed in the 2007 Draft Framework, but it is found throughout NM. With the exception of some riparian areas, this PJ-to-ponderosa pine transition zone is the densest native plant community. It is dense, like the forests above it, because of fire exclusion. In this zone, the PJ is more susceptible than ponderosa pine to frequent, low-intensity fire, and so would not have been present historically; thus, a restoration to the historic range of variability would remove the PJ in the transition zone. However, given the growing scientific consensus that plant communities will move up the mountain as the climate warms, removing this PJ band today may result in a tree-free zone in 50 years, as the current ponderosas die off. On the other hand, removing the existing ponderosa - assisting migration of the PJ up the mountain – means that we

are removing individual pines that are best placed to have the genetics to reproduce in a warmer climate.

What do you want?

Assuming we want a hillside that has trees on it, apply a modified ponderosa pine restoration prescription. Take 90% of the trees in the transition area. Leave all the ponderosa pine, especially any advanced regeneration. As much as possible, leave the residual stand with groups and openings. Groups can be a mix of species and sizes, but take care to avoid leaving ladder fuels that may cause loss of larger trees. All the juniper can be removed, since they are most susceptible to fire, and most likely to burn intensely under current conditions. Run a prescribed fire through the area as soon as you can.

Monitor: grass cover, woody regeneration, fire effects, and let all of us know how it comes out.



Key 5b. Transition to ponderosa pine

Post-treatment Maintenance

If a seed source is nearby – and in New Mexico, a PJ seed source is always nearby – a treated area will begin to regenerate almost immediately with juniper (Jaremko-Wright 2014). This inevitably leads some to conclude that areas where PJ woodland is present should be managed as woodland, and current efforts to exclude regeneration is comparable to excluding fire during the last century. However, if your answer to “What do you want?” is “I want more grass in my PJ”, then you will need to maintain the herbaceous layer and control PJ encroachment.

In a restoration context, where we are interested in restoring full ecological function, fire is the preferred control method, and regular broadcast burning is the preferred way to apply fire. Fire historically was part of the ecosystem, and reintroducing it may provide benefits beyond woody plant control. For fire to work, grass has to be allowed to grow to the point fire can carry and be hot enough to kill young trees. This may not be possible in areas managed for cattle. In these cases, fire can be applied directly to

individual seedlings with a drip torch or fusee. This practice will greatly increase labor cost, and it should be done when moisture content of the grass is high.

Herbicide control is another option. NMSU has done significant work on herbicide control of PJ, including investigating control of larger trees. Their information is listed under Recommended Reading.

Another option is mechanical control, which means cutting or digging out PJ regeneration. This work will be tedious and carry significant labor costs, but clearing a treated area every five years should be sufficient. A family-owned property outside of Nogal maintained an alligator-juniper savanna in this manner for several decades; the area had several large junipers scattered throughout, with only grass underneath. The property changed hands about 2007, the new owners no longer do the mechanical control, and small junipers are colonizing the area.

The use of intense cattle grazing is not recommended. A few years ago, NMFWR was approached to test the idea that by concentrating herds on grassland where PJ seedlings were present, the hoof action would trample and kill the regeneration. While designing the potential study, cattle producers sympathetic to the idea said that control most likely would not be possible and the cost of herding would be prohibitive. The idea was never tested. Finally, bison promoters say that bison will horn-up seedlings growing in grassland and serve as an effective control on PJ regeneration.

Monitoring

Post-treatment monitoring will be critical for meaningful progress. The PJ plant community is so robust, and so adaptable, that we can't do sufficient research that takes into account every combination of variables. This means every project is an experiment. It also means that monitoring will not be useful unless we share results with one another. At minimum, the following questions need to be answered for each project.

- Does grass come back? How quickly?
- Do trees come back into the areas where they were removed? How do they compete with grass?
- Is enough grass present for fire to carry? How does fire behave?
- In PJ shrubland, how does the oak/sage respond?
- Do invasive species establish?
- Who do I need to tell about my observations? Who would benefit? Where can I talk about it?

If you'd like help building out your Monitoring plan, check out NMFWR's protocol manual <https://nmfwri.org/projects/upland-forests-monitoring-field-manual/>

Recommended Reading

For general restoration information, the NMFWRRI webpage:

<https://nmfwri.org/restoration-information/restoration-resources/>

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