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USDA Forest Service  
Southwestern Region  
Forest Health Protection  
Arizona Zone  
AZ-FHP-17-3



# Forest Health Protection Report

## **Oystershell Scale Impacts and Mitigation Options on the Kaibab and Coconino NF's**



April 2017

# Oystershell scale impacts and mitigation options on the Kaibab and Coconino National Forest's

Amanda M. Grady, Entomologist

## ***Background***

This report documents a site visit to evaluate aspen stands experiencing oystershell scale damage on the Kaibab and Coconino National Forest's. The site visit was requested by Kaibab NF, foresters including; Josh Giles, Jessi Outzs, Michael Sedgeman, Woody Rokala and Coconino Silviculturist, Mark Nabel. On November 19, 2016, Amanda Grady accompanied the individuals listed above, to evaluate stand conditions within three aspen exclosures. Two were located on the Williams Ranger District, Kaibab NF in the vicinity of Spring Valley. The third exclosure was located on the Flagstaff RD, Coconino NF and accessed from HWY 89-A via the Pump House Wash recreation site on FR 237.

## ***Introduction***

Aspen is one of the most ecologically important broad leaf trees of western forests. In Arizona, it occurs at the southern edge of its distribution and occupies less than one percent of the forested landscape on the Williams RD, Kaibab NF (Fairweather et al. 2014), and across Arizona (O'Brien 2002). Conifer encroachment, insect and disease, fire, fire suppression, abnormal weather events, drought and ungulate herbivory all influence the condition of aspen stands across space and time in Arizona (Fairweather et al. 2014, Fairweather et al. 2008). Large scale aspen mortality events have occurred in northern Arizona in the recent past and are likely to continue in the future, further restricting the range of aspen in the Intermountain West (Rehfeldt et al. 2009). Despite many pressures, aspen regeneration was and is occurring, but not always surviving due to heavy browsing by elk in northern Arizona (Fairweather et al. 2008, Fairweather et al. 2014). To avoid this, aspen exclosures are required to ensure establishment beyond the regeneration and small sapling phases (Fairweather et al 2014, Segar et al. 2013, French 2009, Fairweather et al. 2008, Shepperd et al. 2006, Shepperd and Fairweather 1994).

In an effort to mitigate diminishing regeneration, the Coconino NF began building aspen exclosures in the mid-80s, and the Kaibab NF starting constructing fences in 1995 (Fairweather et al 2008). These features are expensive to create and maintain but are essential in perpetuating aspen on the landscape. Forest Health Protection (FHP), Forest personnel, graduate students and professors from Northern Arizona University have documented aspen dieback and declining aspen health inside and outside of exclosures through ground and aerial surveys (Stand Exams 2015, Zegler et al. 2012, and French 2009, Fairweather et al. 2008). Some of the previous monitoring efforts identified oystershell scale as a significant pest of aspen



stands inside and outside of exclosures at lower elevation sites on the Williams RD (Zegler et al. 2012 access database). Management activities need to occur within some of these exclosures and the surrounding stands to maintain aspen as the desired vegetation. This evaluation provides the back ground on oystershell scale biology, current aspen conditions of visited exclosures, aspen management alternatives and recommendations related to oystershell scale mitigation and monitoring.

### ***Oystershell scale Biology***

The oystershell scale, *Lepidosaphes ulmi*, is a common armored scale insect that feeds on the sap of underlying bark tissues of several hardwood trees and shrubs.

**Common hosts-** include; aspen, willow, poplar, lilac, maple, cherry, birch & ash among others. Over 125 common hosts have been identified (FHP 2011). Hosts with thin bark are most susceptible to scale feeding and damage. The outer covering of mature female scales are most often encountered on host trees once populations increase and encrust portions of the bark. These outer coverings “mature scales” are about 1/8<sup>th</sup> of an inch long, range in color from gray to brown and resemble the general shape of an oyster’s shell (Figure 1).



**Figure 1. Mature oyster shell scales.**

**Importance-** Armored scales are generally a pest of urban shade trees that are managed in high value settings like fruit orchards and nurseries. On the Kaibab and Coconino NF’s, persistent oystershell scale outbreaks are contributing to crown dieback in the overstory and stand decline. Regeneration are also infested with oystershell scale in some of these stands. Feeding damage kills cells at the feeding site and often increases host susceptibility to other pathogens, especially cytospora fungi on aspen (Cranshaw 2013). Under outbreak conditions oystershell scales (OSS) can encrust branches and tree boles leading to limb and whole tree mortality. Crown dieback is the principal symptom of severe infestations. Outbreaks are generally persistent and localized and often go undetected until crown dieback begins to occur. Aspen regeneration are particularly vulnerable due to thin bark, especially if they are overtopped by infested hosts. Heavy scale infestations often occur where trees are stressed and where dust is a common environmental condition (like along unpaved forest roads). Dust impedes the respiration of other natural control agents like beneficial insect predators and parasitoids (Dean 1955). Generally scale populations are maintained by the naturally occurring biological control agents (Dean 1955).



**Biology-** There is one generation of OSS produced per year in this region. Winter is spent in the egg stage beneath the old protective cover of the mother scale. General emergence occurs from late May to early June (Cranshaw 2013). Most eggs hatch over a brief two to three week time frame. Newly emerged first instar nymphs known as “crawlers” are the only mobile instar stage capable of active dispersal. During this time the small pale yellow nymphs move across host tissues looking for new feeding sites. Once they begin feeding crawlers molt, produce a protective wax covering and become sedentary. Populations are thought to reproduce asexually. Eggs are laid in late summer to early fall. The egg stage overwinters beneath the dead mother scale. The free living crawler stage is the most vulnerable stage in the developmental cycle of armored scales.

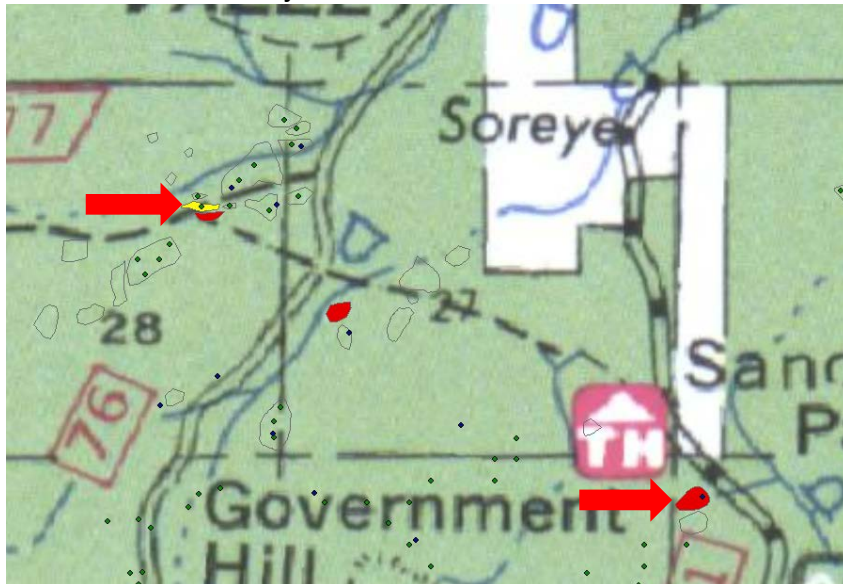
**Dispersal-**mechanisms may influence management of OSS. Dispersal is mostly limited due to the sessile nature of most life stages. Armored scales disperse by, passive transport on infested material which generally account for long range dispersal, or as active crawlers they can walk or be windblown from infested materials (FHP 2011, Beardsley and Gonzalez 1975). Most of the time female scales disperse by walking from the overwintering egg site to the new feeding location. The walking/wandering stage vary by scale species. In the Rocky Mountain and Southwestern Regions, the OSS crawler stage generally lasts a few days, but can be extended over a few weeks (FHP 2011, DeGomez 2009).

In general crawlers of armored scales are believed to travel short distances. However, wind dispersal of oystershell scale crawlers was studied by Wearing and Colhoun (2011) in New Zealand. They reported a decrease in number of crawlers infesting fruits, from 90% to less than 1% at 64 meters (210 feet) away from the infested shelterbelt. Their data support previous information that oystershell scales are often wind dispersed within an orchard or between adjacent orchards. A dispersal study for another armored scale, the California Red Scale reported crawlers were wind blown up to 312 meters from a scale infested lemon orchard (Willard 1974). Blank and others (1997) suggest that the distance of the invasion depends on the strength and uniformity of prevailing winds during the crawler stage.



## Existing Conditions

On the Kaibab NF, we visited two aspen exclosures in the Spring Valley area (Figure 2). The first exclosure (un-named in Kaibab NF aspen fence layer) was near Sanderson Pass, approximately 300 feet west of the X-C trail head and will be referred to as the Sanderson Pass exclosure throughout the remainder of the report. The second exclosure visited (2009\_RS\_Hill) was south of R S Hill off of FR 815/104 and hence forth referred to as the R S Hill exclosure. Both exclosures are fairly small in size. The RS Hill exclosure is nearly one acre (.96 acres) and the Sanderson Pass exclosure is 2.41 acres (Figure 2). Both exclosures are adjacent to roads. The RS Hill exclosure is adjacent to a dirt road while the Sanderson Pass exclosure is located just off



**Figure 2.** Specific exclosures visited on the Kaibab NF include the 2009\_RS\_Hill exclosure shown in yellow with the red arrow in the northwest portion of the map and an un-named exclosure identified with the red arrow which is referred to as the Sanderson Pass exclosure throughout this document.

of a main gravel/county road. Both areas can be dusty due to vehicle traffic which reduce the presence of natural control agents including, predators and parasitoids that often control scale populations in forested settings (Dean 1995). Both exclosures were recently burned by wildfire (RS Hill exclosure) or prescribed fire (Sanderson Pass exclosure). Both exclosures have severely infected overstory aspens with symptoms of crown dieback, suggesting

the OSS outbreak has been a persistent infection at these sites for several years. In many areas aspen regeneration is occurring within the exclosures and beneath the infected overstory trees. Much of this regeneration is severely impacted by OSS, where more than 50% of the entire stem is encrusted with OSS's (Figure 3). Some trees seem to be less susceptible to OSS damage, as many stems have variable levels of scale densities affecting branches, the main bole and regeneration "suckers". Conifer encroachment is also impacting both exclosures. Stands of overstory aspen continue beyond the exclosures. Oystershell scale infestations are also occurring beyond the exclosures in these natural stands.





Both closures have been monitored in the recent past. In 2015, common stand exam data was collected from within and around the RS Hill enclosure (stand exam plot 227). Plot information indicate that several dominant and co-dominant ponderosa pine trees have encroached, with diameters ranging from 15.9 to 30.4 DBH. Most of the aspens identified within the plot had small diameters and intermediate crown positions. Many of the documented stems (n=35 stems) were saplings and seedlings less than 5 feet tall. Many of these small saplings and seedlings are severely



**Figure 3. Small saplings encrusted with oystershell scales on the Kaibab NF.**

infested with OSS that encrust large portions of their small stems (Figure 3). Within plot 227, stand exam data documented, cytospora cankers, a dead top and elk damage. Oystershell scale was not recorded in plot 227 or within the general vicinity of the four stand exam plots measured on August, 2015. However, this damage is often missed as it is less conspicuous and often blends into the bark. Overstory crown conditions and the amount and severity of infested stems all indicate this outbreak has been occurring for several years and of course prior to the 2015 stand exams. Damage types reported in the general area (across stand exam plots 224, 225, 226 & 227) include stem decays and cankers (code 22), animal/elk damage (41) and physical effects (99) such as dead tops and open wounds.

The Sanderson Pass enclosure was monitored by Tom Zegler and Katie Ireland between 2009 and 2010, while gathering data on aspen health associated with their graduate degrees from Northern Arizona University. Together they evaluated 59 plots. They used 48 plots for their analysis of aspen health (Zegler et al. 2012). A single plot, Trt 40, occurred within the Sanderson Pass enclosure. From the access database, 17 of 59 plots monitored (28%) listed OSS as one of the top three damaging agents. These data could be used to prioritize OSS treatments across the South Zone of the Kaibab. The 17 plots identified with high occurrences of oystershell scale are shown below (Table 1). All except one of the 17 plots were located below 8,000 ft., and 65% of the plots occurred below 7,500 ft. (Figure 4). Plot Trt 40, was the only plot with high occurrences of oystershell scale measured within an elk enclosure by Zegler and Ireland (Table 1).

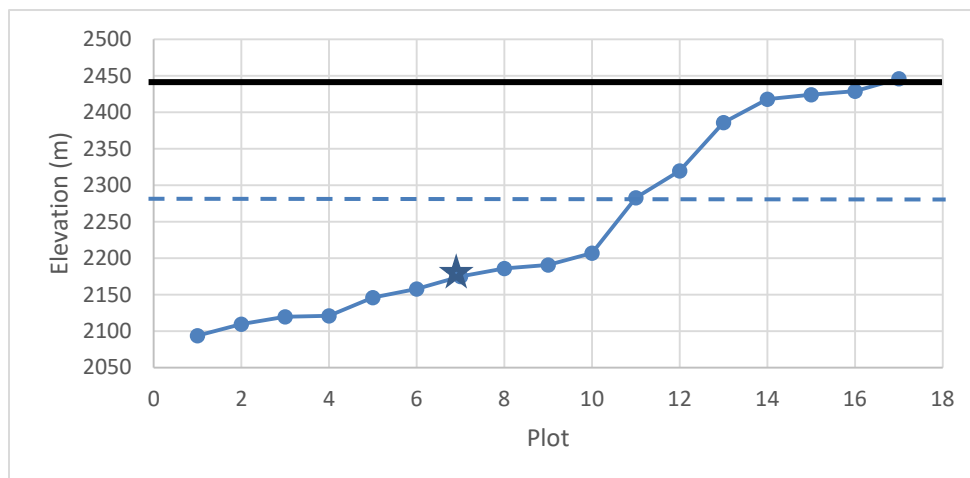
According to the access database, diameters of the aspen stems monitored within the Sanderson Pass (plot=Trt 40) enclosure ranged from 8 to 26 inches in DBH. Damage agents reported in that plot included; general stem cankers, white trunk rot (*Phelinus tremulae*) flat headed wood borers (*Agrilus liragus*), bark beetles, large aspen tortrix (*Choristoneuran conflictana*) oyster shell scale (*Lepidosaphes ulmi*), mechanical damage and sunscald. All trees



in the plot had oystershell scale damage and some had additional damage. Only the top three damage agents were recorded. Ponderosa pine and Gambel oak were also documented within the Sanderson Pass enclosure.

**Table 1. Aspen plots with a high occurrence of oystershell scale on the Kaibab NF, (From Zegler and Ireland access database).**

Location	Trt	UTM_Easting	UTM_Northing	Elevation (m)	Elev (ft)	Aspect	In_enclosure
Davenport Knoll	34	393729	3886232	2094	6870	162	n
Wild Horse Canyon	38	394840	3884054	2110	6923	262	n
Davenport Knoll	26	394425	3885475	2120	6955	330	n
Holloway Spring	22	399867	3885574	2121	6959	96	n
Coleman Knoll	36	392910	3891886	2146	7041	310	n
Coleman Knoll	31	393130	3891664	2158	7080	25	n
Aspen Hill	40	397074	3895347	2175	7135	330	y
Summitt Mountain	51	396208	3889088	2186	7172	36	n
Summitt Mountain	43	395973	3889174	2191	7188	2	n
Summitt Mountain	32	395887	3888469	2207	7241	334	n
Government Hill	95	414071	3910805	2283	7490	51	n
Government Hill	42	413124	3911132	2320	7612	350	n
Government Hill	23	412449	3910848	2386	7828	300	n
Newman Tank	133	420291	3917766	2418	7933	278	n
Mountain	170	417484	3912764	2424	7953	322	n
Government Hill	5	413744	3910188	2429	7969	350	n
Newman Tank	130	420554	3917587	2446	8024	207	n



**Figure 4. Oystershell scale plot occurrences by elevation. Nearly all plots with a high occurrence of oystershell scale occurred below (8,000ft) indicated by the black solid line. More than half (11 of 17 or 65%) of the plots with high occurrences of oystershell scale occur below 2,286m (7,500ft) as indicated by the blue dashed line. The Sanderson Pass enclosure is represented by the blue star.**





**On the Coconino NF** we visited one small aspen exclosure that was accessed via the Pump House Wash recreation site on FR 237. This aspen exclosure is less than a quarter of an acre. The exclosure was mostly surround by conifers but aspen did occur in the canyon adjacent to the exclosure and occurred in greater abundance outside of the exclosure (Figure 5 & 6). The area was also recently burned, such that charred understory was still present during our November visit. The overstory aspen component is almost completely gone, only one small diameter aspen stem occurs within the exclosure. Fortunately some aspen regeneration is occurring within this exclosure, however most seedlings and small saplings are also severely infected with oystershell scale. Oystershell scale is also affecting the adjacent aspen outside of the exclosure.



**Figure 5. Aspen exclosure near Pump House Wash on the Coconino NF has a single overstory aspen stem.**



**Figure 6. General stand conditions surrounding the aspen exclosure visited on the Coconino NF.**

### ***Local Aspen Knowledge***

Paradigms of aspen management have shifted towards management based upon the ecological processes that influence that particular stand. This functional framework for improved aspen management has been recommended by several papers and is endorsed by the Western Aspen Alliance (Rodgers et al 2014). They recommend placing aspen into stable and seral aspen as main categories that should influence future management. Seral aspen stands are created when disturbance occurs and in later successional states conifers overtop aspen. Aspen dominance in seral stands may last decades or even a century. Mixed severity or stand replacing fire inevitably reset succession in these disturbed stands. Stable aspen stands are not



generally intermixed with conifers, rather they have few or no conifers and are largely fire-resistant and difficult to burn (Shinneman et al. 2013).

Seral aspen stands require disturbance or management activities to reduce conifer encroachment which will perpetuate aspen, the desired vegetation. Aspen exists mostly in a seral functional type in Arizona, depending on slope, elevation, aspect and latitude (Fairweather et al 2008). Fairweather and others (2008) monitored aspen health on the Coconino NF following a severe frost event, exceptional drought and several defoliation episodes. Within those aspen stands monitored, their findings showed a high occurrence (95%) of aspen mortality on xeric, low elevation sites (<7,500 ft), substantial mortality (61%) on mid elevation sites (7,500-8,500 ft), and only 16% mortality occurring in mesic high elevation (>8,500 ft) sites. Most low elevation aspen stands were limited to north aspects whereas mid to high elevation stands were located on various aspects.

A preliminary aspen inventory analysis was conducted by the Kaibab NF in 2009 (French 2009). In the discussion French (2009) reports, clones monitored south of I-40 had a higher risk rating than aspen stands north of I-40, which generally inferred an elevational relationship associated with, reduced precipitation, higher temperatures and quicker snow melt thus greater exposure to herbivory. Findings from the Coconino NF study and the Kaibab assessment, suggests aspen stands occurring in the low and mid elevation zones are incurring more stress and are more at risk of tree mortality. Oystershell scale damage recorded by Zegler and Ireland also support this general trend of treatment needs in elevations below 8,000.

### ***Aspen Management Alternatives***

Some aspen management guides can be general but a few guides evaluate specific treatment methods for regenerating and restoring aspen (O'Brien et al 2010, OSU 2010, Shepperd et al 2006). These guides include tips for conifer removal in aspen stands and aspen specific management practices such as clearfell-coppice harvest, root separation, removal of competing vegetation, protection from browsing, prescribed fire, and combined treatment techniques Shepperd et al 2006). Although some of these guides are specific to areas outside of the Southwestern U.S. much of the data come directly from studies that occurred in northern Arizona.

All guides endorse aspen management on a site-specific basis since that is the level at which management actions will occur. Site-specific conditions and characteristics will help identify the necessary actions. Look to specific case studies and those treatment options for further guidance on general aspen management and restoration. O'Brien and others (2010) suggest a four step approach to aspen management. The steps include; 1) assess the condition of aspen, 2) identify problematic conditions and causes, 3) select and perform appropriate treatments, and 4) monitor to assess treatment effectiveness. Steps one and two have occurred in some



fashion on the Kaibab and Coconino NFs in the recent past and could be used to evaluate and prioritize specific stands for treatment. This May, FHP will help locate aspen stands and document conifer encroachment via aerial surveys. These data could also help the Forests evaluate and prioritize treatments for their aspen restoration programs.

Below we define common aspen management alternatives described by Shepperd and others (2006), and Obrien and others (2010) and tie alternatives to site-specific conditions that may warrant that action and any potential negative outcomes.

**Clearfell-Coppice** treatments remove all aspen trees and promotes even aged aspen stands. This method fully stimulates the roots to produce new suckers by completely removing all parent trees. This method reduces some of the ecological benefits of old trees from the stand. Clearfell-coppice alternatives are more geared to large stand management and not generally a preferred option in the southwest (Obrien et al 2010) unless the area is fenced after treatment. Recent practical experience supports leaving large aspen trees inside a coppice treatment (Shepperd et al. 2006). This method could be appropriate in fenced stands where suckers will be protected from herbivory. However, if the above ground stems are limited and decadent the below ground biomass is also limited, under these circumstances removal of all stems may not lead to successful suckering (Shepperd 2004). Soil compaction from harvesting equipment may also limit suckering. Leaving some stems jack strawed to reduce access from herbivores may help with recruitment where clearfell-coppice treatments occur outside of fenced areas (Shepperd et al. 2006). Jack straw or hinge tree treatments have had variable success. This limits herbivore access temporarily and has worked on the Coconino NF where aspen stems did reach larger heights but these techniques will increase fuel loading and fire severity. When wildfires move through the area, the shallow rooted aspen may not sucker (Shepperd 2004). The pros and cons of jack strawing conifers to protect unfenced aspen should be discussed further with the Forest Fuels Specialist.

**Root separation** via mechanical severing of lateral roots is a method of stimulating aspen suckering without removal of the old tree component from the stand. Shepperd (2004, 2001) conducted two studies in Arizona to evaluate suckering response from root separation. In one study a crawler tractor with a ripper attachment was used to separate lateral roots of an open mature aspen stand that was partially harvested 15 years before. The treatment stimulated 486 suckers per acre while the un-ripped, but fenced portion produced only half that amount. The second study occurred on the Coconino NF (Shepperd 2001) and ripped along the side of a small isolated aspen stand growing beside a meadow. Using a single tractor pass cutting to a depth of 20 cm resulted in suckering of over 10,500 stems per acre. Severed lateral roots produced suckers about 1 to 1 1/2 tree lengths away ~14 meters away. This treatment offers the potential for stimulating and expanding the size of some existing stands. New aspen age



classes could be made this way. A single pass on the outside of a fenced enclosure could stimulate suckering in the fence up to 14 meters away. Multiple passes could excessively injure roots and reduce suckering. This treatment should not occur if root disease is affecting the stand. Ganoderma root rot is common in most aspen stands, but is most abundant on moist sites with deep soils (Fairweather et al 2006). Ripping will provide new entry ways for disease spread and could cause more fence maintenance when diseased trees fall on/near fences.

**Removal of competing vegetation** changes the growing environment and available space. This is often all the management action that is needed to successfully regenerate aspen and increase stand health. If older aspen trees are stressed they may already be trying to regenerate. This is often the case in seral aspen stands where aspen is a minor component of the stocking (Shepperd et al. 2006). Removal of competing vegetation maintains aspen already on site and the ecological functions it provides. Single tree and group selection treatment to remove conifers can provide the sunlight needed to raise soil temperatures providing the proper growth environment for suckers to thrive (Shepperd et al. 2006). Jones and others (2005b) suggest using fences to protect suckers from herbivory especially if the stand is decadent and in advanced stages of decline. The below ground resources are not adequate for aspen establishment as unprotected suckers will not continue to re-sprout after multiple herbivory events. Shepperd (2004) describes using this treatment alternative on the Kaibab NF, where removing conifers and fencing the area surrounding two mature aspen resulted in over a hundred established aspen trees after 5 years. Where commercial logging is not practical or when tree removal from the site is not the preferred action, hand falling, followed by pilling and burning is a good practice. However, see the prescribed fire section for further slash management and burning limitations. Lop and scatter is also a cost effective slash management alternative (OSU 2010). Many aspen stands do not easily burn, leaving some material on the ground may help broadcast burns be more effective.

**Prescribed Fire** can be an effective tool to regenerate aspen. All three of the enclosures visited were recently burned and showed abundant suckering post fire. Removing competing vegetation and blackening the soil creates ideal growing conditions for suckers. Of course suckers will need protection from herbivores unless the fire is a large-landscape level fire which reduces herbivore pressure by creating a seemingly in-exhaustible resource of new aspen growth. This situation is occurring in the area affected by the Wallow Fire on the Apache-Sitgreaves NF. Broadcast burning is sometimes recommended when fuels are dry or when other vegetation can be used to carry fire where fuel loads are light. Lop and scatter slash management may help carry fire in stands with these conditions. Prescribed crown fire has also been used by Shepperd (2004) in Utah, but will require natural fuel breaks to keep the fire within the desired treatment area. These types of burns should occur when fuel moisture is high to limit damage to shallow aspen roots. This method is risky, but known to rejuvenate



aspen, reset vegetative succession and can also increase understory vegetation, diversity, forage production and water yields (Bartos and Campbell 1998). This type of fire likely created many of the aspen stands we see today. Heed caution when burning heavy logging slash in harvested areas. Take care to time pile burning during wet soil conditions. Intense heat penetrating into the soil can kill aspen roots below piles (Shepperd 2004). Broadcast burns with heavy loads of 1000 hour fuels will likely kill too many shallow aspen roots and may result in poor suckering. Shepperd and others recommend placing piles a tree and a half-length away from aspen stems to avoid excessive burning that is known to limit suckering under dry conditions.

**Combined treatment techniques** are often the best course of action especially in areas of heavy conifer encroachment. Shepperd (2004, 2001) tested a combination of mechanical treatments and prescribed fire combined with fencing and achieved great results in northern Arizona. All ponderosa pines were removed within and surrounding an isolated aspen stands using a commercial timber sale and the entire area was fenced. Logging slash was scattered throughout the area and a prescribed burn was applied to one half of the enclosure the next spring following snow melt when soils were wet. The prescribed fire had produced more and taller suckers that survived over a five year monitoring period (Shepperd 2004). Stands in most need of immediate management actions will be dominated by conifers and have a small component of aspen, or are suffering from insect or disease conditions like in the case of oystershell scale. Under these conditions a large number of conifers and infested aspen may need to be removed. The resulting sucker density may be low in these areas because the root systems are likely sparse. In these stands prescribed fire alone may not be as effective especially if large fire resistant conifers occupy a good portion of the stand.

Care should be taken to protect residual aspen during the mechanical treatment phase. Track mounted mechanical feller bunchers are thought to be the most efficient equipment for conifer removal without damaging aspen stems or roots (Shepperd et al 2006). Careful directional hand felling can also work. If prescribed fire or broadcast burns are not planned as a follow up treatment then slash debris should be cleared from the site to let light penetrate and create the optimal growing environment for suckers.

### ***Oystershell Management Alternatives***

Oystershell scale is generally a common pest of ornamental or orchard trees and is rarely a management concern in forested settings (Ciesla 2011). Where available we provide aspen and oystershell scale specific management references and recommendations. However, studies to manage and mitigate oystershell scale from aspen stands is limited, particularly in forested settings. Here we extend pertinent research about armored scale management in ornamental



and orchard conditions to the forest setting where aspen within exclosures are managed as high value stands.

There are two general types of treatment for armored scale insects, within the suppression or mitigation spectrum. These two general approaches include cultural or chemical control. A combination of control methods will likely provide the best results and will be specific to each stand or exclosure. Some of the recommendations and treatment options are best estimates on most appropriate treatments based on specialist experience and available literature. Monitoring to evaluate post-treatment effectiveness is a key component that should be a priority for aspen restoration programs (Shepperd et al 2006, Obrien et al 2010).

### **Cultural Control**

Scales thrive on plants under stress. Vigorous plant growth provided by proper siting and care appear to reduce oystershell scale damage in urban and ornamental settings. In terms of the forested setting, much of the aspen within and outside of elk exclosures are in a state of declining stand health. Competition from conifer encroachment reduce aspen vigor above and below ground (Shepperd et al. 2006). Conifers should be preferentially selected for removal to provide growing space for aspen, the preferred vegetation. Scale outbreaks are often associated with stress and dusty road conditions (Dean 1955) that reduce beneficial insect predators. Aspen exclosures are generally accessible by Forest roads, which often become dusty prior to monsoon relief in the Southwest. Position of future exclosures away from dusty forest roads may help maintain beneficial predators and parasitoids that often control scale populations. Maintaining aspen in a vigorous state may also help reduce opportunities for oystershell scale outbreaks.

**Physical Removal** of oystershell scale can be accomplished in small localized areas and is a good option to consider for treating regeneration, small saplings and small individual trees. This is also an ideal treatment for small exclosures like the one visited on the Coconino NF (Figure 5), where few small and short stems can be quickly treated then any small saplings and regeneration can be treated subsequently. Treatments should occur in layers or phases, such that, the infected overstory is treated or removed first. Then boles of small stems can be scrubbed clean and saplings and regeneration can be targeted next. This will reduce the likelihood that the dislodged scale covers and eggs would make it onto host material in the understory. Old scale coverings and eggs can be physically removed or dislodged from smaller trees by gently scrubbing the bark with a soft plastic pad (Figure



**Figure 7. Gentle scrubbing can physically dislodge oystershell scale from bark of small accessible stems.**





7). A soft sponge is likely better suited for cleaning regeneration to avoid causing tissue injury. This treatment should occur after eggs are laid in the fall but before crawlers emerge in the spring, or after crawlers have settled for the season. Realistically, only small trees and areas can be treated this way. A strong jet of water can be used to physically dislodge old scales and eggs when they are present. The crawlers can also be washed off the bark surface when they emerge. However, be sure to use light pressure to avoid inadvertently injuring thin bark, especially of young trees. A pressure washer should not be used on regeneration or saplings. This treatment option may also apply in small to mid-sized exclosures and stands.

**Sanitation/removal of infested material** via single tree or group selection is another management option. This is most appropriate where larger areas of infested overstory occur and crown dieback is prominent. Selectively cut conifers and dominant, co-dominant and potentially some intermediate aspen that have moderate to severe OSS infestations (showing major crown dieback symptoms and large portions of bark are encrusted with oystershell scale) and other confounding damage agents, like stem decays, and cankers. Stem decay is often a sign of old age and a good indicator that the stand may be nearing rotational climax and could benefit from treatment.

Aspens with symptoms of foliar diseases like melampsora rust, marsonnina ink spot or defoliator activity should not be targeted for removal as most aspen can tolerate periodic damage from these agents. It is important to limit the number of stems to be removed so that severely to moderately infested stems are prioritized. This may be more important in areas where heavy conifer encroachment has occurred and may have limited the aspen root system (Shepperd et al. 2006). Viable root stock cannot be maintained without at least some living ramets to produce photosynthetic energy (Shepperd et al 2006). Take care to not remove too much of the overstory especially if adequate regeneration or sapling size classes are missing from the stand. Also take care not to use fire where minimal overstory is occurring and below ground health may have deteriorated. Under these conditions aspen suckering may not occur and the stand may transition to complete conifer dominance. A vigorous, dense stand will produce more suckers if burned or cut than a poorly stocked stand/clone because of the proportionality of above ground to below ground biomass (Shepperd et al 2001).

Where appropriate overstory removals of infested material should be prioritized and could occur in conjunction with removal of competing conifers to improve residual stand vigor and promote aspen dominance. As stated above in the physical removal section, these treatments should occur in phases to prevent overstory material from infecting understory host vegetation. Another way to minimize spread of oystershell scale during treatments may be through proper slash management of infested material.



**Slash management-** Literature and guidelines for oystershell scale management and slash management is limited. It is unknown how slash management of infested material may influence outbreaks and control efforts. Most often, aspen and conifers are cut then either dispersed via lop and scatter followed by prescribed fire or piled then burned. Conifer slash could be treated this way. However, lop and scatter of infested aspen material will likely perpetuate the OSS infestation, because dispersal of windblown OSS crawlers is common. Viable eggs can occur on slash material cut after eggs are laid in the fall then hatch and could be windblown onto aspens in the spring. If mature scales occur on cut material they will asexually produce eggs at the end of the summer- early fall. So all cutting times may produce aspen slash with viable eggs.

Strategic placement of slash piles down wind of the prevailing wind direction will likely reduce potential for windblown crawlers to re-infest host material in the treatment zone. This is a good precautionary step and further supports piling away from lateral roots to avoid heat injury during pile burning. According to Wearing and Colhoun (2011) the number of windblown oystershell scale crawlers was reduced linearly from 90% to less than 1% at 64m (210ft) away from the infected material. Another option would be to physically remove scales from slash material if the egg stage is present (late fall to spring). Or apply chemical control. However, it is unknown if the benefits outweigh the costs of these timely and potentially expensive additional actions.

### **Chemical Control**

Several chemicals are registered against armored scale insects, however chemical applications may inadvertently reduce the population of beneficial insects that usually maintain scales at acceptable levels (Dean 1995). Some chemical control may be necessary in stands with severe infestations where cultural treatments alone will not adequately reduce the population. Chemical treatments may need to reoccur if the underlying stress is not reduced. Where infestations are severe a few applications may be required for control. Pesticides with some persistence may be more effective as the crawlers hatch over an extended time. Chemical control is time sensitive and specific to certain life stages that require weekly monitoring to help time treatments for optimum effectiveness. Before applying a pesticide, weekly monitoring for the crawler stage is needed. To monitor egg hatch and crawler emergence use a piece of double sided sticky tape and wrap it around a bole/stem above the encrusted old scales. Change tape weekly. Scales will migrate up the bole towards the light and get stuck to the tape. Begin monitoring in early to mid-May.

Below is a review of different types of pesticides registered for the control of scale insects, such as; insecticidal soaps, horticultural oils, insect growth regulators and other contact insecticides. All pesticides should be used according to their label and the label should be read in its entirety.



Labels can be scanned for signal words that indicated the product's potential hazard. For example, CAUTION generally indicate low toxicity, WARNING indicates moderate toxicity and DANGER indicates a high toxicity. Each Forest will need to work closely with their Pesticide Use Coordinator and registered applicators to select specific pesticides and to develop a pesticide use proposal (PUP). Amanda Grady is available to further discuss pesticide choice with the Forest Pesticide Coordinator. More information on pesticide use proposals is provided in later sections of this report.

**Insecticidal soaps** use potassium salts of fatty acids to control a myriad of insect pests including armored scales. This active ingredient is also used in herbicides, fungicides and algacides. The fatty acids penetrate the insects' body covering (exoskeleton) and disrupt the cell membranes. The cells contents will then leak out causing the insect to dehydrate and die. These products are somewhat selective towards soft-bodied insects. Adult insects with hardened outer bodies are less susceptible to control with this active ingredient. Soap salts, as they are commonly referred to are not persistent in the environment, the soil half-life is less than one day. Microbes in the soil rapidly break down this active ingredient (National Pesticide Information Center). The product, Safer Brand O-insecticidal soap concentrate is one product that uses these soap salts as the active ingredient. The label displays the WARNING signal word. The label warns to not use this product on vegetation stressed by drought. To control crawlers time treatments in the spring as they begin to emerge. Spray material to wet bark, limbs and stems. Severe infestations may require a few applications that may need to be supplemented with other control treatments. Although these products are generally considered safe they are still hazardous to humans and domestic animals and will require proper personal protective equipment (PPE) as do all other pesticides. These products can be hazardous to aquatic invertebrates and should not be used near surface water.

**Horticulture oils (Dormant season and summer season)** horticulture oils are mineral oil based products. Their intended use is for covering the air holes (spiracles) that insects breathe through which cause asphyxiation and death via smothering. Horticulture oils are effective against scales, aphids, and mites. These oils pose few risks to people and most beneficial insects. Toxicity is minimal compared to other pesticides and oils quickly dissipate through evaporation, leaving little residue (Cranshaw and Baxendale 2013). Dormant season oils should be applied while plants are dormant. This treatment is directed against the overwintering egg stage. Superior oil is a dormant season product registered against scales. The label displays the CAUTION signal word. Thorough drenching of trunks, limbs and twigs is essential for maximum insect control. The product should drip or run off of twigs, stems and the main bole. Often times these treatments require several applications or should be used in tandem with other treatments especially during severe infestations.



The label warns not to use this product on trees weakened by disease, drought, drying winds or high nitrogen applications. To reduce potential injury associated with drought stress water the trees well a few days before the oil application. These oils should not be applied directly to water or where surface water is present.

Summer season oils have been refined to use on vegetation when foliage is present. Summer oils can be effective against oystershell scale during the post crawler stage sometime in June. The young stages of oystershell scale, with minimally developed wax covers, can be effectively smothered with these types of sprays. Horticulture oils can also be combined with crawler treatments for better control.

**Contact insecticides** may have broad or general targets. These products adversely affect the beneficial insect population and are generally highly toxic to bees. These insecticides work by preventing the insects' nervous system from working properly. People and other animals are affected the same way if exposed. Some broad spectrum contact insecticides include Malathion, pyrethroids, and bifenthrin. These active ingredients are all registered for use against scale insects. Bifenthrin and Malathion are highly toxic to fish and other aquatic species including leopard frogs (Johnson et al 2010). Carbaryl is another common contact pesticide used against many different types of insects including scales and other forest pests. Carbaryl is also highly toxic to fish, bees and earthworms (Bond et al 2016). Sevin is a commonly used product that uses carbaryl as the active ingredient. The label displays the CAUTION signal word. Carbaryl can be used against the crawler stage of scales. All contact insecticides should be timed to treat the crawler stage. The pesticide should be sprayed on the trunk, stems and twigs. Follow the label for treatment of forested areas and rangeland trees. Contact insecticides may provide a few years of control.

**Insect growth regulators (IGR)** affect the development of certain insects. Most interfere with exoskeleton development or the molting process of juvenile insect stages. Unlike classic insecticides IGR's do not affect the central nervous system. IGR's generally take longer to kill insects depending on the product and lifecycle of the insect pest. These products can be applied during the crawler stage via aerial or ground applications. Pyriproxifen is an active ingredient that is particularly effective against scale insects and is quite selective in its effects. Most beneficial insects are not adversely effected by this product. Pyriproxifen is sold for commercial applications under the trade name Distance. The Distance label displays the CAUTION signal word. This active ingredient should be used against the crawler stage. Distance does not control adult insects, but greatly reduces their production of viable eggs.

Buprofezin is another active ingredient in the insect growth regulator category, which is registered for use against the crawler stage of armored scales. The product should be applied when crawler populations are beginning to emerge. The label displays the WARNING signal



word. Like other IGR's, evidence of control is slower than typical contact insecticides. Crawlers may remain active on the vegetation for 3 to 7 days, however pests have stopped feeding and damage is low during this period. Products with this active ingredient are not disruptive to beneficial insects and mites. This is a contact insecticide that will require good spray coverage to be effective. The label says to limit applications to no more than two per year. Insects can develop resistance to products that are used repeatedly. Different chemicals or mode of action within the IGR type should be used to avoid resistance.

**Systemic insecticides** have the ability to move systemically within the plant and are useful in control of several insects that affect trees and shrubs. Systemic injections are not recommended for scale treatment because they require injection points that create bark/bole damage that may produce additional entry ports for other fungi that commonly affect aspen. Some common systemic insecticides that contain imidacloprid or chlothianidin as the active ingredient generally have little effect on oystershell and other armored scales because the pesticides often fail to reach concentrations necessary to reduce infestation at the feeding sites. These chemicals are good for controlling soft scales rather than armored scales and are not recommended for OSS control.

Dinotefuran is a systemic insecticide that is effective against armored scales and is often recommended for oystershell scale management of high value trees. Dinotefuran is more effective because it is water soluble and can be translocated to feeding sites more readily (Cranshaw 2013). Dinotefuran may be applied as a soil drench/injection or as a spray applied to tree foliage or boles. Granular forms and the soil drench require rain following application to move the active ingredient into host tissues before the scales begin feeding. The bole application may have better results but soil drenches will reduce negative impacts to beneficial insects. Trade products including Safari and Zylam are available to commercial applicators for scale treatments. Safari is recognized as an excellent product for scale control. It is often rotated with Distance an IGR. Safari is another broad spectrum product that could potentially have adverse effects on beneficial insects. However, use as a soil drench may reduce the impact of non-target insects if they are not feeding on the treated vegetation. Basal drenches and soil injections may be less effective if the trees do not get adequate rain after the treatment. When used as a soil drench it could take several weeks to be translocated into the affected areas to provide control. Safari should not be used as a soil drench when the area is water logged, saturated, or frozen. Because Safari is more water soluble it has the potential of leaching into ground water particularly in areas with sandy or cinder soils. The label also warns against use while plants are flowering.



### ***Pesticide Coordinators and Pesticide Use Permits***

Forest level Pesticide Coordinators should be contacted to coordinate development of the pesticide use permit (PUP) specific to oystershell scale management. Currently the Coconino NF Pesticide Use Coordinator position is vacant. For the time being, Kit MacDonald, the Kaibab NF's Pesticide Coordinator is covering the Coconino NF needs. His contact information is provided below. As the pesticide use coordinator and applicator Kit will identify what products to use. Before the Forest can proceed with pesticide use they must first go through the NEPA process. The Forest may proceed if there is a decision memo recommending a categorical exclusion (CatEx), an environmental analysis (EA) determines a finding of no significant impacts, or if an environmental impact statement (EIS) recommends pesticide treatment as the alternative of choice. For more info on pesticide use or the PUP process see Appendix I.

Christopher (Kit) MacDonald, Kaibab NF Pesticide Coordinator, [cdmacdonald@fs.fed.us](mailto:cdmacdonald@fs.fed.us), 928 635-8299

Allen White, Regional (R3) Pesticide Coordinator, [allenwhite@fs.fed.us](mailto:allenwhite@fs.fed.us), 505-842-3280

### ***Recommendations***

For general aspen management we recommend the four step approach identified by O'Brien and other (2010) or a similar process that evaluates, treats and monitors effectiveness of treatments. The four steps identified by O'Brien and others include; 1) assess the condition of aspen, 2) identify problematic conditions and causes, 3) select and perform appropriate treatments, and 4) monitor to assess treatment effectiveness. The Coconino and Kaibab NF's have both monitored aspen stands on their own or in conjunction with Northern Arizona University and Forest Health Protection. Those previous monitoring efforts could be used to help each Forest prioritize aspen stands that require treatments to maintain aspen as the dominant vegetation. Seventeen plots with a high occurrence of oystershell scale were identified by Zegler and Ireland on the South Zone of the Kaibab NF. These plots could be used to evaluate stands and prioritize treatments specifically for oystershell scale. These stands may help the Forest identify area (acres) that may need treatments. This will guide the NEPA tool used to plan treatments. This May, FHP will conduct aerial surveys to map the location and amount of conifer encroachment within aspen stands on the South Zone of the Kaibab NF and on Mogollon Rim and Flagstaff RD's of the Coconino NF. Ground monitoring will also occur later this year. All of these efforts and data could be used to prioritize treatments and identify the amount of area that could benefit from treatments.

Step two in the process has occurred on the Kaibab and Coconino NF's where they have identified oystershell scale outbreaks that require management actions to mitigate damage. This report is intended to assist with step three, selecting and performing the appropriate treatment to mitigate oystershell scale infestations. The recommended treatments will vary by





site-specific existing conditions. Below we provide a few scenarios and the recommendations associated with those site specific needs.

**In the case of small aspen exclosures with few and short trees**, such as the one visited on the Coconino NF, we recommend cultural control projects to scrub off current scale infestations from the tree bole, branches and twigs by mid-May. Here, a strong jet of water could also be used to dislodge the wandering crawlers in the spring. Once scales have settled by June to July, scrubbing old scales from stems, saplings and suckers is recommended. Taking care to clean old scales and new eggs off the existing aspen is an easy treatment. Friends of the Forest or other volunteer based groups could be organized to help conduct some of these treatments. Forest entomologist, Amanda Grady is available to provide field training on these control techniques as needed.

This particular exclosure is also surrounded by conifers. None are currently occurring within the exclosure. However, removing some of the surrounding conifers could help stimulate more suckering and reduce stress caused by competing vegetation in the overlapping root zone. The aspen also extends beyond the exclosure. Here the stand is in a state of decline, where conifers encroach and oystershell scale infestation are severe. Where possible competing vegetation should be removed, however if not protected, the suckers that sprout after treatment could be killed by herbivores. Because crawlers are known to be windblown to new feeding sites, the surrounding aspen stands should also be treated out to approximately 200 feet where possible. This will reduce the short term likely hood that the outbreak will persists following treatments within the exclosure. Slash management of severely infested aspen stems need to be treated. Do not use lop and scattered techniques with oystershell scale infested material. If possible pile aspen slash downwind from the prevailing wind direction so that windblown crawlers do not re-infest the stand when they emerge. A distance of ~200ft away from non-infested material should be adequate. Piles should be burned the following spring during moist soil conditions.

**If the infested exclosures or stands are large and conifer encroachment is occurring** then there are a few options. If the Forest would like to maintain some overstory aspen we recommend removal of the competing vegetation and sanitation or removal of infested material. Infested aspen material should not remain in the stand post treatment. Aspen slash should not be used for lop and scatter, however, conifer slash may be treated this way if follow up prescribed burning will occur. If prescribed fire will occur then it should be implemented when soils are moist. Aspen slash could be piled and burned the following spring when soils are moist. At a minimum slash piles with infested material should be created downwind of the treatment area. If aspen slash piles are placed downwind and at least 200 feet away from nearby aspen then infection from windblown crawlers should be limited. The above treatment



may not mitigate the OSS population completely. Some infested stems may remain and thus a follow up treatment with cultural or chemical control will likely be needed to adequately reduce the OSS population. Large diameter or tall stems out of reach of cultural control methods could be treated with a spray application or soil drench pesticide. Regeneration and small saplings should also be cleaned with a plastic or soft sponge. This combination of treatments to remove competing vegetation, coupled with sanitation treatments and cultural or chemical control will likely provide the best results.

**In enclosures where the entire overstory is severely infested** and very few non-infested stems occur then a clear-fell-coppice treatment combined with removal of competing vegetation may be more appropriate and will likely provide better control. Some aspen that are not infested could be left on the site. These should be inspected carefully and any observed scales should be removed as best as possible. Under this scenario both aspen and conifer slash would need to be managed as described above. After overstory removals occur we recommend monitoring suckers, and if needed culturally/physically remove scales from suckers. A single pesticide application with insecticidal soaps, horticulture oils or an insect growth regulator may be a useful follow up treatment if suckers are moderately infested.

Sanitation treatments alone will remove large portions of infested material and may get the stand back on a healthy trajectory towards aspen dominance. However, subsequent chemical control treatments following overstory removals will increase OSS control. There are a few options for chemical control that are effective against OSS. Timing is an important consideration. All contact insecticides should be applied to treat the crawler stage which occurs from late May to June. If the Forests would like to proceed with contact chemical control efforts to mitigate oystershell scale then we will need to establish a monitoring program to identify the onset of egg hatching and crawler emergence. We can easily monitor OSS emergence using double sided sticky tape in bands around infested stems. Monitoring should begin in early May and occur weekly until emergence occurs and treatments are scheduled. Forest Health Protection can help with this monitoring to identify chemical control opportunities. As suggested by O'Brien and others (2010) a monitoring program to evaluate treatment effectiveness should become a priority. Because limited information exists on OSS treatments in the forested setting we should prioritize monitoring of oystershell mitigation treatments and relay that information to other Forests and landowners seeking to mitigate OSS in the Arizona and the Southwestern Region.

Insecticidal soaps and horticulture oils are some of the least toxic products that are effective against armored scales. Dormant horticulture oils can be applied to target the overwintering egg stage and will not require the intense monitoring to detect the crawler stage. Summer oils can also be used to target the post crawler stages where timing is also less critical. If the



Forests are concerned about using broad application contact chemical that may negatively affect beneficial insects or aquatic life then we recommend using insecticidal soaps, horticulture oils, insect growth regulators that use Pyriproxifen or Buprofezin as active ingredients or systemic insecticides that use Dinotefuran as either a soil drench or sprayed as a bole/stem application. Carbaryl is another choice that will provide persistent protection across the emergence period with one application. Once treatments occur, monitoring to evaluate efficacy should be a priority. Old scales will remain on the tree even when dead. To evaluate if treatments are working old scales will need to be removed from a portion of the bark so that we can easily detect new scale activity. Because chemical control has not been applied locally to treat OSS we should use any chemical treatment as an opportunity to understand efficacy under different infestation levels where possible.

We recommend submitting a 2018 suppression proposal to Forest Health Protection for treatment of oystershell scale. This is a competitive funding program that could help the Forests fund oystershell suppression projects. We will forward the request for new prevention suppression projects this fall. Amanda Grady is available to help with NEPA, the PUP process, volunteer education and monitoring for pesticide treatment windows. If you have any questions please call Amanda at (928) 556-2072 or email her [agrady@fs.fed.us](mailto:agrady@fs.fed.us).

### ***References***

Baker, F.A., 2000. Important pests of ornamental aspen. Utah State University Extension Publication. [http://digitalcommons.usu.edu/extension\\_histall/422](http://digitalcommons.usu.edu/extension_histall/422). All archived publications. Paper422

Bartos, D.L. and R.B. Campbell Jr. 1998. Decline of quaking aspen in the Interior West-examples from Utah. *Rangelands* 20: (1) 17-24.

Beardsley J. W. and R. H. Gonzalez. 1975. The biology and ecology of armored scales, *Annals Rev. Entomology*. 1975.20:47-73. Downloaded from [www.annualreviews.org](http://www.annualreviews.org)

Bond, C., Hallman, A., Buhl, K. and Stone, D. 2016. *Carbaryl General Fact Sheet*; National Pesticide Information Center, Oregon State University Extension Services. <http://npic.orst.edu/factsheets/carbarylgen.html>

Ciesla, W.M. 2011. *Forest Entomology: A Global Perspective*. John Wiley and Sons

Cranshaw, W.S. 2008. Oystershell scale. Extension Fact Sheet No. 5.513. Fort Collins, CO: Colorado State University, Cooperative Extension. 2p.

Dean, H. A. 1955. Factors affecting biological control of scale insects on Texas citrus. *Journal of Economic Entomology* 48:4 444-447.

DeGomez, T. 2009. Oystershell scale in northern Arizona above 6,000 foot elevation. The University of Arizona, Cooperative Extension, Fact sheet AZ1248



Fairweather, M.L., B.W. Geils and M. Manthei. 2008. Aspen decline on the Coconino National Forest. . 53-62 in Proc. Of the 55<sup>th</sup> Western international forest disease work-conference, 2007 October 15-19, Sedona, AZ McWilliams, M.G. (ed.). Oregon Department of Forestry, Salem, OR.

Fairweather, M.L., E.A. Rokala and K. E. Mock. 2014. Aspen seedling establishment and growth after wildfire in central Arizona: An instructive case history. *Forest Science* 60(4): 703-712.

Forest Health Protection, Rocky Mountain Region. 2011. Oystershell scale: Tiny armored scales of many hardwoods. Fact sheet. 1p

French, M. 2009. Preliminary aspen inventory analysis, South Zone Kaibab NF, USDA, Forest Service.

Johnson, M., Luukinen, B., Gervais, J., Buhl, K. and Stone, D. 2010. *Bifenthrin General Fact Sheet*; National Pesticide Information Center, Oregon State University Extension Services. <http://npic.orst.edu/factsheets/bifgen.html>.

Jones, B.E., T.H. Rickman, A. Vazquez, Y. Sado and K.W. Tate. 2005b. Removal of encroaching conifers to regenerate degraded aspen stands in the Sierra Nevada. *Restoration Ecology*. 13 (2) 373-379.

O'Brien, M., P. Rogers, K. Mueller, R. MacWhorter, A. Rowley, B. Hopkin, B. Christensen and P. Dremann. 2010. Guidelines for aspen restoration on the national forests in Utah, Western Aspen Alliance, Utah State Univeristy, Logan, UT. 48 p.

O'Brien, R. A. 2002. Arizona's Forest Resources, 1999. USDA Forest Service, Rocky Mountain Research Station, Ogden, UT, Resource Bulletin, RMRS-RB-2, 116p

Oregon State University (OSU). 2010. Lamd managers guide to aspen management in Oregon. Oregon State University Extension. <http://extension.oregonstate.edu/catalog/>

Rodgers P.C., S.M. Landhausser, B.D. Pinno and R. J. Ryle. 2014. A functional framework for improved management of western North American aspen (*Populous tremuloides*). *Forest Science* 60(2):345-359.

Shepperd, W.D. and M. Fairweather. 1994. Impact of large ungulates in restoration of aspen communities in a southwestern ponderosa pine ecosystem. In: Covington W.S., and L.F. DeBano. Eds. Sustainable ecological approach to land management. Gen Tech. Report. RM-247. Fort Collins, CO: USDA, Forest Service, Rocky Mountain Forest and Range Experiment Station. 8p.

Shepperd, W.D. 2001. Manipulations to regenerate aspen ecosystems. In: Shepperd, W. D., D. Brinkley, D.L. Bartos, T.J. Stohlgren and L.G. Eskew. Comps. Sustaining aspen in western landscapes: Symposium proceedings: 2000 June 13-15, Grand Junction, CO. RMRS-P-18. Fort Colins CO: U.S> Deartment of Agriculture, Forest Service, Rocky Mountain Research Station: 355-365.

Shepperd W.C., D.L. Bartos, and S.A. Mata. 2001. Above and below ground effects of aspen clonal regeneration and succession to conifers. *Canadian Journal of Forest Research*. 31: 5) 739-745.



Shepperd W. C. 2004. Techniques to restore aspen forests in the western U.S. Transactions of the western section of the wildlife society. 40: 45-48.

Shepperd W. D., P.C. Rogers, D. Burton, and D. L. Bartos. 2006. Ecology, biodiversity management and restoration of aspen in the Sierra Nevada. Rocky Mountain Research Station, GTR-178.

Shinneman, D.J., W.L. Baker, P.C. Rogers and D. Kulakowski. 2013. Fire regimes of quaking aspen in the Mountain West. Forest Ecology and Management 299:22-34.

Wearing, C.H. and K. Colhoun. 2011. Impacts of shelter tree species on the pest status of oystershell scale (*Diaspidiotus ostreaeformis* Hem: Diaspididae) in Central Otago, and options for integrated pest management, New Zealand Journal of Crop and Horticulture Science, 39:1, 35-49.

<http://dx.doi.org/10.1080/00288330.2010.524146>

Willard, J. R. 1974. Horizontal and vertical dispersal of California Red Scale, *Aonidiella aurantii* (mask.) (Homoptera: Diaspididae). Aust. J Zool., 1974, 22, 531-48.

Armored scale insects and control. Clemson University Cooperative Extension. Pesticide list updated 10/2016. [http://www.clemson.edu/extension/hgic/pests/plant\\_pests/trees/hgic2012.html](http://www.clemson.edu/extension/hgic/pests/plant_pests/trees/hgic2012.html)

## ***Appendix I***

### ***Guidance for pesticide use on NFS lands***

USFS procedures for approval of pesticide use on NFS lands are based on direction provided in;

1. Forest Service Manual (FSM) 2150- PESTICIDE- USE MANAGEMENT AND COORDINATION
2. Forest service Manual Region 3 Supplement (FSM R3 Suppl.) 2150 –PESTICIDE-USE MANAGEMENT AND COORDINATION
3. FSM 2320- WILDERNESS MANAGEMENT
4. FSM-2650- ANIMAL DAMAGE MANAGEMENT
5. Forest Service Handbook (FSH) 2109- PESTICIDE-USE MANAGEMENT AND COORDINATION HANDBOOK

USFS – WO directives on policy and regulations including regional supplemental directives may be found at <http://www.fs.fed.us/about-agency/regulations-policies>. This guidance itself may be accessed on the Region 3 website for invasive species (<http://www.fs.usda.gov/detail/r3/forest-grasslandhealth/invasivespecies/>).

Pesticide use proposals (PUP Form FS-2100-2) are required (FSM 2151.2) for each pesticide application on NFS and other areas managed by the USFS. The Regional Pesticide Use Specialist/Coordinator, Allen White can help develop the PUP and will be required to review the PUP. The PUP is used as part of the environmental analysis to determine whether a proposed



pesticide use is appropriate. The PUP form must be completed for any proposed application of a vertebrate pesticide, insecticide, herbicide, fungicide, or any other kind of pesticide registered by EPA (except for household pesticides and for pesticides in amount less than 1 pound of active ingredient for any one project (except for any use of cyanide and strychnine)) (FSH 2109.14, Chapter 70).

Please review the PUP form FS-2100-2, instructions, and an example of a completed PUP in the GUIDENCE FOR APPROVING PESTICIDE USE IN REGION 3 document (enclosed). The PUP form is also available at [http://www.fs.usda.gov/Internet/FSE\\_DOCUMENTS/stelprdb5408149.rtf](http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5408149.rtf). The GUIDENE FOR APPROVING PESTICDE USE IN REGION 3 can be accessed at the following link, [https://www.fs.usda.gov/Internet/FSE\\_DOCUMENTS/stelprd3854200.pdf](https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3854200.pdf) and should be consulted for specific guidance and procedures. Here we review pertinent parts of the process.

The PUP form must be filled out with pertinent information except for blocks containing the review and approval signatures, which will be signed at the appropriate level of delegated authority. Requests to the line officer with delegated authority for approval of any PUP should be made through a letter that includes the PUP as an attachment together with supporting information such as pesticide labels, maps, material safety data sheets (MSDSs) or Safety Data Sheets, etc.

Completed PUPs must be kept in agency project files (FSM 2151.2). The file code category of **2150 – Pesticide Use, Management and Training** must always be included in official USFS correspondence for the PUP along with any other pertinent file codes (up to three total) (FSH 6209.12). Unless substantive changes are warranted in a PUP or it is otherwise terminated, a PUP remains in effect for the duration of the project as long as pesticide activities described in the PUP are consistent with pesticide registration/labeling information and a valid NEPA document (FSM 2151.2). Substantive changes in the use of pesticides include, but are not limited to,

1. Adding or removing grazing allotment or other locations where vertebrate pesticides are used,
2. Changes in the type of application methodology of pesticides,
3. Change in supporting documents used for NEPA compliance,
4. New information on areas occupied by Federally listed species, and
5. Alterations in land use where exposure to the public or pets is probable.

Pesticide use on NFS lands or other USFS-administered areas may involve multi-year projects to protect natural resources; therefore, PUPs need not be renewed annually unless substantive changes take place. It is the responsibility of each pesticide applicator to ensure that PUP information is current for their projects (FSM 2151.2). It is also the responsibility of USFS personnel involved with any pesticide-use activity to ensure that USFS pesticide-use policies are followed in all agreements involving NFS lands (FSM 2151).





## ***NEPA Compliance***

Management activities on NFS lands or other USFS-administered areas such as pesticide applications may not be undertaken unless documentation for a project is in compliance with the National Environmental Policy Act (NEPA) (FSM 1950). Pesticides cannot be applied on NFS lands or other areas managed by the USFS without (1) a signed decision based on NEPA compliance and environmental review, and (2) a completed and reviewed PUP on file at the respective USFS office (FSM 2151.2). The signed decision allowing pesticide activity must be one of the following:

1. Decision Memo (DM) for a Categorical Exclusion (CE)
2. Decision Notice (DN) based on a Finding of No Significant Impact (FONSI) for an Environmental Assessment (EA)
3. Record of Decision (ROD) for an Environmental Impact Statement (EIS)

Pesticide risk assessments are used in NEPA documents to quantitatively evaluate the probability (i.e., risk) that use of a particular pesticide might pose harm to humans or other species in the environment. **The USFS Forest Health Protection program has prepared a number of Human Health and Ecological Risk Assessments (HERAs) for management activities involving specific pesticides**, which may be accessed at <http://www.fs.fed.us/foresthealth/pesticide/risk.shtml>. The Regional Pesticide Coordinator, Allen White, should be consulted before using any alternative pesticide risk assessment in a NEPA document other than those found on the USFS website. Specific pesticides registered against scale insect treatments at this site include;

- Bifenthrin
- Carbaryl
- Dinotefuran
- Malathion

