UT Extension
SP676

Professional Hardwood Notes
Technical Information on Hardwood Silviculture for Foresters

Oak Shelterwood: A Technique to Improve Oak Regeneration

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The oak shelterwood method has been developed to enhance the regeneration potential of oaks growing on intermediate and high-quality sites. The method involves a well-timed mid-story removal to improve the number and vigor of oak advance regeneration and a subsequent overstory removal to facilitate regeneration of the stand (Figure 1).

Oak Regeneration Dynamics

Successful regeneration of oak on intermediate and high-quality sites (upland oak site index > 65 to 70 feet) is limited due to the lack of the vigorous advance regeneration and/or saplings/pole-sized trees that are capable of sprouting. Vigorous advance regeneration and/or stump sprouters are required at the time of regeneration on intermediate and high-quality sites, due to the abundance of competing species. Oak advance regeneration that is small in stature and low in vigor can quickly become overtopped by co-occurring species after a regeneration event. On poorer-quality sites, oaks are subjected to less competition, and often contain an adequate pool of advance regeneration or trees that are capable of sprouting.

In many instances, oak stands on intermediate and high-quality sites contain well-developed, mid- and under-stories of shade-tolerant species typically composed of red maple, sugar maple and American beech. This stand structure leads to light levels at

Untreated with well-developed mid-story.

First growing season after mid-story removal.

Figure 1. Oak shelterwood method and the implementation of the mid-story removal treatment in a typical upland oak stand.

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the forest floor that are not sufficient to provide for the long-term growth and development of oak advance regeneration. When a cohort of new seedlings is established under an intact canopy with a well-developed mid-story, the cohort languishes. The seedlings peak in height growth between 6 inches and 2 feet and mortality quickly reduces numbers. Ultimately, their ability to respond to increased light levels from a canopy disturbance is limited or non-existent.

The more shade-intolerant the species of oak, the more pronounced the effect. Figure 2 shows the height growth and survival of a cohort of northern red oak, one of the most shade-intolerant oaks, which has established and grown under an intact canopy on a high-quality site. After 10 years, only 10 percent of the original cohort is left, with an average height of less than 1 foot. Figure 3 shows similar height growth development for white oak, one of the most shade-tolerant oaks, on an intermediate-quality site. Both of these indicate that under undisturbed canopies with well-developed mid- and under-stories, the cohort establishes, grows negligibly in height and over time dies off. This process repeats itself throughout the life of the forest unless a disturbance occurs at the right time to break the cycle.

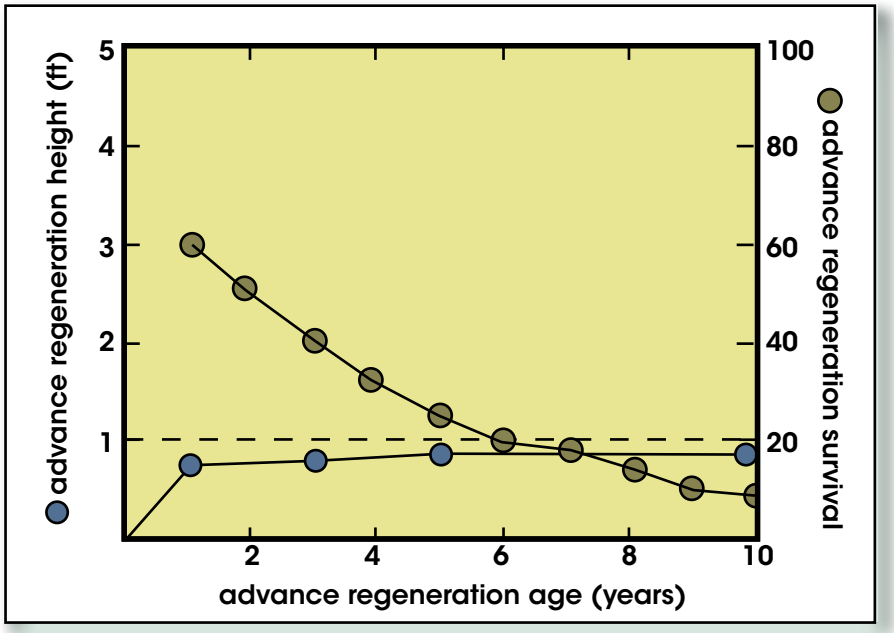

Figure 2. Northern red oak advance regeneration cohort height growth and survival under a typical mid-story on a mesic site.

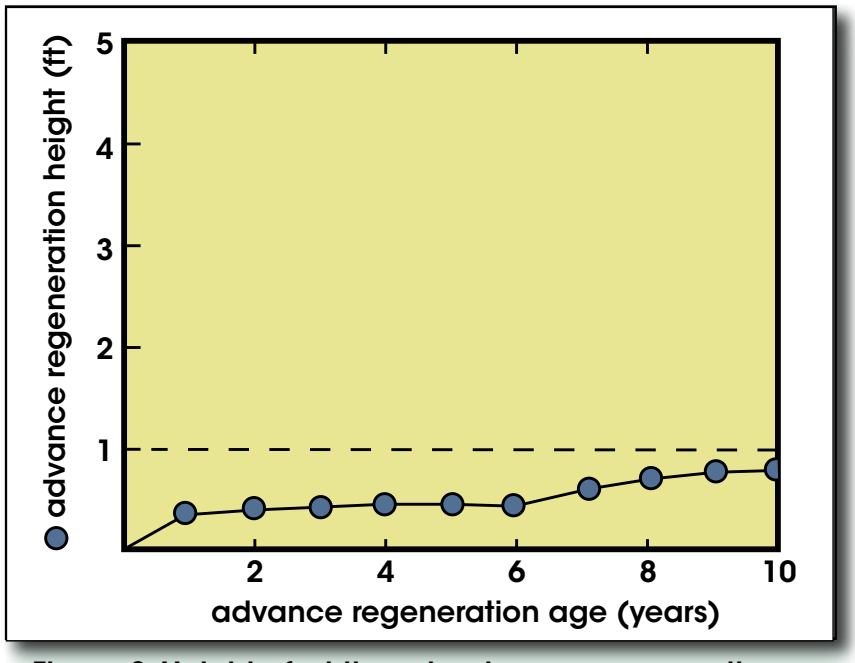

Figure 3. Height of white oak advance regeneration growing under a typical red maple mid-story.

Basics of the Oak Shelterwood Method

The oak shelterwood method has been developed to culture vigorous oak advance regeneration. It accomplishes this through a well-timed mid-story removal, improving light levels for adequate oak advance regeneration development, followed by a canopy release after the advance regeneration has reached a height where it can compete successfully with co-occurring species. The basic science behind the oak shelterwood method is well-documented. While species- and site-specific information for this method is under development, enough is known that recommendations can be made regarding its use in many oak-dominated stands.

The methods concept is simple. After the initial establishment of a cohort of oak seedlings, the mid- and under-stories are removed using herbicides. Typically, approximately 20 percent of the total stand basal area is removed, starting from the smallest trees that can be operationally treated (typically ½ to 1 inch dbh) increasing in diameter but stopping short of removing trees that would open holes in the main canopy. The removal of leaf area close to the ground without opening up the canopy increases diffuse light levels to a point where the newly established seedlings are not severely suppressed and can maintain continued height growth. Survival of the cohort will also improve.

It is important to note that opening the canopy can easily allow for sufficient amounts of direct sunlight to reach the forest floor, spawning the regeneration of many co-occurring species. Many of these species can quickly overtop small oak advance regeneration and lead to their demise. Therefore, it is imperative that the mid-story removal is aimed at increasing diffuse light levels and minimizing main canopy openings.

The ultimate aim of the mid-story treatment is to provide for an adequate number of high-vigor oak advance regeneration that can successfully compete when the overstory is finally removed. If the numbers and size of advance regeneration are sufficient, site preparation treatments at the time of overstory removal will not be required.

Figure 4. Suppressed oak advance regeneration.

Vigor of Advance Oak Regeneration

Vigor, as used in the context of the oak shelterwood method, describes the ability of the advance regeneration to respond quickly in height growth at the time of its full release, typically associated with some type of regeneration harvest. While all aspects of vigor are not thoroughly understood, vigorous advance regeneration is typically indicated by height and stem diameter and form. In turn, these provide clues to the strength of the root system that is a function of its size and available carbohydrate supply. Ultimately, it is this factor that has much to do with the success of advance regeneration upon full release.

While it is true that the sprouting nature of oak can lead to root systems that are older and can be much larger than indicated by the top, there is a general relationship between height, root mass and root carbohydrate stores for a young developing cohort of oak seedlings. As a cohort languishes under a dense mid-story, root carbohydrate reserves are reduced and stems lose apical dominance. Figure 4 shows an advanced regeneration white oak that has been suppressed under a red maple mid-story for 14 years. It is less than 2 feet in height and has lost apical dominance.

The key to the mid-story removal is to implement it directly after seedlings are established and to provide seedlings with enough light to generate root systems stocked with carbohydrates, allowing them to maintain apical dominance. The vigorous root system is especially necessary to ensure good sprouting if the stem is severed during a regeneration event. Even if the stem remains intact after a regeneration event, the crown must quickly develop a main leader and the root system must be well-developed to allow the advance regeneration stem to rapidly increase in height. At a minimum, oak advance regeneration stems should be 3 to 4 feet tall. It is also helpful if the oak advance regeneration possesses apical dominance. However, this latter attribute can be overcome if the root system is vigorous enough.

Which Stands Can Benefit

The system has been developed for stands that currently have oak-dominated overstories on intermediate to high-quality sites (site index > 65 to 70 feet for upland oak). Generally, these are bottomland sites with well-drained, silty loam soils. Upland high-quality sites are found in coves and north or northeast slopes with significant A horizons. Intermediate-quality sites are common on upper east- and lower south- and southeast-facing slopes. When site indices drop below 65 feet on upland sites, oaks are generally capable of regenerating themselves. This is because these stands carry less leaf area and the under-stories are generally higher in diffuse lighting, allowing for the development of vigorous advance regeneration. Also, poorer-quality sites have less vigorous competition from co-occurring species.

On sites above 65 to 70 feet site index, mid-stories are much more developed, limiting advance regeneration growth. Also, the challenge from co-occurring species can be significant upon full-canopy release. Bottomland sites are highly variable and may or may not contain well-developed mid-stories. When mid-stories are present, these stands can benefit from the oak shelterwood treatment.

Typically, this system has been used in stands where the overstory has the potential to provide adequate acorn crops of appropriate oak species and develop advance regeneration. However, when oak advance regeneration is lacking, this system has the potential to be used with underplantings of oak seedlings. Oak seedlings can be planted directly after the mid-story treatment and have been shown to respond well to mid-story removal. The overstory should be removed after the seedlings have acclimated to the environment and obtained heights of at least 6 feet.

There may be stands where the oak advance regeneration occurs in groups or clumps. In these cases, implementation of the mid-story removal treatment should only occur in and around the areas where the oak regeneration exists. It should be noted that there may be reasons to treat all unwanted mid-story species throughout the stand, even in areas where no advance regeneration is present. This could be done to remove or reduce unwanted species and might be advantageous for long-term management and reducing the need for a site preparation treatment in association with a regeneration event.

Timing of the Treatments

This system was designed to be implemented when oak advance regeneration is present. Implementing the mid-story removal prior to the establishment of an oak cohort is risky. If abundant numbers of seedlings are not established within a year or two after the mid-story removal, the advance regeneration of shade-tolerant species (typically present in most oak-dominated stands) will respond to the treatment, and oaks that establish themselves after the treatment will be in jeopardy. Recent studies also indicate that implementing the mid-story removal when the seedlings have been suppressed for several years may severely limit their ability to respond quickly to the treatment. These studies indicate that the seedlings lose vigor quickly. When provided improved diffuse lighting from the mid-story removal, it takes several years for the seedling to respond with detectable height and diameter growth. Generally, the longer the period of suppression of individual cohorts of seedlings, the smaller their numbers, the less vigor they have and the longer they take to respond, if at all.

Implementation of the Oak Shelterwood Method

Step 1. Candidate Stands

Implementation of this method should start with the identification of stands that could benefit from the method. Selection criteria include:

- intermediate to high-quality sites (> 65 to 70 feet site index for upland oak, or the equivalent),
- co-dominant and dominant oaks present (unless underplanting is possible)
- management objectives require maintenance of an oak component
- requiring regeneration now or in the near future

Step 2. Determining Oak Regeneration Potential of Candidate Stands

Once candidate stands have been defined, they should be scouted for their oak regeneration potential. Regeneration targets for maintenance of an oak-dominated canopy typically require a minimum of 50 to 100 dominant or co-dominant oaks at the time of canopy closure after a regeneration event (typically 10 to 15 years after regeneration). This requires that stands contain, prior to a regeneration event, advance regeneration at least 3 to 4 feet tall or sapling/pole oak stems that have the ability to stump sprout. The latter should be trees less than 10 inches

in diameter and 65 years old for white oaks and 35 years old for red oaks.

Due to differences in competition pressure and condition of the advance regeneration, it is difficult to determine the exact number of advance regeneration stems per acre that are required to successfully regenerate an oak-dominated stand. However, if advance regeneration is non-existent or less than 2 feet tall (regardless of the numbers), then the stand is lacking in oak regeneration potential and the oak shelterwood method could be employed to improve this condition. If there are less than 100 advance oak regeneration greater than 3 to 4 feet in height and/or stump sprouters per acre (normally 100 to150 per acre), then some successful oak regeneration can be expected. Use of the oak shelterwood method in these stands would improve the oak percentage in the regenerating canopy. If stands contain the proper advance regeneration pool and/or adequate stump sprouters, then a regeneration harvest can be scheduled immediately and the oak shelterwood method is not required.

As indicated previously, this system could also be used with artificial regeneration. This would involve the underplanting of seedlings prior to a regeneration event and the oak shelterwood method used to improve their vigor prior to a regeneration harvest. Research has indicated that bare-root seedlings cultured in this fashion do have the ability to positively respond to the system.

Step 3. Timing the Mid-Story Removal

Proper timing of the mid-story removal is important for the overall success of this method. If an abundant acorn crop in the last several years has generated a large number of seedlings that still have apical dominance, then the mid-story removal treatment should be implemented as soon as possible (see below). If the seedlings are few in number, are extremely small (≤ 2 foot in height) with the majority of them having

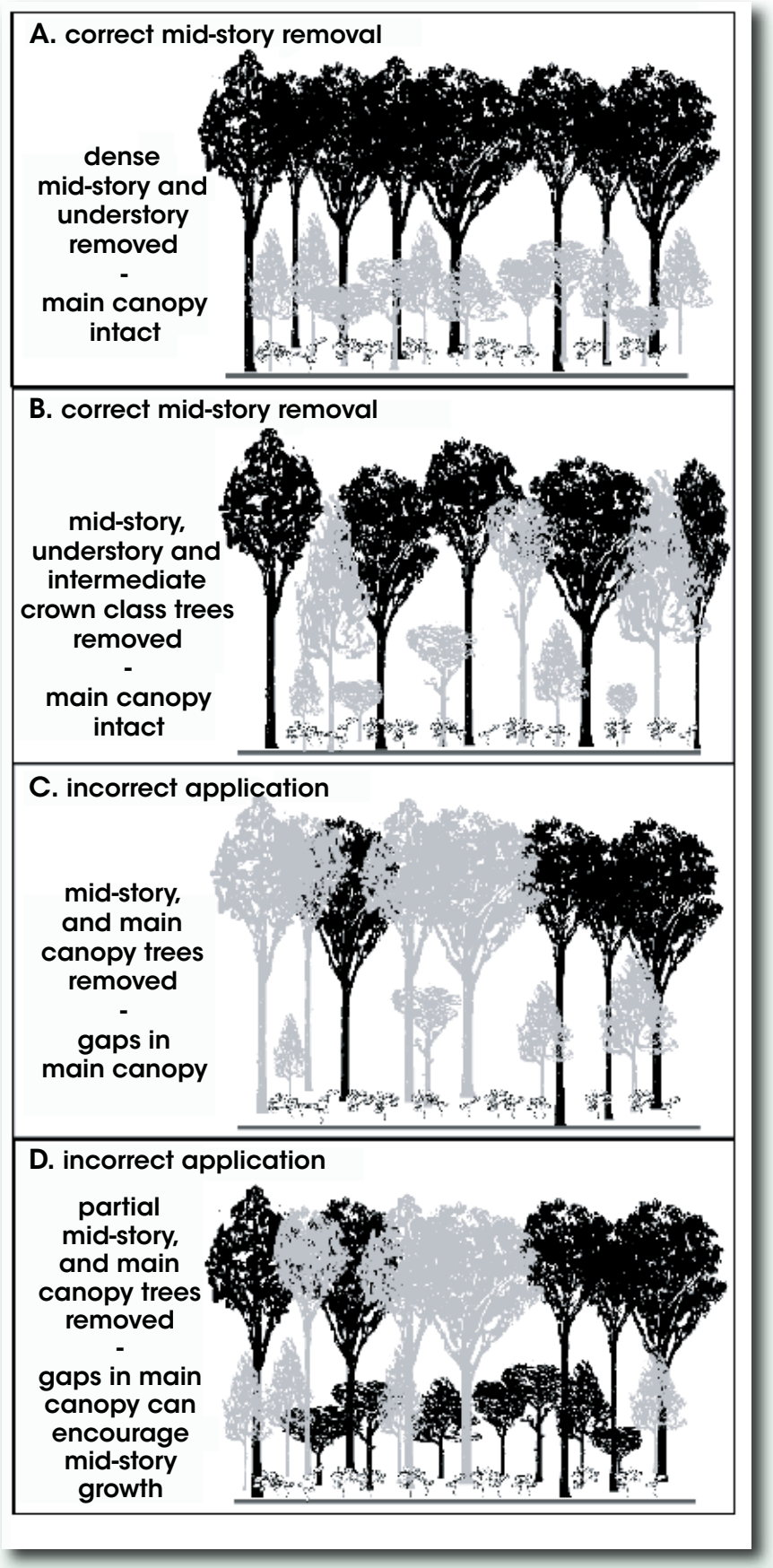

Figure 5. Correct and incorrect application of mid-story removal.

lost apical dominance, then the mid-story removal should be delayed until an abundant acorn crop produces a new cohort. The small, poorly formed advance regeneration present may not be capable of a reasonable response to the mid-story treatment, and waiting for a new cohort to develop may be required. Once a cohort of seedlings has established, implement the mid-story removal.

As a general recommendation, if there is no advance regeneration present, do not attempt the mid-story removal. There are two reasons for this. First, there is no evidence that implementing the treatment will improve oak seedling establishment. Second, the improved light conditions from the mid-story removal will stimulate the advance regeneration of competing species if present. Even if a good acorn crop occurs several years after a pre-emptive mid-story removal, the newly established cohort may be significantly behind in height growth, ultimately leading to its demise.

It is important to note that under conditions where there is no competing advance regeneration and there is reason to expect a reasonable mast crop in the next year or two, the pre-emptive mid-story removal might prove beneficial. However, caution should be exercised in implementing the mid-story removal prior to establishment of oak advance regeneration. The only other situation that would reasonably allow for a mid-story removal without the presence of advance regeneration is if oak is artificially established in the stand. This is typically accomplished using 1-0 or 2-0 bare-root seedlings.

Step 4. Implementing the Mid-Story Removal

The objective of the treatment is to remove the mid-story and understory to provide a significant increase in diffuse lighting without opening up the main canopy. Typically, a target removal of approximately 20 percent of the stand basal area should be planned. While determining the basal area removal is good for planning purposes, typically the treatment is implemented by removing sub-canopy trees, starting with the smallest trees that can be treated. Begin with the smallest, and move up in size but stop short of removing co-dominant or dominant trees (Figure 5).

In some stands, the under- and mid-story may all be overtopped crown class trees and they can be completely removed (Figure 5a). In some cases, the under- and mid-story trees may include overtopped and intermediate crown class trees. Removal of intermediate crown class trees can occur as long as co-dominant or dominant crown-sized gaps are not created (Figure 5b). Figures 5c and 5d show cases where main canopy openings were created, allowing direct radiation to enter the forest. Figure 5d shows a mid-story that was left intact coupled with openings in the main canopy. Under these conditions, the remaining mid-story trees will flourish and increase their leaf area and crown size, further decreasing light levels on the ground.

In almost all cases, the under- and mid-story trees should be treated with herbicides. Simply cutting shade-tolerant under- and mid-story trees will lead to sprouting and cause a greater shade problem for advance oak regeneration than if they had been left standing as single stems. Using herbicides ensures the elimination or significant reduction of competing species and also has the added bonus of removing or reducing the seed source of competing species from the stand. Because oak advance regeneration can not be harmed, individual tree treatments must be used. Methods usually include tree injection, hack and squirt, or basal bark application. Selection of herbicides is generally not critical. However, there have been instances where a significant number of trees per acre have been treated with herbicides with soil activity and some effects on the advance regeneration pool have been observed. Conduct the mid-story removal during the season that is most appropriate for the herbicide treatment prescribed.

Step 5. Monitoring the Advance Regeneration

In the years after the mid-story removal, inspect the stand to ensure that the oak advance regeneration is progressing in growth and to determine if any competition problems have arisen. If there is a seed source of shade-tolerant species in the area, then new advance regeneration of these competing species may establish. These can be taken care of as appropriate through a follow-up herbicide treatment.

Unfortunately, oak seedlings may take some time to respond to the treatment. Response may occur the first year or two after the treatment, especially if the seedlings are of a fast-growing species, are young and exhibiting good apical dominance, and are growing on a good-quality site. Examples of these species and sites would be northern red oak on mesic upland sites or cherrybark oak on bottomland alluvial sites. It may take several years for a slower-growing species such as white oak on an intermediate-quality site to respond.

Step 6. Full Release

The timing of the final release treatment, usually a regeneration harvest, should coincide with the oak advance regeneration attaining a height of 3 to 4 feet or more, the taller the better. The more intense the competition is estimated to be upon release, the larger the advance regeneration should be. Once the advance regeneration has reached the appropriate size, the overstory can be removed by the most appropriate regeneration harvest. Complete clearcuts, patch clearcuts or group openings are generally recommended. Regardless of regeneration harvest, make sure that enough overstory is removed to ensure vigorous regeneration response. If necessary, a site preparation treatment for natural regeneration can be employed to aid in regeneration success. However, successful implementation of the oak shelterwood treatment would negate the need for this treatment.

Other Considerations

There is evidence that oak advance regeneration that has been suppressed for a number of years can respond positively to coppicing. This allows for the root system to produce a top with apical dominance and possibly in better balance with the root system. However, thorough testing of this technique has not been conducted.

The role of prescribed fire in the oak shelterwood method is also a question. Prescribed fire can be used to top-prune poorly formed advance regeneration. However, the intensity of prescribed fire that could be used would only top kill under- and mid-story shade-tolerant trees, resulting in significant sprouting and ultimate interference with oak advance regeneration development. It is possible to combine a prescribed fire with herbicides (either pre- or post-fire treatment). However, the results of this method of competition control have not been thoroughly tested. There have been instances where prescribed fire has been used to successfully remove competing species that were shade-intolerant (ex. yellow-poplar) or where the shade-tolerant competition was newly established from seed. Regardless, prescribed fire might have potential to use in this method, but the risks, benefits and the specific stand and competition conditions must be closely evaluated.

Summary

The oak shelterwood method is a useful tool to help improve the ability of oak to regenerate. Proper timing and implementation are critical for the effective use of this method. Application steps include:

- Determination of appropriate stands based on site quality, oak dominance and oak regeneration potential
- Proper timing of the mid-story removal treatment to ensure that oak advance regeneration is present prior to implementation
- Proper removal of under- and mid-story trees so as not to open the main canopy and to kill treated trees
- Implementation of the final regeneration harvest after the advance regeneration has reached adequate size.

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