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New Forests Project
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TREE STANDS FOR SEED PRODUCTION

INTRODUCTION

Since 1982, the New Forest Project (NFP) has provided agroforestry tree seeds, technical information and other reforestation support to small scale efforts in the developing world. Because of the increasing use of agroforestry as a tool to improve food production, restore land, and alleviate some of the negative environmental effects of unsustainable agriculture, the demand for seeds is continually growing. However, shipments of seeds are becoming more restrictive and expensive and it is therefore in the best interest of NFP, its partner organizations and farmers around the developing world to find ways to produce seeds locally. This will facilitate availability, reduce dependence on seeds from abroad, increase the use of local varieties and increase project sustainability.

One way to do this is to grow tree stands locally for the specific purpose of seed production. Non-profit organizations promoting agroforestry and reforestation can establish their own stands or can work with local farmers to do so. Though it is generally not possible for an individual farmer to establish a seed producing stand, local organizations can promote the establishment of stands among farmer or community groups by coordinating efforts and providing guidance and technical assistance. The following document was developed to provide information on how to establish and manage tree stands specifically for seed production with the ultimate goal of increasing local availability of seeds. Whenever possible it is recommended to also consult a technical specialist before establishing a seed producing stand.

BACKGROUND

Tree seed stands (or small-scale seed orchards) are groups of trees that are established and managed to maximize seed production. Fruits from these trees are harvested exclusively for seed collection. These seeds can be stored and distributed locally to grow new trees for multiple benefits and uses. In the case of agroforestry species, a big majority of these trees

grow very fast and seed production in a stand can start to occur in as little as on year after the stand has been established.

Some of the benefits of growing seeds locally include:

- Seeds are adapted to local environmental conditions.
- Seeds are available locally when the right growing conditions occur (i.e. before the rainy season).
- Dependence on foreign sources of seeds is reduced or eliminated.
- Seeds no longer get lost or damaged during transportation from distant places.
- Creates the potential of generating income by selling extra seeds or by implementing bee keeping activities around flowering trees.
- Seed stand trees can provide services such as shade, soil and water conservation.

UNDERSTANDING SEED QUALITY

Before undertaking the establishment of seed producing tree stands it is very important to first understand seed quality, since good quality seeds are needed to generate good quality trees. Bad quality seeds will produce trees with bad traits and/or that grow poorly.

When dealing with seed quality there are three factors that have to be taken into consideration: genetic quality, physical quality and physiological quality:

- The ***physical quality*** of seeds includes their size, color, age and seed coat condition. Cracks, damages or the presence of pests or diseases may all negatively affect germination.

- The ***physiological quality*** of seeds includes the seed purity, moisture content and integrity of tissues, all of which will influence germination capacity.

- The ***genetic quality*** is determined by the information contained in the genes within the seeds, and is therefore inherited. High genetic diversity is a decisive factor in the success of any tree-planting project. If a mother tree has desirable traits (such as vigor/fast growth, pest and disease tolerance/resistance, and quality products/services) there are good chances that its seeds will produce offspring with similar characteristics. Seeds of good genetic quality that are grown in the right environment and managed in the right way usually generate trees with desirable traits. Additionally, good genetic variability will increase a trees' capacity to adapt to local environmental characteristics (i.e. rainfall, light, humidity, temperatures and soil characteristics) [1].

[1] For more information on tree seed quality visit the www.worldagroforestry.org for the following online publication: Mbora A., Schmidt L., Angaine P., Meso M., Omondi W.,
Ahenda J., Barnekov Lillesø. JP., Mwanzia J.M., Mutua N. A., Mutua Wangu R.., Jamnadass R. 2009. Tree Seed Quality Guide World Agroforestry Centre, Nairobi, Kenya. 28pp. ISBN: 978-92-9059-272-3

ESTABLISHING SEED-PRODUCING TREE STANDS

Preliminary steps in the process of establishing a tree stand include selecting the right species, the right seeds to grow the trees from, and the right place/s to establish the tree stand/s.

Selecting the right species

It is very important to decide ahead of time on the right tree species to grow in the stand, since each species provides different products or services and is adapted to grow under specific ecological conditions[2]. Therefore, it is necessary to decide first which are the products and/or services that are most needed from the trees, understand their growing requirements, and compare them to the environmental conditions of the area (soil, elevation and climate). Whenever possible, native[3] species should be used. However, native species may not always provide some of the benefits that are being sought after (i.e. they may not grow fast enough or not fix nitrogen). In these cases it is necessary to use non-native tree species. When using non-native species it is important to ensure that they do not pose a risk of becoming invasive [4]. Additionally, the species selected should come from an area with similar environmental conditions as to those at the site where the stand will be established. Finally, if the species selected is cross-pollinating and is new to the area, it is important to ensure that the right pollinators are present.

Obtaining seeds

As mentioned above, it is necessary to start off with seeds of good quality:

- To ensure genetic quality seeds should have been collected from at least 30 healthy mother trees, ideally surrounded by other good quality trees of the same species.
- Do not select seeds of isolated individuals since the seeds may be self-pollinated and have low genetic diversity that can lead to low germination rates or seedlings that do not grow well.
- To reduce chances of trees being related to each other (which reduces genetic variability) select mother trees that have a minimum distance

It is important to select seeds from the best trees when establishing a tree seed stand. Picture source: Mulawarman et al, 2003

[2] For detailed information on individual agroforestry tree species, their ecology and growing conditions and their products and services visit the World Agroforestry Center's Agroforestree Database: http://www.worldagroforestry.org/resources/databases/agroforestree

[3] *Def.* Species that are naturally present in a given area.

[4] *Def.* Species that have the potential to spread rampantly and can interfere with the growth of native species, potentially affecting entire ecosystems.

of 100 meters between each other.

- Select seeds that are mature and of good physical quality, otherwise germination rates can be low. See page 8 for information on how to determine seed maturity.
- If possible, mother trees should be growing in sites with similar environmental conditions as to where the seed stand will be established (altitude, temperatures, rainfall).
- Before collecting seeds make sure you have permission from the owner of the seed source to collect them.

When selecting mother trees, look for characteristics that you would like your trees to have. For example:

- If you are collecting seeds for species that will be grown for firewood, gather seeds from individual trees that have demonstrated to grow fast and are easy to coppice[5].

Good firewood tree Bad firewood tree

- If you are planting trees to obtain timber, gather seeds from trees that have a good height, a straight stem of good diameter and good quality timber.

Good timber tree Bad timber tree

- If you are planting trees for fodder, pick seeds of individuals that have high productivity of leaves and pods, have many branches and multiple stems and are easy to coppice.

Good fodder tree Bad fodder tree

Pictures source: Cordero J. and D. H. Boschier, 2003.

To reduce problems of ***low genetic diversity*** try to **avoid**:

- Collecting seeds from single stands of trees where the origin of the mother tree is not known, since they may have been planted from seeds coming from one or only a few individuals.

[5] *Def.* Cutting down young trees to the ground level in order to allow many new shoots to re-grow and be cut down in subsequent years.

- Collecting seeds from isolated individuals since they may have been self-pollinated or pollinated by only a few individuals.
- Collecting seeds from single human made stands since the stand may have been planted from seeds of only a few individuals.

If you only have access to trees from one specific site, it is possible to use the seeds from this site if the trees of the stand have proven to be successful (healthy, big, well spaced, uniform in size and cross-pollinating) and they are growing in an area with similar environmental conditions to the site where the seed stand will be established.

If there isn't a good supply of local mother trees, it is recommended to purchase the seeds from reputable seed distributors that can guarantee genetic diversity and the physiological quality of the seeds. The New Forests Project may also be able to provide seeds.

Keep in mind that you may need to collect up to four times the amount of seeds as compared to the amount of trees you want to grow in your seed stand, since you have to take into consideration that a percentage of the seeds may not germinate, seedlings will die after being transplanted and young trees that are not growing well will have to be eliminated (thinning, see page 7).

Selecting the appropriate site for the stand

In order to maximize tree survival and seed production, it is important to select the right place where to locate the seed-producing tree stand. Some desirable characteristics for the site include:

- Good location with easy access and proximity, as much as possible, to the area where the seeds are going to be stored or used so as to avoid transportation problems.
- The terrain should be level or gently sloping.
- There should be good amount of sunlight and protection from strong winds.
- Soils have to be fertile and have good structure and drainage:
    - Soil pH should be tested to make sure it is within the range needed by the species that will be planted.
    - Nutrient levels should be evaluated, especially nitrogen levels (for growth) and phosphorous levels (for flowering). Deficiency of other micro or macronutrients can also have an impact on seed production.
    - Soil compaction[6] especially in abandoned agricultural lands can be a problem because it prevents root growth and can restricting water flow. In such cases, it may have to be ripped[7] ahead of time.

- If the species is out crossing or insect-pollinated, the patch of land should be slightly removed (at least 100 meters but better if 200 meters or further) from the area where other trees of the same species are being grown. This avoids cross-pollination with

[6] *Def.* Soil particles that are pushed close together
[7] *Def.* A mechanical treatment for breaking up the soil (plowing or turning) below the depth of normal tillage operations.

trees that may be of inferior quality and ensures genetic purity of the seeds in the stand. The distance has to be greater if neighboring stands are extensive or pollination for the species can occur over long distances. In some cases, adjacent stands can be managed (for example, by coppicing) so that they do not flower while pollination is occurring in the multiplication stand.

- Self-fertilized species such as Leucaena need only be separated from related species by a few meters to prevent contamination.
- If the species of trees that will be planted depend on pollinators for seed production, make sure that these are present in the area.
- If unfenced or isolated, make sure it is safe from animal browsers or possible human theft.
- Land tenure or land use rights should be secure.

Growing the seedlings

See NFP's "Tee Growing Guide" for instructions on how to establish a nursery, sow and grow seedlings. Guide can be downloaded at: http://www.newforestsproject.org/nfp/en/newforestsproject/html/Technical_Doc_English_Final.pdf

Planting the trees

Once the seedlings are old enough to grow in the field, they should be transplanted to the site where the tree stand will be permanently established. The site has to be prepared ahead of time by clearly marking it out, fencing it if necessary, clearing previously existing vegetation including roots, and digging the holes for the seedlings (see NFP's "Tree Growing Guide" for more details on this). When digging the holes it is important to keep in mind that ***tree spacing in seed stands is generally wider than in other plantations***. Wider tree spacing is necessary to allow light to penetrate and reach the crowns in order to stimulate flowering, pollination and seed ripening, as well as facilitate access to collect the seeds. Initial spacing of seedlings may be closer than the final one to maximize initial seed production, but once the trees get larger, inferior individuals should be removed. Ideally, a stand should end up having at least 100 trees, to ensure genetic diversity. Following is a list with recommended initial and final spacing for seed stands of some common tree species (Table Source: Kindt et al, 2006)

Species	**Initial spacing (m)**	**Final spacing (m)**
Azardirachta indica	8x8, 6x6	5x5,6x6,8x4
Calliandra calothyrsus	3x3,4x2,8x2	3x3,3x3,4x2
Gliricidia sepium	3x3,4x2,8x2	4x4,8x2,3x6
Grevillea robusta	3x3,4x2,8x2	3x6,4x4,8x4
Leucaena spp	3x2,4x2	3x2,3x3,4x2
Melia volkensii	2.5x2.5,3x3,4x4	5x5,6x6,8x4,8x8
Moringa oleifera	3x3,4x2,8x2	3x6,4x4,8x4
Prunus Africana	4x4,5x5	5x5,6x6,8x4,8x8
Sesbania sesban	3x2,4x2	3x2,3x3,4x2

TREE STAND MANAGEMENT

Once the seedlings have been transplanted good stand management will maximize seed production and the following practices will be needed:

Weeding

It is helpful to weed around the seedlings to eliminate competition from other plants. This is especially important during the first months when the roots of the trees are not well established yet and weeds will compete for water and nutrients. Alternatively, a cover crop that does not compete with the seedlings may be planted to choke weeds and reduce labor costs. A cover may also prevent soil erosion and conserve soil moisture.

Thinning

Once the trees are well established, it is recommended to selectively thin the stand. Thinning consists in removing poor quality trees that have not grown well because they have been outcompeted by neighboring trees, affected by pests or diseases, or impacted by other environmental factors. Individuals with dead or discolored leaves, remnants of insect damage, bad shape, small crowns or growing too close to other individuals should be cut down. Ideally, the final stand should have trees that are equally spaced and have the tops fully exposed to sunlight. In some cases, three out of every four individuals may either die or have to be eliminated but each individual thinning should not remove more than 30-40 percent of the trees. All this should be taken into consideration when determining the size of the site and the amount of seedlings to be grown in the nursery.

Other Management Practices

In some cases it may be necessary to implement additional management practices such as:

- Fencing the site to prevent browsers especially during the early stages of the trees.
- Coppicing (see page 4 for definition) to increase crown density in some species in order to have more flowering and fruiting, and make it easier to collect the seeds. Coppicing should be done at the start of the rainy season, to minimize tree moisture stress and allow rapid regrowth.
- Pruning should be conducted periodically to remove lower branches that have grown large or no longer produce flowers.
- Fertilizing to increase flower and seed production. The application of a phosphorous fertilizer is recommended just prior to the flowering season, which for most species corresponds with the rainy season.
- Establishing a border row around the stand where seeds should not be collected from to avoid seeds originated from cross-pollination with inferior individuals outside the stand.

SEED PRODUCTION, COLLECTION AND PROCESSING

Different tree species will start to produce seeds at different times. Some fast-growing agroforestry species will start to produce seeds within the first year after the trees become established. However, the quantity of seeds may be limited and quality may be low in the first crops. As trees prosper and become more mature and larger, seed production and quality should increase.

Flowering and Seed Production

In general there are specific times of the year when trees produce their fruit and seeds. Some species flower only once a year while others may do so several times in a year. Also, some species may flower continuously and others irregularly. Flowering characteristics are specific to each species but are also influenced by local environmental factors. In areas with a marked dry season (summer) a big number of trees produce their fruit at the end of this season. Finally the production of seeds can vary from one individual tree to another within a same stand in a given season and seed maturity can vary throughout the crown of one single tree.

Seed Maturity

Seeds should not be harvested before they have reached maturity. Immature seed will have low viability, germination potential and storage life. The interval between flowering and seed maturation varies from one species to the next and is also affected by local environmental conditions. The signs for seed maturity also change from one species to the next. For legumes such as Calliandra, Gliricidia, Leucaena and Sesbania, seeds usually take six to ten weeks to reach maturity. For most species, seed is mature when it can no longer be crushed between thumb and forefinger. Often, the color of seed changes on maturation. Many agroforestry species are legumes and the seed of most tree legumes is mature and ready to harvest when pods become dry and turn color from green to brown, grey or yellow. One same tree may have both mature and immature seeds. In general, seeds may not be mature if the tree still has flowers. Seed maturity can be tested by cutting open some seeds and observing the embryo (or endosperm): a mature seed has a firm embryo while an immature seed has a milky embryo. Cutting open seeds will also allow to check if the seeds are infected with pests.

Seed Collection/Harvesting

Correct harvesting time is essential. To get good quality mature seeds it may be necessary to harvest several times within a stand. The aim of harvesting is not necessarily to collect all seed from a stand, but to collect a reasonable proportion of the seed in a cost-efficient manner, while ensuring that seeds are mature and of good quality.

It is best to harvest seeds when there is a majority of trees with mature seeds. The widest possible genetic base should be obtained by collecting approximately the same quantity of fruit from individual trees with different samples throughout the crown. In practice, the quantity of seed produced by, or the ease of harvesting from, individual trees may vary greatly. It is

important not to bias sampling by collecting substantially more seed from certain trees, especially in a small stand, because this narrows the genetic diversity of the collection. If variation in seed maturity between trees leads to seed being harvested from a stand at different collection intervals within a season, it is important to mix these seeds before being distributed to users.

Some issues to take into consideration include:

- Seeds should be collected when the trees are at the peak of seed production.
- The very first fruits that appear on the branches are often not the best, since they can be immature and contain poor quality seeds. It is recommended to wait until there are various fruits/seed pods on the branches that appear to be ripe before harvesting.
- Harvesting windows can be fairly narrow, lasting 2 to 4 weeks.
- Late harvesting can result in yield loss due to seed shedding, pod shatter and pest predation.
- Harvesting intervals should be long enough so as to allow a reasonable quantity of seed to mature since the last collection.
- If a species sheds mature seeds easily, more frequent collection will be required.
- If applicable, it is better to collect fruit during dry weather since dry seed is less susceptible to pest and disease attack, and drier conditions will reduce the time required to dry seed before storage.

Methods of Seed Collection

There are various methods for collecting the seeds once they have reached maturity:

- Waiting until the fruit falls to the ground and collecting it directly from the ground is the easiest way. However, if using this method, avoid collecting seeds that may have started to rot or have suffered insect damage.
- In small to medium trees it is possible to collect the fruit directly from the branches once they have reached maturity. Work can be aided by using ropes, hooks or telescopic shears (if available). Always being careful not to damage the branches in the process.
- If fruit is not easily reached, a tarp can be placed underneath the tree and the tree can then be shaken manually to allow mature fruit to dislodge and fall on the tarp below. If necessary the branches can be shaken using implements such as rakes, hooks or ropes, taking care not to damage the branches during the process.

- Climbing the tree is also an option but requires **extreme caution** to avoid the risks of falling. It is recommended to do this in teams of two or three and use safety ropes, harnesses and ladders that are in good shape. Also, being careful with wasps and bees and ensuring that the trees are not in contact with power lines.

Sorting Fruits

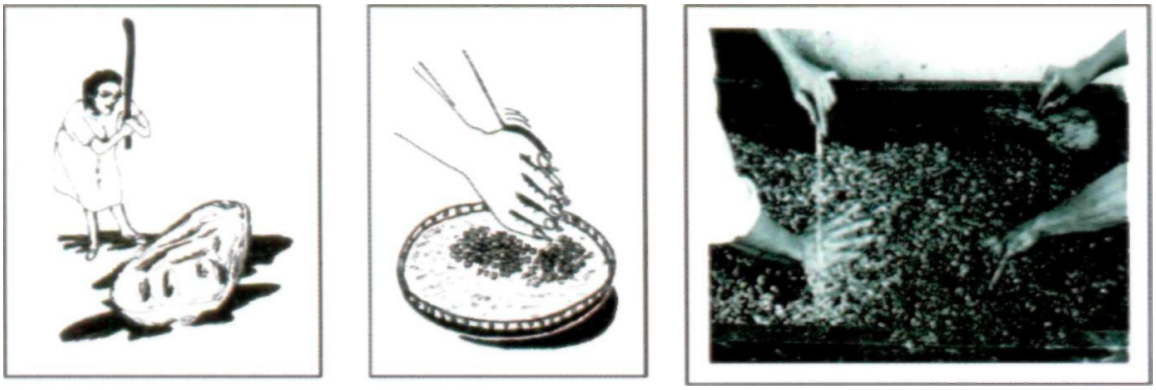
Not all fruits collected in the field are mature or of good quality and may have to be sorted to separate those that are good for seed extraction. Fruit that is undeveloped or infected with insects and disease should be discarded. Fruits that are not fully mature should be separated and allowed to after-ripen. They should be placed in a shaded place with good air circulation and examined every 2-3 days. Ripening may require 2 or more weeks. After-ripening is important, because extraction of seed from immature fruits can damage the seed.

Seed Extraction

Extraction is the process of removing seed from fruits. All extraction methods should be conducted carefully to avoid damaging the seeds and leading to losses in viability. For most species, seed should be extracted from fruit as soon as possible, if seed extraction is not done correctly or soon enough the seed may die. Appropriate extraction methods vary by species and fruit type. Some common tools used during extraction include sacks, tarps, trays, buckets, tanks and sandpaper. The extraction method used should not damage seed so that a significant loss in viability occurs. During extraction, impurities (for example, diseased or partly eaten seed, contaminating seed, soil, chaff and insects) should be removed by winnowing or hand-sorting.

Following is a listing of some of the most common extraction methods:

- Firmly rubbing together the seeds to remove the outer skin and other debris.
- Breaking open the fruit or pods and removing the seed
- For many legumes, pods can be dried in the sun for two days and then rubbed across a coarse wire mesh through which seed falls.
- Drying the fruit on big plastic sheets or tarps under direct sunlight until the dried fruit opens to release the seed. Normally 2-3 days of drying is enough. Rubbing and crushing the fruits after drying will expedite seed extraction. Seed of *Leucaena* are extracted by this method.
- The dried fruit of other species open slowly over an extended period of time. To hasten seed extraction, fruits of this type should be placed in sacks and lightly beaten with a stick or firmly crushed. Seed of *Gliricidia sepium* are extracted by this method.
- The fruit of some species can be scraped with an abrasive material such as sand or ash to remove the fleshy outer layer.
- Some fruits, especially those with fleshy fruit need to be scrubbed and washed with water to separate fleshy material from the seed. Before washing, the fruit can be soaked in water overnight and, if necessary, crushed or lightly beaten to soften the flesh. It is important to scrub and wash away all the fleshy material and juice, otherwise insects and fungi may infest the seed.



Various extraction methods-beating a fruit, scraping fruits with an abrasive material, and scrubbing it to remove fleshy material. Picture Source: Mulawarman et al, 2003

Once the seeds have been extracted it is usually still necessary to clean and sort the seed from impurities. This can be done by blowing away impurities, which are usually lighter, or by separating them in water since healthy seeds are usually heavier and will sink while impurities or infected seeds will float.

Seed Drying

If the seeds are to be planted immediately, no further processing is needed. If the seeds are to be stored they must be dried in order to put the seed into a state of dormancy and maintain its physiological and physical qualities. Generally, the lower the moisture of seed, the longer it can be stored. Orthodox[8] seed with a moisture content of 1O% or less will maintain high viability for several years if stored correctly.

In order to dry the seeds, the following has to be taken into consideration:

- Seeds should be placed on a tarp or cloth and laid out in direct sunlight for 2-3 days.
- Longer time may be needed if:
    - Seeds are larger in size
    - Humidity is high, in which case drying may take 5-7 days.
- At night or if it is rains, the seeds should be put in containers and kept indoors.
- Avoid overheating, since heating the seeds to temperatures of 45 °C and above can kill them. When the sun is extremely hot the seeds should be placed under partial shade or moved to the shade during the midday hours.
- Local methods to dry rice, maize, or other agricultural seed can be appropriate as well.

Some signs of seed being sufficiently dry include being easy to bite, crack, or cut and when mixed or shaken making a rustling or cracking sound.

[8] *Orthodox* species are those with seed that remains viable for a period of one to two years if dried and stored correctly. All species provided by NFP are orthodox species. Seeds of species that last only 1-2 weeks under ideal conditions are called *recalcitrant*, and those that last up to 4 weeks are called *intermediate*.

Viability loss

In order to diminish chances of seeds dying during the process of collection, drying and storing it is important to avoid putting the seeds in hot water or exposing them to full sunlight, avoid leaving them in a closed vehicle, avoid sudden changes of temperature (i.e. taking them from a warm place and putting them in a refrigerator) or drying them too quickly (FAO).

Seed Storage

If orthodox seeds are not stored correctly they can die very quickly. However, if they have been dried and stored properly they can maintain their germination capacity for 1-2 years at room temperature, or even longer periods of time if dried even more or kept under cooler temperatures. As a general rule the lower the temperature and the lower the air humidity the longer will the seed maintain viability. High air humidity will make the seeds absorb moisture and loose viability. Fluctuating temperatures or exposure to direct sunlight can also cause loss of viability.

- Ideally orthodox species should be stored with moisture content of 5-8% [9] or lower
- Temperatures should range from 0-5 °C. If a refrigerator is not available, choose a cool place with constant temperatures.
- The seeds should be stored in clean, dry and airtight containers and the air volume should be small compared to the seed volume. Airtight containers make it easier to maintain seed storage conditions and thus seed viability. If these are not available, sacks, bags, baskets or tins can be used. The empty space in baskets, tins and jars should be filled with material that absorb air moisture, such as charcoal, rice husks, or crumpled newspaper.
- Seeds should be labeled with the species name, collection date and seed source.
- The seed storage room should be cool, dry, dark, well ventilated and protected from insects, rodents and fungus.

Seed Distribution

Ideally, when distributing the seeds those who receive them should also get the following information:

- geographic location of the tree stand where they were collected
- geographic location of the original seeds that were used to establish the stand
- environmental conditions of the seed stand
- size and age of the stand
- date the seeds were collected

[9] Moisture content of orthodox seeds can be determined by the ***salt test***. Fill a quarter of a ***clean and dry*** glass jar with salt and a sample of seed, close the jar tightly and shake. If damp salt sticks to the side of the jar, the seed is too moist for storage, if the jar is dry and no salt sticks to its sides, it is ready for storage.

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