OPERATIONAL GUIDELINES FOR HANDLING SEEDLINGS

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Abstract.-- Realizing that seedling mortality is not caused by any one phase of the reforestation process, the North Carolina Division of Forest Resources has developed seedling handling standards for lifting, delivery and storage, and field planting.

Like most of you, we have experienced varying degrees of seedling survival problems over the last few years. The high cost of site preparation and the increased use of improved seedlings make poor survival much harder to take and also harder to explain to the boss and/or landowner.

We feel that poor practices in the nursery will reduce survival to some degree. If improper practices continue through storage, transport and planting, the cumulative effect will mostly likely end in a planting failure.

We have developed standards for seedling processing in three general categories: (1) Nursery Lifting and Processing Standards, (2) District/County Delivery and Storage Standards, and (3) Field Handling and Planting Standards.

These three stages of the reforestation process are divided into three classes of days: (1) Normal Conditions, (2) Critical Conditions, and (3) Severe Conditions.

As you might expect, any one of these requirements could be below par, but excellent conditions in the other requirements could compensate and allow a Normal Condition to exist. Just as in setting fire readiness plans, some experience and judgement is required. I will go through the highlights of these standards.

NURSERY LIFTING AND PROCESSING STANDARDS

NORMAL CONDITIONS

Temperature:	35°F to 75°F
Relative Humidity:	50% +
Wind:	Less than 10 miles/hour
Soil Moisture:	75% to field capacity (100%)

Lifting

1. Use of all types of seedling lifters permissible.
2. Roots of seedlings on lifter conveyor will be exposed maximum of three minutes.
3. Full, tightly packed boxes will be removed from the field and placed in the packing shed within 20 minutes. Partially filled boxes where roots are exposed will be covered with moist burlap, etc. to prevent drying out.

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Packing

1. Boxes of seedlings on conveyors in packing room will be protected from heat and direct sunlight.
2. Seedling roots will be exposed a maximum of two minutes from time removed from box to weighing for packing.
3. Standard amount of moisture retention material will be added to bag.
4. Packed bags will be protected from heat and direct sunlight until placed in storage.
5. Unrefrigerated bags may be loaded on non-refrigerated transports without pre-chilling when properly loaded (see transporting).
6. Full boxes of seedlings may be left on the packing room coveyors overnight if properly watered and temperature maintained from 35°F to 55°F.

Loading and Delivery

A. Non-refrigerated transports
   1. Must be covered to protect from direct sunlight.
   2. Bags not stacked over three deep per layer.
   3. Spacers used to provide air circulation between layers.
   4. At least 12" of air space between top of bags and cover.
   5. Vehicle must not be parked in direct sunlight. In case of emergency, stops should not exceed more than 45 minutes in direct sunlight. Advise supervisor if exposure exceeds this amount.
   6. Torn bags will be repaired immediately.
B. Refrigerated transports
   1. Pre-chilled seedlings (36 hours) may be transported for up to five hours without spacers for air circulation.
   2. Seedlings that have not been pre-chilled must be loaded as if the van were not refrigerated, i.e., with no more than three layers deep with spacers being used.

CRITICAL CONDITIONS

Temperature:	76°F to 85°F
Relative Humidity:	30% to 50%
Wind:	10 miles/hour +
Soil Moisture:	50% to 75%

Lifting

1. Use of Grayco harvesters given top priority (if other lifters must be used -- entire beds will not be undercut ahead of lifters).
2. Roots of seedlings on lifter conveyor will be exposed maximum of three minutes.
3. Full, tightly packed boxes will be removed from the field and placed in the packing building within 10 to 15 minutes. Partially filled boxes of seedlings will be covered immediately with moist burlap, etc. to prevent drying out.
   a. Lift fields close to facility, when possible.
   b. Use additional tractor(s) for delivery from field to packing building.
4. When soil moisture reaches less than 50%, fields will be irrigated prior to lifting.

Packing

1. Boxes of seedlings on conveyors in packing room will be protected from heat and direct sunlight, and boxes not processed within 30 minutes after arriving in packing building will be watered.
2. Seedling roots will be exposed a maximum of two minutes from time of removal from box to weighing for packing.
3. Roots of seedlings will be watered (or sprayed with other material) just prior to being packed.
4. Packed bags will be protected from heat and direct sunlight until placed in storage.
5. Without exception, seedlings will be chilled for 36 hours before loading.
6. All boxes of seedlings in the packing room will be processed daily and none left unfinished.

Loading and Delivery

A. Only pre-chilled seedlings will be loaded for transport.
B. Non-refrigerated transport
   1. Use only if absolutely necessary.
   2. Must be covered to protect from direct sunlight.
   3. Bags not stacked over two deep in layers.
   4. Spacers must be used to provide air circulation between layers.
   5. At least 12" of air space between top of bags and cover.
   6. Emergency stops only, advise supervisor if stops made.
   7. Early evening transportation should be utilized when possible.
   8. Torn bags will be repaired immediately.
C. Refrigerated transport
   Pre-chilled seedlings (36 hours) may be transported for up to five hours without spacers for air circulation if unloaded promptly upon arrival at destination.

SEVERE CONDITIONS

(Freezing Conditions)

Temperature: 32°F or less and/or frozen ground conditions
Relative Humidity:
Wind:

Lifting

All lifting operations will cease.

Packing

1. If seedlings have been stored properly in packing building, packing may be done.
2. Seedlings stored in boxes for packing will be protected by maintaining a temperature between 32°F and 55°F in the packing building and will be watered as needed to prevent drying out.

3. Seedling roots will be exposed a maximum of two minutes from the time removed from box to weighing for packing.
4. Packed bags will be protected from heat, direct sunlight, and/or freezing until placed in storage.
5. Unrefrigerated bags may be loaded without pre-chilling only on insulated or refrigerated vans using proper loading techniques. Do not ship on transports without adequate protection.

Loading and Delivery

A. Non-refrigerated transports

Transportation of seedlings on vehicles without proper protection from freezing is not allowed.

B. Refrigerated transport
   1. Pre-chilled seedlings (36 hours) may be transported for up to five hours without spacers for air circulation.
   2. Seedlings that have not been pre-chilled must be loaded as if the van were not refrigerated, i.e., with no more than three layers deep with spacers being used.

(Hot, Dry Conditions)

Temperature:	85°F +
Relative Humidity:	30% or less
Wind:	15 miles/hour +
Soil Moisture:	Less than 50%

Lifting

Usually will cease; however, Senior Staff Forester, Nursery and Tree Improvement, will be notified of conditions, and he will make final decision. If lifting is done:
1. Fields will be irrigated. Do not lift in sandy soil.
2. Only Grayco harvesters will be used.
   (Roots of seedlings on lifter conveyor will be sprayed).
3. Roots of seedlings on lifter conveyor will be exposed maximum of three minutes.
4. Full, tightly packed boxes will be removed from the field and placed in the packing building within ten minutes. Partially filled boxes of seedlings will be covered immediately with burlap, etc. to prevent drying out.
   a. Lift fields close to facility.
   b. Use additional tractors for delivery from fields to packing building.

Packing

1. Boxes of seedlings on conveyors in packing room will be protected from heat and direct sunlight, and boxes not processed within 30 minutes after arriving in packing building will be watered.
2. Seedling roots will be exposed a maximum of two minutes from time of removal from box to weighing for packing.

3. Roots of seedlings will be watered (or sprayed with other material) just prior to being packed.
4. Packed bags will be protected from heat and direct sunlight until placed in storage.
5. Bags will not be loaded on transports without pre-chilling (36 hours).
6. All boxes of seedlings in the packing room will be processed and not left overnight.

Loading and Delivery

A. Only pre-chilled seedlings will be loaded for transport.
B. Non-refrigerated transport
Seedlings will not be transported on units without refrigeration.
C. Refrigerated transport
Pre-chilled seedlings (36 hours) may be transported for up to five hours without spacers for air circulation if unloaded promptly upon arrival at destination.

DISTRICT/CONTRACTOR DELIVERY AND STORAGE STANDARDS

NORMAL DAY

Temperature: 35°F to 75°F
Relative Humidity: 50% +

Delivery

1. Vehicles used for transporting seedlings will have a cover to shade and protect seedlings.
2. Bags/bundles will not be stacked over three deep per layer unless spacers are used to provide air circulation between layers.
3. At least 12" of air space between top of bags/bundles and cover will be left to avoid heat build-up.
4. Vehicles will not be parked in direct sunlight. In case of emergency stops or breakdowns when stops exceed 45 minutes, seedlings should not be planted until their condition has been determined.

    a. Things that indicate seedling deterioration:

        (1) Sour smell -- fermentation
        (2) Yellow needles
        (3) Trees hot to the touch
        (4) Mold developing

        If any of these conditions exist, contact the District Staff Planting Coordinator prior to planting.

    b. Things that indicate dead seedlings:

        (1) Bark, especially on roots, slips off easily
        (2) Cambium layer has turned brown.

        (Do not plant if these conditions exist.)

5. Inspect and repair torn bags immediately.

Storage

1. Store seedlings in building, shed, etc. that will protect from freezing, heating, and direct sunlight.

   a. Ideal temperature 35° to 38°F. (These temperatures usually can be maintained only with refrigerated units.)

      (1) Bags stored under ideal conditions can be kept at least three months (usually longer.)
      (2) Bales with seedlings dipped in clay slurry will keep from eight to ten weeks.
      (3) Bales with seedlings packed in moss will keep from eight to ten weeks, but will require watering of bales at least two times per week.

   b. Termperatures inside storage area from 38° to 50°F.

      (1) Bags stored under these conditions can be kept up to three or four weeks.
      (2) Bales with seedlings dipped in clay slurry will keep two to three weeks.
      (3) Bales with seedlings packed in moss will keep two to three weeks, but will require watering at least two times per week.

   c. Temperatures inside storage area above 50° not exceeding 75°F -- seedlings should be removed within three to five days.

2. Bags/bundles should be stacked on pallets or slats and should not be stacked over two deep without spacers to allow air circulation between layers.

CRITICAL DAY

Temperature: 76°F to 85°F
Relative Humidity: 30% to 50%

Delivery

1. Field delivery in non-refrigerated vehicles should be held to a minimum. Seedling delivery from a non-refrigerated storage point to destination should not exceed one hour's time.
2. Vehicles used for transporting seedlings will have a cover to shade and protect seedlings.
3. Bags/bundles will not be stacked over two deep per layer unless spacers are used to provide air circulation between layers.
4. At least 12" of air space between top of bags/bundles and cover will be left to avoid heat build-up.
5. Vehicle will not be parked in direct sunlight. In case of emergency stops or breakdowns, seedlings should not be planted until their condition has been determined.

a. Things that indicate seedling deterioration:

(1) Sour smell -- fermentation
(2) Yellow needles
(3) Trees hot to the touch
(4) Mold developing

If any of these conditions exist, contact the District Staff Planting Coordinator prior to planting.

b. Things that indicate dead seedlings:

(1) Bark, especially on roots, slips off easily.
(2) Cambium layer has turned down.

Do not plant if these conditions exist.

6. Inspect and repair torn bags immediately.

Storage

1. Store seedlings in building, shed, etc. that will protect from freezing and heating. If temperatures inside storage area is above 75°F, do not store seedlings more than 24 hours.
2. Bags/bundles should be stacked on pallets or slats and should not be stacked over two deep without spacers to allow air circulation.

SEVERE DAY

Temperature: 85°F + or 32°F or less
Relative Humidity: 30% or less

Delivery

1. Field delivery in non-refrigerated units should not be made when the temperature is 85°F or higher.
2. Field delivery in non-insulated units when the temperature is 32°F or less will be made only if the vehicle is covered adequately to prevent freezing.
   a. Caution -- seedlings can heat excessively on a cold day if vehicle is parked in the sun and seedlings are dead packed, preventing air circulation.
   b. Unload seedlings immediately upon arriving at destination.
3. Inspect and repair torn bags immediately.

Storage

1. Seedlings should not be stored in bags/bundles for more than a few hours at temperatures above 85°F.
   -- Lethal temperatures occur in bags/bundles at 118°F, but seedlings can be weakened or damaged if the temperature in the bag/bundle remains at 85°F for very long.

2. Do not store seedlings in an area where the temperature is 32°F or less.
   a. Do not allow seedlings to freeze.
   b. If trees have not been frozen more than 36 hours:
      (1) Thaw seedlings slowly
      (2) Determine condition
   c. If frozen more than 36 hours, then seedlings most likely have been severely damaged and should not be planted.

FIELD HANDLING AND PLANTING STANDARDS

NORMAL CONDITIONS

Temperature:	35°-75°F
Relative Humidity:	50% +
Wind:	Less than 10 miles/hour
Soil Moisture:	0-30 build-up

On-Site Storage of Seedlings

1. Bags/bundles should not have prolonged exposure to direct sunlight. Store the seedlings in a shaded location at all times.
2. If no shade is available at planting site, improvise a portable shelter such as a lean-to made of opaque plastic, canvas, or plywood.
3. Bags/bundles should not be stacked in layers more than two deep without spacers. Spacers allow air to circulate freely around the seedlings and keep them cool. (Heat builds up even at low storage temperatures when the seedlings are stored in direct sunlight or without air circulation--especially in sealed bags).
4. Keep close check on seedlings stored at the planting site and water uncoated roots of seedlings in bags or bundles if roots begin to dry. Be careful not to puddle water in bags as excess water can drown root tips or promote mold on the seedlings.
5. Do not water coated roots of seedlings since the water will remove the coating. Since the coating of roots will not give absolute protection against moisture loss, restrict the exposure of the roots the same as if they were uncoated.
6. Inspect and repair torn bags immediately.
7. Keep opened bags closed tightly by folding flap over bag and laying flat-side down or by placing a band or cord firmly around bag. Keep in shade.
8. Keep opened bundles covered at all times with wet burlap. Keep in shade.
9. If opened bags of seedlings, coated or uncoated, must be kept for over two days before planting, seedling roots must be dipped in water and bag tightly closed, or heel seedlings in.
10. If opened bundles of seedlings are not used shortly after opening, they should be heeled in.
11. Store trays of containerized seedlings in shade and keep root plugs wet until seedlings are planted. During storage, open book-type containers and check moisture of root plugs.

Culling Non-Plantable Seedlings

1. Open only one bag/bundle at a time. Be careful not to leave open more than a few minutes.
2. Remove only a small number (handful) of seedlings at a time. Do not allow the roots to be exposed to the sun or wind any longer than five minutes.
3. Cull 1-0 loblolly or 2-0 white pine seedlings that have:
   a. Broken, skinned or weak stem
   b. Fermented smell
   c. Mold on needles
   d. Slippery bark
   e. Root collar smaller than 1/8 inch
   f. Root collar larger than 3/8 inch (large seedlings must be balanced; have a balanced root-to-top ratio)
   g. Root systems less than four to five inches long
   h. Root systems longer than 12 inches if more than 50% of the laterals must be pruned in order to plant
4. Cull 1-0 longleaf seedlings if root collars are smaller than 1/4 inch or tap roots shorter than seven inches.
5. Cull containerized pine seedlings that are very small and poorly developed. Also, cull seedlings if root plug has become dry and hard.
6. Cull hardwood seedlings having root collars smaller than 1/4 inch. Also, cull broken or skinned seedlings and seedlings with stems that have not hardened off.
7. Roots must be kept visibly moist at all times. If not visibly moist, dip roots in water. If being placed back in bag, shake excess water from roots prior to placing in bag to prevent puddling. (Do not dip coated seedlings). Close bags properly.
8. For best results, assign one trained person to be responsible for culling seedlings. Closely supervise and check on culling procedures. Be sure person(s) properly trained.

Root Pruning Seedlings

1. Assign only properly trained persons to be responsible for root pruning. For best results, assign only one well-trained person to root prune. Closely supervise and check on root pruning.
2. Remove only a small number (handful) of seedlings at a time. Do not allow the roots to be exposed to the sun or wind any longer than five minutes. Root prune seedlings at same time as being culled, if feasible.
3. Roots must be kept visibly moist at all times. If not visibly moist, dip roots in water. If being placed back in bag, shake excess water from roots prior to placing in bag to prevent puddling. (Do not dip coated seedlings). Close bags properly.
4. Do not root prune unless necessary to plant seedlings at proper depth and to avoid J-rooting. Planting tongs must be used to plant long roots that are not pruned.
5. If pruning is necessary, do not remove more than 50% of lateral roots. (Will reduce survival and growth).
6. Prune roots to uniform lengths. This can be done by aligning root collars in bunches before pruning roots.

7. Use a sharp knife, machete, axe, or hatchet for root pruning. Never break or twist roots off by hand.
8. Do not prune roots of small loblolly and white pine seedlings (5-8 inch tops) shorter than five inches in length.
9. Do not prune roots of larger loblolly and white pine seedlings (8-12 inch tops) shorter than seven inches in length.
10. Prune longleaf tap or lateral roots only if absolutely necessary. Limit pruning to excessively long roots. Clip longleaf needles back to 4 to 5 inches, if feasible.

Tree Planting Operations

1. Train all new personnel prior to allowing them to plant. Give refresher training to experienced planters at start of seasons (and later if poor techniques are observed). Do not assume labor is trained or skilled.
2. While hand planting, carry seedlings in a canvas bag, bucket, etc. to protect the roots. Bags should contain wet hydro-mulch, wet sawdust, etc. Be sure roots are visibly moist before placing in container. If not, dip roots of uncoated seedlings in water. (Do not carry seedlings in hand with roots exposed).
3. If machine planting, be sure roots are visibly moist before placing in seedling box on planter. If not, dip roots of uncoated seedlings in water. Cover roots in seedling box with wet burlap to protect from exposure.
4. When handling, carefully separate seedlings to reduce damage or breaking lateral roots. (Damage to laterals will reduce survival).
5. When hand planting, make a fairly straight hole 8 to 10 inches deep. Do not use dibbles or other tools that will not make a hole or slit at least eight inches in depth.
6. Remove only one seedling at a time from container.
7. Insert root system to bottom of hole and lift seedling to proper planting depth. Be sure not to bend, ball, or leave roots outside hole.
8. Adjust planting depth according to drainage or soil type:
   a. On well-drained sites (sandy loams and sandy soils) plant root collars two to three inches below ground line, except for longleaf. Plant the longleaf collars at ground level when hand planting. Machine plant by lightly covering bud to allow for soil washing away.
   b. On poorly-drained sites (silt and clay soils) plant root collars one inch below ground line.
   c. Plant containerized seedlings deep enough to allow tops of plugs to be covered with soil (prevents drying by wicking effect).
   d. Warning -- seedlings should not be planted in excessively wet, sticky soils or in standing water. Allow the site to dry before planting.
9. Close hole properly. (If soil not tightly compressed around roots, moisture cannot be taken up by the seedling). Make sure hole firmly closed at bottom.
10. Periodically check machine planting to insure proper seedling depth and proper packing by the machine.
11. Space seedlings at approximate spacing prescribed for tract. Avoid planting seedlings in areas of loose soil that cannot be compressed around roots or closer than 2 to 3 feet of hardwood stumps and sprouts.
12. Plant seedlings just as near the edge of windrows as possible.
13. Closely supervise and maintain quality control of all planting.

CRITICAL CONDITIONS

Temperature:	76°F - 85°F
Relative Humidity:	30% - 50%
Wind:	10 miles/hour +
Soil Moisture:	30 - 80 build-up

On-Site Storage of Seedlings

1. Bags/bundles should have minimum exposure to direct sunlight.
2. Otherwise, very closely follow same standards for Normal Conditions.

Culling Non-Plantable Seedlings

1. Make a special effort to keep roots of seedlings exposed to sun and wind for no longer than three minutes.
2. Otherwise, very closely follow same standards for Normal Conditions.

Root Pruning Seedlings

1. Make a special effort to keep roots of seedlings exposed to sun and wind for no longer than three minutes.
2. Roots must be kept visibly moist at all times. Prior to placing back in bag or planting containers, dip uncoated roots in one of the following:
   a. Super water gel (one ounce of Terra Sorb gel/gallon water).
   b. Clay slurry (five pounds Kaolin Clay/gallon water).
   c. Plain water (shake excess from roots before placing in bag).
3. Otherwise, very closely follow same standards for Normal Conditions.

Tree Planting Operation

1. If seedling roots have not been coated with gel or clay as described above, they must be carried in water. Also, tops of seedlings should be wet (reduces transpiration).
2. Otherwise, very closely follow same instructions for Normal Conditions.

SEVERE CONDITIONS

Temperature:	32°F or less; ground frozen* or 85°F +
Relative Humidity:	30% or less
Wind:	15 miles/hour +
Soil Moisture:	80+ build-up

*NOTE: If weather forecast indicates cold temperatures that will freeze ground for several days immediately after planting; do not plant.

On-Site Storage of Seedlings

1. Seedlings will not be stored at planting site under these conditions. Bags/bundles should be stored in buildings, sheds, etc. that will protect from freezing and/or heating.

2. Refer to Storage Standards as given under DISTRICT/CONTRACTOR DELIVERY AND STORAGE STANDARDS, Severe Conditions.

Culling Non-Plantable Seedlings

1. Culling will not take place at planting site.
2. Culling is permissable in a building, shed, or other protected area.
3. When culling in such an area, follow very closely the same standards for Normal Conditions.

Root Pruning Seedlings

1. Pruning will not take place at planting site.
2. Pruning is permissible in a building, shed, or other protected area.
3. When pruning in such an area, follow very closely the same standards for Normal Conditions.

Tree Planting Operation

All planting should STOP, unless localized site exceptions exist.

Localized Site Exceptions

If a localized site exception to the severe soil or weather conditions does exist, planting may continue. Follow the standards for Critical Conditions.

SUMMARY

We realize this system will not solve all problems with survival, but we believe it is a start in the right direction.

Pressures from tree planters and from within our own organization will probably prevent strict adherence to the guidelines, but if we can reduce plantation failures by 50%, we will have made the effort worthwhile.