Planting Guide for Hybrid Poplar (Populus simonii) in Kulun Qi, Inner Mongolia

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Abstract

The Shanghai Roots & Shoots office of the Jane Goodall Institute is undertaking to plant 1 million seedlings near the city of Kulun in Inner Mongolia. A primary need of this effort is a planting guide specifically aimed at the harsh conditions faced by local farmers in trying to afforest large portions of the local desert. This paper outlines the key practices to be followed to attain successful afforestation in the area.

内蒙古库伦旗杂交杨树种植指导手册

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摘要

作为中国唯一一家获准注册的涉外环保公益机构，上海根与芽青少年活动中心在内蒙古库伦旗地区开展了大规模的植树造林活动以改善当地的生态环境。上海根与芽的目标是在该地区种植一百万棵树！由于库伦旗沙化地区的地理气候条件特殊，确保树苗栽种的成活率是整个项目成功的关键。本手册的目的即帮助库伦当地的农民更好地了解如何采用正确的方法植树造林，从而达到最好的生态效果。

Introduction

Populus simonii is the species of choice for planting the sandy lands in the Kulun Qi area of Inner Mongolia (Lu 2001). Much has been published on the agricultural development problems and successes in the County of Kulun, or Kulun Qi, which is part of the Tongliao Prefecture (Brogaard and Li 2005) (figure 1). There is no doubt whatsoever that the planting of *Populus simonii* in the broad expanse of desert (figure 2) will benefit the local farmers with land stabilization. Many other species can be planted in the area, as well (Forest Society of Tongliao City 2003).

The necessity for planting in Inner Mongolia is well understood (Katoh and others 1998; FAO 2000; Zhao and others 2006). Historically, the area was mostly grass, forbs, shrubs, and trees, but decades of overgrazing have reduced the vegetation to xeric plants that dot the landscape. The spread of agriculture led to the destruction of the fragile soil, which in turn led to wind erosion. Unable to keep up with the shifting sand, the owners abandoned much of the land.

The environment in the area of Kulun Qi is marked by very cold, harsh winters in which the temperatures dip below 0 °C (32 °F). The winds create an even more negative wind chill factor. The snows are heavy. The soils are primarily sand, especially in those abandoned areas where tree planting is most needed.

The challenges faced in afforesting such an area are many (Carle and Ma 2005). As harsh as winter is, spring comes

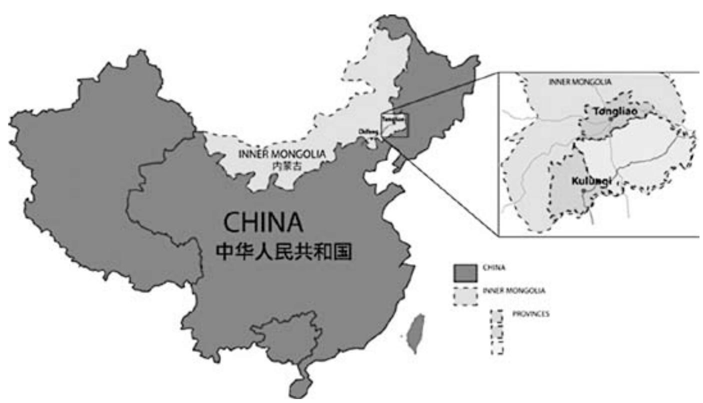

Figure 1. Map showing the general location of Kulun Qi or Kulun County in Inner Mongolia.

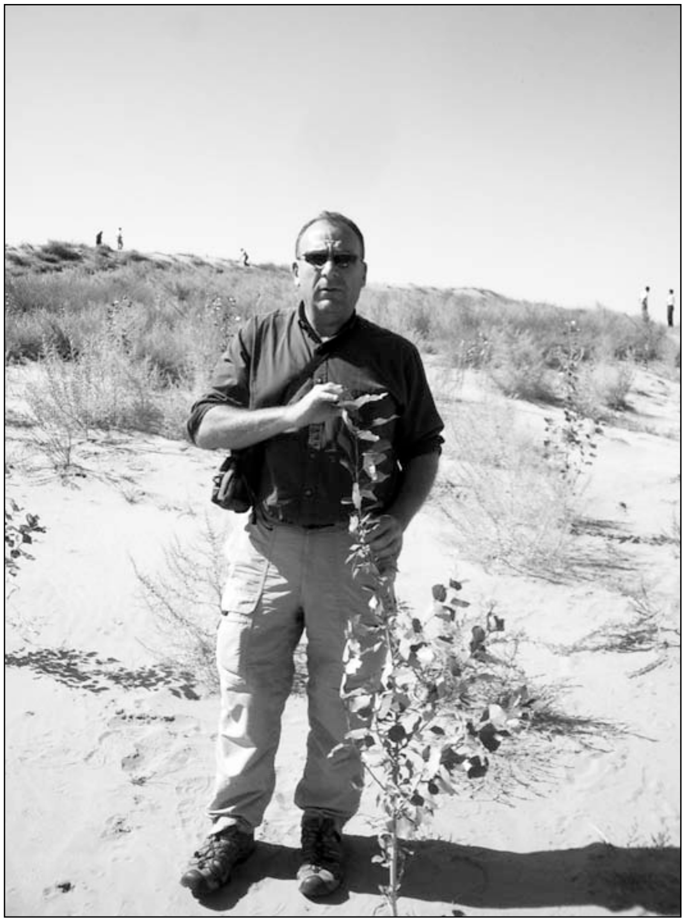

Figure 2. Joe Tatelbaum (left) and Tori Zwisler, volunteers of the Jane Goodall Institute–Shanghai, Roots & Shoots Program, with successful plantings of cottonwood in Kulun Qi in April 2007.

quickly. The snow melts rapidly and for a time replenishes some of the subsurface ground water. This is the water that the cottonwood plantings can make the most use of in order to establish good root-soil contact. As the summer progresses, evaporation increases and root access to soil water moves deeper. The prime reason for the very deep planting of cottonwood cuttings [up to 1 m (3.3 ft) deep] is because of the need to access moist soil as the summer temperatures rise into the 42 °C (107 °F) range and higher.

The purpose of this paper is to specify recommendations and procedures for the successful planting of cottonwood (*Populus* spp.) in the Kulun Qi area of Inner Mongolia. The Shanghai Roots & Shoots Office of the Jane Goodall Institute has undertaken to plant 1 million trees near the City of Kulun to support local agroforestry operations, as well as to fix carbon to combat global climate change. Cottonwood is often planted in riparian areas in more temperate climates, but this area is extraordinarily harsh in both winter and summer. Site-appropriate procedures, from the timing of lifting in the nursery all the way through to handling at planting, are key to attaining successful afforestation, which could be defined as greater than 90 percent survival at the end of the first growing season.

Methods for Successful Afforestation

Production and assessment of planting material. Cottonwood seedlings are grown from cuttings. These are derived from stool beds: sections of stem material, cut into lengths of 30–40 cm (12–16 in), are planted into bareroot beds and grown for 1 yr, usually to a height of 1.5 m (4.9 ft) or more. In order to obtain 1-yr cuttings for field planting, these seedlings are cut at ground line in spring, bundled, stored moist, and shipped to the field for planting as “whips” or long stems without roots. The rootstock left in the nursery bed is then allowed to produce a new shoot and grow another year, yielding 2-yr-old seedlings. The whole plant (root and stem) then is dug up in spring, bundled, kept moist, and shipped to the field.

There are permutations of this process, such as lifting cuttings in the fall of the first year and either storing the cuttings in a refrigerated cooler or storing the cuttings horizontally under several feet of soil in the ground. If stored in the ground, the cuttings are dug up in the spring, kept moist, and then shipped to the field. The same can be done for 2-yr-old seedlings.

The type of seedling used in planting operations is not critical. Cuttings without roots can do just as well as those with roots. Keeping the seedling tissues hydrated (moist) all the way to the planting hole will give the highest incidence of root development and planting success, as measured by high survival and growth.

At the time of planting in the field, the minimum morphological dimensions should be ≥1 m (3.3 ft) in height and ≥5 mm (0.2 in) in diameter at the base of the cutting. The diameter of a cutting with roots is measured at ground line. The seedlings should be devoid of defects, such as cambium scars; the buds should be large; and no part of the plant should show cold damage.

Seedlings with roots should be checked for stripped roots, in which the outer sheath over the xylem has been stripped away. Stripped roots look white or may appear rotted, depending on how the seedlings were handled. Some stripping is to be expected, but some care should be taken during lifting to minimize this problem.

Also make sure that the seedlings have healthy axillary buds at lifting and planting (Radwan and others 1987). It is wise to take a razor blade or sharp knife and cut some buds vertically to see if the buds have suffered cold damage, which will appear black or brown. A cold-damaged bud will not grow. The same thing can be done to check for browning in the cambium. Brown cambial tissue is dead. Such physiological damage will greatly retard active growth after planting and may even mean rapid mortality. In some severe cases, the seedlings are not worth planting because they are already dead. Green cambial tissue is live tissue and a key target characteristic (Rose and others 1990).

Planning and preparation. Success in afforestation depends a great deal on good planning, good organization, and availability of the proper equipment. It is important to preassign the lands to be planted, make arrangements for local planters to be available, and determine how many seedlings (cuttings) will be needed to plant the area.

Great consideration needs to be given to how long it will take to get the seedlings to the site from the nursery, how the seedlings will be cared for before and during planting, and whether water will be available. Given that the Kulun Qi area is desert with deep sands, it is especially critical that the seedlings be kept moist at all times up to being placed in a moist planting trench or hole and that the seedlings be planted within no more than an hour of trench or planting hole preparation. The sandy soils dry out so quickly that moisture will be lost to the newly planted seedlings if the seedlings are not planted and trenches or holes filled in quickly. It is not good practice to get all of the seedlings into position for planting and then realize that the bulldozer-trencher or planting crew will not be available for another 5 d.

Even daily local weather conditions must be taken into account. One long-standing rule of thumb is that weather conditions that the planters find ideal likely are not very good for the seedlings. Arrangements need to be made in advance should seedlings need to be stored locally for planting, even for several days, until weather conditions improve.

Site selection and planting layout. Where seedlings are planted on the landscape has a lot to do with planting success. In the Kulun area, the land appears flat for hundreds of kilometers, yet, in terms of microtopography, the ground is highly variable. To attempt to plant every square meter is very unwise.

In terms of strategies for planting dunes, much depends on preplanning and understanding the variable shapes of dunes and their accessibility to heavy equipment. Careful consideration must be given to planting between dunes, where the ground is flatter and it is easier to get the trenching equipment deep enough to reach moist soil. It is necessary to get the cuttings down to a 1-m depth, and it can be very difficult for a trencher pulled behind a bulldozer to get down deep enough along the slope or top of a dune. Dunes may also require cover species other than cottonwood in order to be stabilized, due to the exposure to winds, shifting sand, and greater depth to moist soil.

All sites chosen for planting should be carefully laid out before beginning operations. It is important to know the size of the area to be planted, the number of seedlings (plus 5 percent) that will be required to cover the entire area, and the spacing and layout to be used. Consideration needs to be given as to how many seedlings will be planted in a row, how many rows will be planted, and how far apart the rows will be.

The layout should take into account the changing sand depth across the site and the presence of dunes. The sand is likely to be deeper on the rising shoulders of a dune, which can lead to planting failure if the planting holes are not deep enough to get the roots into moist soil. The idea is to get the flatter areas and lower spots between dunes successfully growing trees and come back later to plant the dunes with more drought-hardy species.

For a plantation planting, the seedlings are commonly planted 1.5–3 m (1.6–3.3 yd) apart in the row and the rows are placed 2–3 m (2.2–3.3 yd) apart. Usually dense spacings are used if the local people intend to harvest some of the saplings for stakes in the next couple of years, taking every other sapling in a row. In agroforestry plantings, it is common to plant the seedlings 1.5 m (1.6 yd) apart in the rows and space the rows 4 m (4.4 yd) apart. The area between the rows is used for crops such as beans and corn.

Site preparation. The common way to plant cottonwood in dune areas is to use a bulldozer with an attached trencher. The trencher plow digs a trench that is 30–40 cm (11.8–15.7 in) wide and around 50 cm (19.7 in) deep. It serves no purpose to dig the trenches the day before planting, because the sandy soil will dry out. Depending on the distance between trenches (furrows), this depth usually moves enough sand from the surface to reach moist soil. At 50 cm (19.7 in), the planters can dig another 50 cm (19.7 in) deeper, if necessary, to get the seedlings into moist soil and fill in the hole with moist soil.

Moving the seedlings from nursery to field site. One of the most critical aspects of any planting operation is transporting the seedlings to the site. This is so critical because the best success in desert regions such as Kulun is usually obtained through a technique called "hot planting." This technique requires that the seedlings be lifted in the nursery within 24–36 h of field planting. The seedlings are often lifted the day before planting, stored at the nursery or carried to the site for storage, and planted the next day. The purpose is to sustain physiological quality by reducing any stresses on the seedling between the nursery and the field environment. Coordination between the nursery manager and the field-planting supervisor is necessary to ensure the timely delivery of seedlings in good physiological condition to the planting site.

Minimizing seedling stress during transport and planting. The seedlings are at the greatest risk of physiological and morphological damage once they leave the nursery because of several factors.

(1) Seedlings that are not kept moist will desiccate, which will lead to moisture stress after planting.

(2) Seedlings that are poorly bundled and roughly treated will end up with scraped cambiums, which creates wounds that can be vector points for disease, insects, and stem weakening.

(3) If the travel time to the field planting site is long and the seedlings are not properly protected, afforestation may be less successful because the seedlings have become physiologically ill equipped to survive.

(4) In too many planting operations worldwide, one of the greatest hazards to successful afforestation has been the mishandling of seedlings just before planting. Perfectly good seedlings are left out on the ground, only to dry out while awaiting the digging of a hole.

Soaking the seedlings is very important to rooting success (Randall and Krinard 1977; Krinard and Randall 1979; Derochers and Thomas 2003). It is good practice to soak the seedlings for 24 h in water before planting. This can be done in the nursery, either by keeping the seedlings in moist soil, out of the wind, before lifting or by wrapping the seedlings in moist burlap.

Seedlings should always be kept moist during transport from the nursery to the planting hole. Keep the seedlings covered in wet burlap or wet them before covering them with a tarp. They should never be left out on carts in the sun and wind. The planting supervisor should bring only the number of seedlings to the site that can be planted in one day or one morning. This is especially important for seedlings or cuttings with roots; root tissue is highly vulnerable to desiccation, much more so than stem (bark) tissue.

Planting. *Weather and planting conditions*. The planting season is important to cottonwood success in this desert region. Usually spring planting in April works best because the belowground soil has been charged by winter snow. It is important that the planting not take place when snow might get into the planting hole to create air pockets after melting. Although it is impossible to predict the optimal window of opportunity for planting, it is good to get started with planting as soon as the soil has warmed to above 10 °C (50 °F) and has moisture.

One factor that is so often overlooked in planting is the time of day and the weather conditions throughout the time of day. Early morning, just after sunup, commonly is the best time to plant. The best conditions are when it is cloudy and cool. Winds should be 0 to <10 km h^{-1} (6.2 mph) if possible. As the morning progresses and the sand warms up, the sand likely will get hotter and windier conditions will prevail. Under such conditions, it is good to carry the seedlings around in buckets of water to keep them hydrated. This will lower the stress on the seedlings. It is wise to stop planting when conditions get too hot or windy. It serves no purpose to plant seedlings under dry windy conditions; this will only yield many dead trees within a matter of months.

One of the best indicators of poor planting conditions is if the soil in the trenches starts to dry rapidly within 15 min or less after the trench is dug. Under ideal conditions, there will more be than enough planters being supplied with seedlings to keep up with the bulldozer-trencher. The supervisor of the planting operation should slow down or stop the bulldozer-trencher so that the seedlings are always being planted into moist soil.

Planting procedures. Seedlings with roots should be planted into deep holes and then covered with moist soil. The sandy soil should be compressed lightly with the toe to remove air pockets. Compacting the soil is not a good practice. Given the nature of these areas with dunes everywhere, the wind will fill in the trench within weeks. It is good to get the base of the root system down as deep as possible, which is about 1 m (1.1 yd) from the soil surface. It is common to have 50 cm (19.7 in) of stem sticking out of the ground. In some cases, it is fine to get cuttings with no roots 70 cm (27.6 in) down into the ground, with 10 cm (3.9 in) above the sand. Key to success is ensuring that there are no air pockets around the stem and there is good soil-stem contact.

The critical secret to success in this planting technique is planting the seedlings into moist soil and covering the hole with moist soil. The deeper the cutting goes into moist soil, the higher the odds of success a year later. Root access to water is critical. Given the harsh conditions of this kind of desert, it is easy to see why presoaking seedlings helps to keep them hydrated long enough to produce new roots and access soil moisture.

There have been cases where, due to mishandling, the top of the seedlings died back because the top of the seedling could not get enough water but, due to deep planting and access to soil moisture, the living root system was able to regenerate a top. Although a year of growth was lost, the seedlings lived and continued to grow. The timing of planting in relation to trench making, the level of soil moisture, and the hydration of the seedling all interact to determine the degree of success.

Monumenting and monitoring. Monumenting is the placing of permanent plot markers at the corners of planting areas in order to identify planting location. Monumenting allows accurate relocation of the plots in the future. Typical markers are PVC, copper-treated wooden posts, or cement or metal posts. The markers are often buried 60 cm (23.6 in) deep and stick up ~90 to 120 cm (1–1.3 yd) out of the ground. A thick aluminum metal tag with identifying information is attached to the post.

Although often overlooked as unimportant, the use of permanent plot markers is critical to tracking and determining long-term success. A map and logbook must be kept noting the location of the plot boundaries, along with information on species, type of stock planted, site and weather conditions at planting, and the date of planting. It is also wise to determine the Global Positioning System locations of the permanent plot markers.

Monitoring the plots is important to determining the survival and the growth rates of the seedlings. In order to track seedling growth, each seedling must be given a specific location number that identifies the planting location and the tree number. For large plantings, it is best to break the area up into 100- to 400-tree blocks. The area planted would have an area number or name with numerous blocks. A decision can be made to put metal tags on each tree or to tag only tree 1 and every 10^{th} tree, such as 1, 10, 20, and so forth.

Within 30 d of planting, every tree should be measured for ground line diameter to the nearest millimeter (0.04 in). Height to the nearest centimeter (0.4 in) should be measured from ground line to the terminal bud. If the tree is drooping because of wind or the like, the height should be measured to the highest point above ground line. Groundline diameter and height of each tree should be remeasured in the fall at the end of the first growing season and again each fall for the next 5 yr.

Survival can be determined by counting the missing or dead trees. At the time of each measurement it is common to record other information, such as seedling damage due to insects, disease, or farm animals. If the seedling shows leaf chlorosis (yellowing), that should be recorded. Did the seedling suffer top dieback and then resprout? Is the seedling multiple topped? Is there more than one shoot coming out of the ground? In most cases, those measuring the seedlings will put specific comments next to each seedling's data entry so that its progress can be tracked over multiple years. It is good to make up data sheets with various typical options than can be marked with a 0 or a 1 to denote condition.

After the data have been collected, they must be analyzed to determine planting success and to help modify less successful practices.

Conclusions

Long-term success is possible and has been demonstrated in the Kulun Qi area. What is required is a long-term, sustained effort to implement successful planting practices that coordinate the growing and lifting of seedlings in the nursery with outplanting in the field. The unique harsh conditions create special challenges unlike anywhere else on earth. Great attention to detail must be considered in every procedure and practice.

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