TACF Ecology & Restoration Workshop

June 17, 2011

Ohio University, Athens, Ohio

- Executive Summary -

Compiled by B. C. McCarthy

This meeting was convened as part of a larger TACF process designed to re-evaluate and revise the Restoration Plan. The workshops involved four major constituencies: Membership, Development/Business, Breeding/Genetics, and Ecology/Restoration. The Ecology and Restoration Workshop was explicitly charged with reviewing the science surrounding the ecology and silviculture of American chestnut, and evaluating how we can best leverage that information to move forward with the larger goal of restoring the species to its original range.

Overall, there was a broad level of consensus regarding many aspects of the ecology and silviculture of the species; however, there were also some knowledge gaps identified where explicit information was still missing (but good guesses could be made based on first principles and knowledge of related species).

Oddly, there is still some minor disagreement (due to conflicting data) about the optimal microsite conditions on which to regenerate chestnut. This is an important issue that needs to be resolved clearly so that we can better identify optimal sites for restoration. There are likely some confounding effects among soil texture, aspect, slope position, pH, and drainage that have led to the current lack of clarity on this issue. Observational studies are difficult because present day sprout populations may reside on either optimal or sub-optimal sites, depending upon *a priori* assumptions. Once the regeneration niche becomes more clearly defined, we need to develop a system, perhaps utilizing ecoinformatics, that examines the landscape to prioritize planting sites based on GIS, DEMs, soil, climate, etc. One possible product could be a simple decision tree for field screening. We also need some quick and easy on-site assays for *Phytophthora* to rule sites in or out for restoration (i.e., develop a hierarchy of criteria at different scales for site screening = ecological site classification system). A site bioassay with 5-10 seedlings planted 2-3 years prior to full-scale planting might also be useful to consider.

There was general agreement that we should rely on regional germplasm for early restoration efforts until we have better controlled studies that examine ecotypic differentiation and patterns of local adaptation. Breeding efforts will likely need to expand in scope beyond just resistance to *Cryphonectria parasitica*, because of the many ecological challenges that seedlings must face under field conditions (e.g., *Phytophthora cinnamomi*, mixed light environments, drought, herbivore pressure, etc.). Due to concerns over genetic diversity, ecological plasticity, and evolutionary stability in a changing environment, most agreed that more native American chestnut germplasm should be infused just prior to large-scale restoration.

In addition to prioritization of site characteristics, we need to evaluate broader areas of risk and associated knowledge gaps to plan for future shifts in climate, insects, pathogens, herbivores, invasive plant species, land-use, etc. As has been shown with many other hardwoods, the greatest risks are at the earliest stages of regeneration (e.g., seed predation and seedling establishment), but there is also ample data to suggest that there is a strong bottleneck (as found in the oaks) at the sapling stage that prevents individuals from advancing to the canopy. We need to embrace the idea of "adaptive management" (essentially learn as we go and refine techniques on the fly) when data are missing. There was general consensus that we know how to plant chestnut—getting it up in to the forest canopy is another story.

There remains some work to do in evaluating appropriate silvicultural strategies for chestnut restoration. Most were in agreement that many aspects of chestnut were reflected in the biology of oak. A program like SILVA-oak could be adapted to chestnut management. Chestnut does respond well to increases in light availability and decreased competition in the understory. Shelterwood or clearcut prescriptions may be best for chestnut, perhaps in combination with prescribed fire; however, the fire tolerance of chestnut at different stages of its life-history are not well understood. Decreased use of forest management, especially even-aged management, in the landscape may hinder restoration efforts. Education will be an important tool linking our proposed efforts with forestry, wildlife, and water & soil management objectives.

Clearly, TACF is at a crossroads in terms of it mission, which must be expanded considerably. We need to shift from a breeding-centered focus to a much broader and holistic perspective that involves genetics, ecology, & restoration, with feedbacks built in throughout. We will be unable to accomplish our broad scale efforts alone. We need dedicated partners to assist. Perhaps start with small to mid-size plantings (perhaps one per state) to educate, engage, and inspire partners and move in to larger production thereafter. TACF also needs to carefully manage partner expectations as we move forward. All agreed that we must be cautious moving forward, especially as it relates to unanticipated or undesirable consequences that may have arisen during the breeding program. Consider a ramped approach to restoration. Saunders submitted an alternative restoration plan (attached) that reflects many of these sentiments and argues for a more measured approach.

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Undigested notes taken by:
Bartig, Burhans, Gilland, McCarthy, Saunders, Steiner, & Swihart

Attendees:

Brian McCarthy, Professor, Ohio University (workshop chair and facilitator)

Jarel Bartig, Forest Ecologist, USDA-FS, Nelsonville, OH (co-facilitator)

Chris Zellers, Grad, Purdue University, West Lafayette, IN

Aaron Stottlemyer, Professor, Penn State Univ—Du Bois, DuBois, PA

Dawn McCarthy, Asst. District Ranger, WNF, USDA-FS, Nelsonville, OH

Carolyn Keiffer, Professor, Miami University—Middletown, Middletown, OH

Kim Steiner, Professor, Penn State Univ, State College, PA (TACF Sci. Cabinet Chair)

Sara Fitzsimmons, Penn State and TACF Regional Science Coordinator

Mike Saunders, Professor, Purdue University, West Lafayette, IN

Harmony Dalgleish, Post-doc, Purdue University, West Lafayette, IN

Bruce Spencer, Forester Ret., TACF Rhode Island Chapter

Mark Banker, Development Director, TACF, State College, PA

Nate Lichti, Grad, Purdue University, West Lafayette, IN

Norm Bourg, Plant Ecologist, Smithsonian Institution, Front Royal, VA

Rex Mann, Forester ret., USDA-FS, TACF Kentucky Chapter

Bryan Burhans, CEO, TACF, Asheville, NC

Rob Swihart, Professor, Purdue University, West Lafayette, IN

Rob Morrissey, Grad, Purdue University, West Lafayette, IN

Keith Gilland, Grad, Ohio University, Athens, OH

Greg Miller, Geneticist and Entrepreneur, Empire Chestnut Co., Carrollton, OH

Hugh Irwin, Forest Ecologist, Southern Appalachian Forest Coalition, Asheville, NC

Pre-Meeting Notes:

Invitations were made (via email) based primarily on experience and contacts of the convener (BCM), input from the CEO (BB) and others, along with members with a known long-time interest in TACF. The list of invitees was by design limited to ca. twenty individuals and was not meant to be exhaustive or exclusive. Undoubtedly, there were many other individuals who could have contributed useful elements to the discussion. Several invitees were unable to make the meeting due to scheduling conflicts. The goal was to create a brainstorming environment that would ultimately provide the discussion necessary to advance chestnut reintroduction efforts (the meeting was not designed as a traditional scientific conference). Ultimately, 28 invitations were made and 21 attended.

Prologue:

This meeting was held as part of a larger strategy initiated by CEO Bryan Burhans to re-evaluate the Restoration Plan in such a way as to ensure a bottom-approach. This comprehensive plan included four Regional Restoration Workshops (focusing on TACF membership), a Breeding/Genetics/Testing meeting (genetics & breeding professionals), a Reintroduction/Ecological meeting (ecology & forestry professionals), and a Development/Business meeting.

Prior to arrival, participants were asked to consider the following questions:

- What do we know about the ecology and silvics of chestnut to date?
- What information do we still need to proceed and insure success of reintroduction?
- What geographic areas should receive priority planting?
- What is the role of ownership (private/public lands) in the reintroduction process?
- What protocols should be used for site selection?
- Do we need to be concerned about ecotypic differentiation?
- How do we integrate with the geneticists to provide reciprocal feedback?
- How do we plan for a dynamic ecological background (invasive species, herbivores, climate)?
- How should reintroduction be tracked and monitored? What should be measured?
- What partners should assist with on-the-ground planting efforts? Funding?
- What mechanisms would be best to reach these partners & maintain communication?
- Can we identify partners to grow seedling stock for outplanting?
- How do we wish to establish feedback into future breeding efforts?

The notes provide here summarize the comments, discussion points, thoughts and issues considered during the Reintroduction/Ecology meeting. Currently, these notes are provided in an undigested format. A 1-2 page summary will be provided prior to the Fall TACF meeting.

Meeting Notes:

The following provides an undigested version of the notes submitted by participants at the end of the workshop. They are included here verbatim for archival purposes. Notes and comments provided reflect the differing styles and material that individual participants keyed in on, and no single set captures the exact nature of the conversation, but collectively provide a good basis from which to make decisions for the present and future. Summaries are provided in the order in which they were received by the organizer.

Brian McCarthy

Do we understand the fire tolerance of chestnut?

What is the role of soil in chestnut distribution and abundance? Is sand the over-riding variable? Some conflicting data…Rhoades found decreased survival with increasing sand??

Miller suggests slope may be more important than sand.

Well-drained soils very important.

Sensitivity to pH may also be important. Chestnuts rarely found above 6.5.

How does chestnut parallel with the oak regeneration problem? Are the two scenarios similar enough that we can make inferences about chestnut in context of oak ecology?

How long do seedlings sit in understory? Some conflicting data here. Many oaks and hickories can remain for decades.

What is the role of diffuse light vs. direct light? What is the minimum threshold for light? Not clear that this information is well known. Will need exact information for restoration guidelines. Light conditions closely related to stand management.

Shelterwood prescriptions may be preferred for optimal chestnut environment.

Under good conditions, may grow too long and get cold damage. May be better to grow under less ideal circumstances. Chestnut seems to thrive under rather adverse conditions (e.g., high/low light, droughty soils, low nutrients, etc.).

How do we make sure we are using material is free of pathogens? General discussion of what moves around on bare root seedlings from nurseries to field plantings.

May be best to move seeds around at greater distances and then nursery stock released only locally.

Should we ship nuts out of range to get seedlings then ship back in for planting? Cut down on disease transmission.

Emphasis has been primarily on resistance breeding with respect to *Cryphonectria*, but what about *Phytophthora cinnamomi*? This will have an immediate effect on where chestnut can be established and expected to survive. *Pc* resistance must become an element of the breeding program ASAP.

One thing that would really help the reintroduction effort is a fast, inexpensive *Pc* assays. At the very least, this can be used for initial screenings to rule out sites that are likely high risk.

Planting seedlings require quite a bit of care and maintenance.

Have to manage expectations about plantations.

Balance btw growth and reproduction. Do we fully understand the patterns of resource allocation in the species (growth, reproduction, and maintenance)? Probably not. Have we inadvertently selected for precocious reproduction in favor of growth?

We should focus on initial source populations and then secondary expansion.

Restoration plan calls for planting where there are sprouts, but are these indicators of actually marginal stands? Did the best chestnut actually disappear and we are missing those sites now? Could affect the development plan.

Consider replacing pine plantations with chestnut. The paleontological data suggests that these two species grew as congeners in the past. The pine-chestnut relationship needs more study. Relationships with mychorrizae? Other soil conditions?

How to manage landowner expectations? Trees die, get over it.

Site may affect susceptibility to blight & needs to be more carefully evaluated.

Is there a relationship btw chestnut and its neighbors? Does not appear to be any nearest neighbor data available.

Restoration plan will need adaptive management approach; i.e., changes should be made "on the fly" as more information comes in. Use best information as available at time.

The Restoration Plan may require a lot more staff than currently available (management, direction, data recording, etc.).

Partners will be key to success.

Cell approach was devised to manage compartments, much like a typical silviculture approach.

Can we prioritize cells? Can we utilize a regression approach by using a variety of cells of a gradient at different scales?

On the ground efforts, data management, and partners are (and will) prove to be the greatest difficulty in implementing the plan.

Where do we get more volunteers from? Simply using "trained volunteers" doesn't seem like it's gonna cut it.

Standardized data form needed for monitoring. To assist partners must be simple and easy to implement.

Concern expressed that we have not included enough American germplasm in the breeding program. Recipe for disaster if we are only using a small defined number of American parents.

Kim suggested raising to a certain point and then infusing a huge number of pure *Cd* F1s at end. Perhaps as many as 200 Americans lines brought in just prior to deployment.

Concern and discussion about maximizing genetic diversity. We will need more Am germplasm in restoration plan to account for local adaptation.

Should restoration plan be reorganized into phases to control science and expectations? Reorganize restoration plan into phases.

Assume a successive refinement.

Define stakeholder presence and need.

Site selection criteria needed, b3f3 limits n guidelines...need a risk assessment.

Concept of restoration planting discussed.

Phases of restoration plan, have science and volunteers running simultaneously, intensive and extensive operations simultaneously, then re-evaluate.

<u>Take home points</u> (based upon round-table contributions at end; each participant contributed what they thought was the single most important discussion point of the day):

Need to determine if b3f3 really is blight resistant.

Is there a relationship to chestnut success and site quality or site conditions?

Be conservative and have more controlled plantings before full-scale release.

Look at test plantings that are out there and age of flowering and fruiting; assess patterns of resource allocation.

Figure out how to use restoration program to breed more American chestnut back in to the hybrids (not practical in the breeding program).

Evaluate the risks we assume by putting out too much b3f3 too soon.

Recognize that restoration plantings are also part of germplasm program and can be brought back to breeding program as necessary.

Establish a modeling framework to evaluate ecological data and to coordinate restoration efforts; develop a soil suitability index.

Establish a multiphase, or two-pronged, approach for restoration with both science and citizen science.

We need a chestnut that can compete with other trees in a forested environment—make sure that's the case.

"Inspiration through demonstration" so people can believe (alleluia).

Start developing the plans for what needs to be monitored and plan ahead for adaptive management.

Establish a two-prong multiphase development program (in parallel to restoration program).

Establish criteria for site selection and criteria for risk, need to determine what the most pressing questions are to collect data.

Define, evaluate, and embrace risk and then manage it through adaptive management.

There is a need to prioritize information gaps; need a carefully designed set of studies to look at multiple constraining features, mycorhizzae, herbivory, invasives etc.

We need self-sustaining populations and mechanisms to achieve that.

Keep stakeholders engaged with restoration strategy.

Figure out how to assess risks and manage for *Phytophpthora*.

Partners and funding will be extremely important as we move in to future.

Evaluate pre-existing frameworks, like SILVAH-oak for conversion in to SILVAH-chestnut for better on the ground management decisions.

Bryan Burhans

<u>Silvics:</u>

Chestnut has the ability for significant recruitment…advanced regeneration likely very heavy and allow for domination of site after crown removal.

Shade tolerance about same as most oak species. Mange like we do oak systems.

What are implications of successful chestnut restoration?

Greg's daughter's research suggests that slope had largest impact on survival and growth.

Well-drained sites seem a better fit. Where does pH fit into overall site suitability? pH 6.0 and above chestnuts do not seem to survive.

You may have to adapt your silvicultural approach depending on the region.

Sara talked about shoot die back, but has this been quantified?

So what were the natural disturbance agents pre-blight?

How do we assay sites for *Pc*? We need to develop a good assay for *Pc*.

By putting *Pc*-susceptible material out we are increasing the probability of failure; we need to find material with *Pc* resistance. Need to move forward with plantings and concurrently look for *Pc* resistance.

Need to monitor our material long term and bring back the best material back into the breeding program.

Need to look at *Pr* assays and potentially apply this to *Pc*. Need more research on *Pc*!

Need to look at several different techniques to grow chestnut: seedlings, nuts, shelterwood, etc. Need to match technique to site requirements.

Recommend that if we are going forward with seedlings, we need to establish relationship with nurseries well outside the range of *Pc*.

However, BCM points out that we may be bringing in other (and even unknown) organisms back into the east.

Thiram is the chemical we used on corn/chufa. Will this work on chestnut to reduce predation on nuts?

Kim notes we really know how to plant. The real question is how do we plant to allow the populations to expand on their own?

We must make sure we periodically thin our seminal populations to maintain the stand's health.

Issue: where should we plant chestnut (Irwin). We first need to identify the best sites to start with planting.

We should plant these as a mixed stand instead of a single–species plantation.

Dispersal ecology and seed predation (Keiffer): big question we need to address.

FIRE! Chestnut typically does very well. The question is, how long do the seedlings need to be established before you run a fire through the stand.

Have we looked at SILVAH-oak developed by the NE Research Station? Can we add chestnut information into that database fro management decisions. However, there is a lot of information about chestnut that we do not know. However, oak and chestnut will have some of the same requirements.

We really need a model of how chestnut grows and how it will spread. Use this model to identify areas where we have uncertainly. Use this model to structure future research.

We probably have enough information to make a good first cut as to where we can reestablish chestnuts. We should be able to map out the first steps to start out with our restoration plan.

NRCS is developing ecological site classification system…we need to work with them.

As tasty as the nuts are, general concern expressed about the chestnuts ever having a chance to get out of the planting area.

Two issues: 1) Development of the initial (seminal) populations that will get to reproductive age and 2) provide the correct conditions to allow for expansion of the population.

“The ghost of competition past” (BCM). Is this an issue? Does present location of sprouts only reflect past ecological conditions? Relevant to present and future?

There may be some problems with only planting on sites with existing chestnut sprouts. It may be that these are the worst sites (or less than ideal) for planting chestnut.

The pines are the nurse trees for chestnut (DM). Group discussion on link between chestnut and white pine.

There is no one-size-fits all management strategy.

USFS biophysical models may be helpful for us to work with.

Need to think about the relationship between site quality and blight resistance.

Restoration Plan Implementation:

Cell concept would: 1) manage spread of material over the landscape, 2) organize and communicate where we are establishing plantings.

There was concern that the cell concept is pushing the “proliferation” of the chestnuts.

Discussion about focusing restoration plantings on a smaller area. However, there are other plantings, such as demonstration plantings, that could be used to address regional needs of members and partners.

Need to get the data from the USFS plantings.

These planting will inspire people.

Need standardized forms available.

Need a list of biotic and abiotic factors for site selection.

Adaptive Management:

We need to better conserve more American germplasm. If we are trying to reestablish a species based on only a few Americans, we are making a mistake (KS).

A last step in breeding program need to interject a number of pure American genome into the breeding program.

We need to define how to get more American germplasm into the population

Could measure recruitment on the planted site as a metric to help with adaptive management (this is a great idea!)

How much American diversity do we need to capture variability? Need research?

Need to push the idea of cryogenetically preserving chestnuts to conserve genetics.

How can we really determine if we have a true American chestnut?

Promote the use of pure American chestnuts in conservation plantings.

Do we restructure the restoration plan into phases to more carefully control the science and data?

Risk assessment.

Need to decide what to do if we have material that needs to be destroyed?

What are the metrics? What are the metrics we would use?

Jarel Bartig (JB thoughts & annotations in parentheses)

Need supporting social structures & policies.

Issue: Southern portion of range (*Phytophthora*) could be a barrier; northern end of the range was probably still exposed but cold tolerance is more the issue

Mammoth Cave created an Ecological Classification System map. Build on it?

Dispersal: preliminary research indicates high removal rate by rodents yet there was a 1 km spread in 70 years in the Wisconsin stand. No seed bank, but prolific re-sprouter. (Maximum migration rate for tree species moving through a fully forested landscape was about 50 km per century [from Louis Iverson's climate change modeling paper]).

Chestnuts have thin bark when young and unprotected buds as adults (fire sensitive). But vigorously resprout after fire – perhaps handled fire similar to hickory. (Low intensity fires as part of the disturbance regime along with storm and wind gaps for oak-hickory systems should fit just fine with chestnut as one of the historical components of this forest system.)

Chestnut is intermediate in shade tolerance. Greenhouse studies show increased competitiveness; natural settings perhaps not to same extent (other effects such as deer).

How does chestnut interact with oak? There are a lot of unknowns at the community ecology level (competition, dispersers, site selection). (Todd Hutchinson and Dave Minney say that chestnut oak and tulip poplar filled in the historic niche left by American chestnut. Brian McCarthy says oak and hickory.)

Group said that it was thought that chestnut liked sandy soils but has since found that: slope may be the most important factor, soil moisture is key, percent sand is important but variable, too much water in the wet season decreases success.

Everyone agreed that chestnut likes well-drained sites. Ph was unknown and variable in Amy's study. (USFS is working on an Ecological Classification System for southern Ohio that uses the WNF OSU terrain model as breaks for Iverson's Integrated Moisture Index Model. Jim Dyer at OU Geography is working with Todd Hutchinson with Government Land Office witness tree data. It would be nice to look at this reference condition data and compare with the ECS. I could also provide the National Hierarchy publication for thinking about ecological classification systems – NRCS has been given the funding and lead now for a national ECS – they will be creating ecological site descriptions. TACF could feed their expertise into these descriptions. For southeastern Ohio, we are already collaborating with them on the WNF ECS effort).

LANDFIRE biophysical settings models were also brought up. (I am working with Randy Swaty, TNC Fire Ecologist with LANDFIRE project to refine the oak systems models for southeastern Ohio.)

The group was somewhat in agreement on categorization of chestnut as intermediate shade tolerant. Mike said it does not do well with mid-story competitors and feels this might not be a good category – it depends on the stage of life cycle. Saplings might not be sensitive. Brian noted the W. Salem stand showed seedlings could sit and wait then rocket up through a light gap like tulip poplar does.

How can we give guidance?

Do we know how long they can survive?

Do we know about root/shoot allocation? (Latham)

Group felt best guidance was not to plant in heavily shaded woods. But what consequence does shade have on range re-expansion?

Mike and Bryan Burhans wanted to treat chestnut like an oak. Greg Miller advocates for open settings for vigorous survival. Bryan suggested even-aged and Mike suggested shelterwood. Bryan Burhans suggested that when cells are established they need to be within active management settings, not closed and unmanaged. Bruce Spencer advocates for using oak management. (I would agree – and the SILVAH-oak silviculture system might be a great tool for the restoration effort).

Greg Miller advocates for conditions most conducive for survival – big investment. He advocates for open area then consider what to do to help naturalize. He feels they are designed for bird dispersal.

Mike suggested two-pronged approach: open, should be regionally adapted; underplantings – learn about natural disturbances.

Strong group agreement against scatter-seeding. Agreed there was a trade-off between rapid, pro-longed growth and stopping growth and becoming more winter hardy. Frost sensitive.

<u>Phytophthora discussion:</u>

All agree there is sensitivity to phytophthora.

> Should choose well-drained sites not suited to phytophthora
> Concern about planting infested seedlings & spreading phytophthora
> Use nursery resources outside of range?
> Direct-seeding is a good solution
> What about protocols for ensuring healthy stock? (This is a place the FS already has protocols in place – TACF should take advantage of its MOU with FS and let them provide solutions/support on this issue).

Issue: lots of people are growing seedlings in a variety of settings and moving them around.

Ken Steiner suggested TACF should focus on long-term survival and ecology. We can learn from the Walnut Council.

Group has big discussion and general agreement for need for management. Also mixed species plantations if using plantations as method or suggests add to pre-existing oak forest. Aren't we interested in getting into natural systems? The group wants both aforestation and reforestation criteria.

Do we know how old seedlings must be to survive a prescribed fire? (This would be a worthy research question to answer. For oaks, they must be around 4 years old with a root collar at least half an inch to survive fire). Bruce Spencer read a study about an old-growth stand and chestnuts were the youngest members; this suggests they came in through gaps. 1,000-5,000 years ago the closest association with chestnut was white pine. Only in the last 1,000 years accounts for association with oaks and other hardwoods. (makes sense – this is same timeframe for shift to fire-intolerant to fire maintained systems). Dawn asked about white pine plantations as potential test sites, since Carolyn found that chestnuts did well near white pine and that there might be a mycorhizal connection. (This is another interesting research question – oaks are endo and pines ecoto. WNF has a bunch of white pine stands in need of restoration and has plans to either convert them to native hardwoods or turn some into wildlife openings. We are about to do an EA on the Athens District – would be cool to consider some chestnut studies. Can Brian and Dawn propose something ASAP?).

How to honor the social commitment while meeting nursery standards? How do we manage landowner expectations?

Mike liked the idea of organizing a conceptual model on chestnut design research – SILVAH–oak could be the organizing framework to help with this. (I would be glad to talk to Susan Stout, Northern Research Station Director about this if the group is interested).

Carolyn is very concerned about dispersal and chances of trees making it out of an area with squirrels. Brian mentioned mast events of oaks – chestnut produces consistently but on the years where the oak have mast events there could easily be a swamping out of rodent predators. Research has shown our systems are much more pulse-driven and less stable today – chestnuts lent stability. (Ohio Division of Wildlife is tracking mast years in SE Ohio).

Restoration Plan:

TACF mission: breed resistant tree (established in 1982) then restore it to landscape (2008 restoration momentum started).

The Chapter's first reaction was to balk at the issue of capacity.

3 Aspects to Restoration Plan:

Planting in each Quad
Volunteer group to adopt plantings; TACF would maintain national database (consider database contract with Nature Serve for this)
Funding (growth of organization, restoration branches)

Challenges: 1) manage expectations from public, 2) capacity and infrastructure.

Issue: cell concept at Quad scale vs functional landscapes (could tackle genetic control to develop a land race at the cell concept, and think about partnering with FS State & Private under their "Stewardship Landscapes" – concept/criteria guidance document about to come out; for SE Ohio it will most likely be the Vinton/Zaleski Landscape, Shawnee Foothills Landscape or perhaps the Athens Unit of WNF).

Issue: can't get return data on project sites – looking at Trees Database. (I will try to help with FS sites; what about a partnership with FIA?)

Issue: not enough American genetics – inject genome in great quantity into last stages of back-cross. Group wants to see this addressed in restoration plan.

Group asked: do we restructure restoration plan into phases?

There was strong agreement about being very transparent, not setting unrealistic landowner expectations. (A clear adaptive management framework would serve this purpose well. You could organize a science framework around "what we know", "what we would like to know" and put together a phased implementation framework that includes the social piece. FS State & Private could really help with the social part and developing clear key messages and doing outreach).

Group wants to see criteria for what is success?

Final Discussion. Group asked to say what they thought most important priority is:

TACF could organize two adaptive management frameworks, one around science needs and one around implementation. TACF has a pretty strong framework for science, just needs to line up needs with partners that have capacity. An implementation framework including the social aspect could also be organized. (I see some very strong linkages to partner organizations that could really boost the capacity of TACF. I would be glad to sit down and brainstorm on this with Bryan Burhans if there is interest).

Rob Swihart

Discussion Session I - Basic ecology and silvics
Jarel Bartig served as facilitator
Harmony presentation
Sandy soils important? Slope/drainage may be more important. Do better in dry sites.
Also, pH above 6 problematic.
Will honeysuckle grow in more acidic conditions? If so, could be a problem in ustory.

Even aged mgt for chestnut restoration?
Shelterwood with underplanting possible (3 stage). Or just focus on clearings for initial plantings?
West Salem site in 1978 was hunted heavily for squirrels. Could have led to greater survival of cached chestnuts and hence facilitated spread.
Direct seeding would remove risk of spreading Phytopthora cinnamomi via seedlings. But seeding would require exclusion of seed predators. Ultimately need to incorporate Pc resistance into chestnut.
Need to know more about climatic limitations on Pc lethality, and how might even-aged management might change lethality by warming soils.
Direct seeding on drier upper slopes can prohibit germination. Greater moisture on lower slopes resulted in better germination in MA.
Grow locally adapted seed outside of Pc range and then ship seedlings back for planting.
Test chestnut with thiram or other repellents to protect seeds from rodents.
Enrichment plantings versus monocultures? Much appeal to the former.
Chestnut lost to yellow poplar in opening due to deer herbivory.
Need ecological selection tests to continue to fuel breeding program for adaptations to biotic or other selective agents.
NRCS ecological site description program could benefit from TACF input. Songlin - suitability map (predictive, spatially hierarchical) to prioritize site selection.
After site selection, do a site bioassay with pure seedlings for 2-3 years.
>1000 yr bp, chestnut most closely associated with white pine. Could pine serve as nursery sites for chestnut?
Blight could be more severe on poor sites or stressed plants, based on Chinese chestnut in native range.

Post-lunch Discussion on restoration plan and adaptive management
Rex Mann overview
Need to treat selection of sites based on suitability index as an experiment (test and refine index)
Geographic extent should be covered when selecting the "intensive" experiment. Then within a cell design smaller-scale studies to test putative factors (soil, light, moisture, slope, mycchorizae, Pc, seed predators, dispersers, herbivores,competitors) influencing restoration success (germination, growth, recruitment, seed prodxn). Ideally these are multi-factorial and focus on factors about which there is greatest uncertainty/importance wrt chestnut restoration. Simultaneously conduct volunteer-driven "extensive" portion of study in which some data are collected and augment intensive study. Both inform next phase, which is full- scale deployment.
Need low-cost assay for species ID
Need clone or cryogenic embryo bank of pure.
Success will depend on seed/seedling availability and money.
Site selection should include ecological risk assessment of planting hybrids (e.g., if restoration planting spreads to another ppty or is "inadequate", what is to be done)?

Need a model-based, well-funded, "intensive" set of restoration cells to understand the restoration effects of hypothesized environmental factors. Will inform suitability mapping and management recommendations for large-scale deployment and spread.

Kim Steiner

Brian observed seedlings in the West Salem stand surviving for 5(?) years or more. All the overstory trees are dead now. Is there some facilitative effect of overstory chestnut on chestnut seedlings, through mycorrhizae etc.?

Sara says chestnut might benefit from a little overhead shade when planted as seedlings (no frost pockets etc.)

Greg thinks American chestnut is designed for bird dispersal – burs open and display nuts for several days before they fall. Not like Chinese chestnut.

Question: Should we only regenerate by seed to avoid moving phytophthora around?

Brian: Owner at West Salem stand indicated that they were hunting the hell out of squirrels etc. years ago, and also that the stands were thinned heavily in the 1970s. These activities might have contributed to the presence of seedlings in recent decades, at least.

Maybe we should contract with the USFS Toomey Nursery.

Greg: We may be inadvertently selecting for early flowering and fecundity.

Carolyn worried about dispersal ecology and the pressures of deer, squirrels, mice etc.

Perhaps we could put off answering questions about dispersal ecology because that is a longer term problem in the restoration sequence.

Competition and site quality are big factors for blight. Greg noted that drought and winter injury exacerbate the severity of blight.

Kim (thoughts maybe): Purpose of restoration cells is 1) breaking task into manageable pieces, 2) record keeping and management, and 3) control of genetic material (land races).

Perhaps focus initially on fewer cells but select on gradient of quality or suitability.

Create a series of West Salems to inspire people.

We need to bring more American trees into the resistance population. Use Jean's sequence strategy from the Genetics Workshop to maximize diversity. We have used about 300 American parents in the entire breeding program to date.

Brian: Can we phase restoration? Phase I – studies about how to plant etc. Could still have volunteer efforts in other areas. Intensive and extensive studies. Phase II – didn't get.

Kim: How can we use the restoration program to introgress more American germplasm into the resistant population? A key question.

Keith Gilland

TACF Ecology and Restoration Workshop
Ecology and Silvics post-presentation discussion

Recruitment rates: what are they? seeds vs. resprouts (Paillet and Rutter's 89 study)?
Game and animal people as stakeholders (wildlife NGO's)

<u>Discussion 1: Basic Ecology and Silvics</u>

-Chestnut likes sandy soils? What about it?
-Gregg: recent study by his daughter on strip mine; great variation in survival and growth, great variation in percent sand, most important factor turned out o be slope. Percent sand was positively correlated with survival and growth but not as greatly as slope. Found water content varied with less survival at water-holding sites.
-Rhoades: paper results basically driven by two extreme points
-Still stick with "well-drained"
-pH sensitivity; is it important, how important?
-Light-tolerance?
Problems with changing tolerances over time? Sprouts vs. seedlings, shade tolerance of seedlings vs. sprouts and importance of under-canopy plantings. Facilitative or competitive effects instead of shade?
Ages of seedling root systems?
High shade or low-shade environments? Importance of mid-story competitors?
Red maple problem: do we manage for chestnut the way we manage for Oak?
Southern Appalachians: Ericaceous problems

Is there a bottom threshold for establishment; i.e. a minimum amount of PAR?
-What is the optimum of other non-chestnut vegetaton? Do we establish pure stands and let it expand into adjacent stands? Or will chestnut actually even expand into intact forests?
-Shelterwood options? Again, treat it like Oak?
-Expense and effort of planting seedlings: we need to do this under conditions that are most conducive to survival. Planting under shelterwood treatments may not be the best treatment due to investment so why not put into open areas. When we put them into open areas, what do we have to do to get trees to reproduce naturally?
-Why not a two-pronged approach? Shelterwood and open areas? Competition from overstory can keep competing vegetation down. IN PA, 50% canopy removal can facilitate survival. In northern climes: shelter lessens cold injury.
-Is cold damage as much of a problem as some people think?
-Consider the natural disturbance agents of chestnut.
-Problems with using the West Salem stand as a model for a chestnut reintroduction? Basal area reduction, elimination of seed predators. Basically, a severely anthropogenically disturbed stands.
-Dispersal data: West Salem stand could have happened naturally but it's far out in the 95% range. This is based on squirrel observations. What about bird dispersal?
-Phytopthera sensitivity: site-selection for sites that don't have a problem or have to protect chemically. Also there's a problem with introducing Phytopthera onto sites that do not have phytophtera currently. Possibility of utilizing nursery resources outside the range to prevent pathogen spread.
-Need for protocols for other species in order to prevent spread
-2 issues: what's there already and what's coming in with planted material. Isolation lab is required to work with Phytopthera.
-How do we tell if a site is infected with Phytopthera: is there an easy assay? Do we recommend sites that are likely to be free from phytopthora instead of performing an assay?
-Control with commercial fungicides?
-Grow seedlings in MI to prevent introduction?
-How do Europeans deal with Phytopthora? Is it site conditions or that they aren't introducing new material that causes infections?
-Can we avoid Phytopthora problems with direct-seeding? It' more effort but is it worth it to keep disease down?
-Some nurseries are more careful.
-Do we make a recommendation to investigate in more detail restoration via seeds vs. seedlings?
-At some point we need to incorporate Phytopthora resistance into the restoration material. Put out a phytopthora-susceptible material, conduct ecological research to get ready for version 2 which will be phytopthora-resistant material.
-Even though we can identify phtyopthora-free sites, we need to remain focused on keeping the breeding program running to produce better material.
-Quantification of all ecologically important characteristics: competitive ability etc.
-What biotic limitations might exist with phyopthora? Is it northern? It's present in the north but seems to have reduced lethality? Is this a concern with increased global temps? Can we draw a line? (42^{nd} parallel)
-Clearcut plantations: Increasing soil temps increasing lethality at sites that are too northern now?
-Adaptation of other assays for phytophthora detection?
-If we want to pursue seedling planting, do we need to partner with growers outside of the range to grow locally-adapted material in another site. Especially with getting a partnership together with the Forest service. This creates the problem of bringing other, new pathogens to a site from outside growing sites.
-Dealing with APHIS if we plant seedlings from other places?
-We need more regeneration research with nuts; protection, site selection, care after planting?
-What's going to enable these trees to spread once a seminal planting is conducted?
-What about failures of plantations? This is common in Oaks but what about in chestnut? Post-planting management? When stands close canopy will we cut them and release them to keep stands from stagnating?
-After the planting, there needs to be long-term care of the plantation.
-Utilizing available sites vs. sites with the highest probability of success?
-How do we balance keeping people involved with an availability of only marginal sites? This is where it becomes important with providing guidelines and reasonable expectations.

-The problem with same-species plantations on relatively uniform sites. Is it beneficial to plant out with other species? The problem of same-species stands and possibl blight resistance decline can be ameliorated by not planting only chestnut.
-Consider landscape potential when introducing trees in isolated pockets.
-Plant before shelterwood harvest, allow trees to establish then release.
-Research into fire, same deal, plant, grow, burn, see what happens.
-A seedling stuck in the forest is not the same as a release. Waht sort of time frame are we looking at for this process?
-Genetic differences in seedlings and their fecundity. What are we selecting for in the breeding program: individuals that flower early and produce lots of seeds, need for long-term ecological studies to see what happens

<u>Discussion 2: Forestry and Silviculture:</u>
Has anyone checked out the SilvaOak (?) prescription system? Would it be beneficial to add chestnut information to that system?
    -do we need more concrete information in order to put chestnut into that system?
How do we need to organize research into chestnut?
    Identify models for chestnut population dynamics.
    The silva system could help in site identification etc.
    Using existing information to identify new sites for planting
    Ecological Classification system: NRCS ecological site classification system.
What about using a decision-tree approach in order to identify a best site?
    Is there a bioinformatic approach to identifying best sites?
Soils and sites etc.
    -Legacy effects on sites that used to be oaks but are now agricultural fields.4
    -Mohican planting on a former pine plantation site.
    -Former oak vs. former pine.
-Importance of legacy effects; refugia for mycorrhizal fungi? How long can a mycorrhizal associate remain in the soil?
-What about planting pure American seedlings as an indicator for site conditions.
-Is supporting chestnut oak a good indicator? Combined with soil quality.
-Generate a soil suitability classification system.
    Dispersal ecology
-Have long-term forest changes made it impossible for chestnut to disperse and establish? How can we deal with this?
-Long-term pattern of pulses of seed production with mast years and years where there is a failure
-Modeling of size thresholds at various stages.
-50-100 cm size class transition ; important.
-Public perceptions and getting deer populations down
    Importance of size classes in the life cycle and population growth
    Initial establishment and then expansion into larger populations
-Focusing on establishing trees also gives us more time to solve the problem of dispersal ecology.
        -What are the limiting factors we can address that limit population spread.
    The need to devote resources (seeds) to studying long-term dispersal issues
    What about studying plantations, areas around the orchards to look at dispersal.
    What about future wildlife populations?
    What about all the trophic interactions? Do we not have enough predators for rodents etc...
    Stability of chestnut vs the periodicity of oaks?
    Are sprouts a flag for where chestnuts die? Are sprouts a possible indicator for chestnut failure?
-Whether or not when building a suitability map can we use the past as an indicator of quality
-Collect baseline data on all sites where chestnuts are introduced
-Problem is the plan says to plant where chestnut sprouts are common
    Historic chestnut density, historic disturbance regimes?
Chestnut as an early successional species, strong response after logging, same as white pine in the lake states
What about chestnut as a cohort of white pine.
Consideration of old CCC pine plantations as planting sites

Chestnut as a generalist but what about its dominance?
What about chestnut sprouts not being in the understory on particularly good sites being an artifact of competition on particularly rich sites where the chestnuts can't compete.
-How do we go about this pine plantation studies? Do we underplant or do we clear and plant?
Frost protection from white pine plantings? Basically a microsite amelioration effect?
What about on the Wayne? Hoosier?
Chestnuts are disturbance-favored

-but what about scale?

-what type of disturbance?

-What about how they conflict? Effects of site on how trees respond to disturbance.

-Maybe the best we can do is try to manage people's expectations for what's going to happen?
Landowner expectations
-How do we manage those? Do we have a consensus on what people can expect out of what we are putting out now?

-Honesty about our uncertainty around the product.

-What about the timber quality of trees infected with the blight? The hybrid trees will still canker, will it make them not valuable as a timber tree?

Chinese chestnut in China? What can we learn from it?

-Genetic variation in the blight resistance of chinese chestnut exists and is extremely variable
-Environmental conditions and their effect on blight responses, it's possible in some cases where cankers develop but are not disfiguring
-Matching landowner expectations with site conditions
-Relationship between site quality and blight resistance
-Excacerbation of blight by drought and winter injury

Effects of competition on chestnut growth, woody and herbaceous competitors?

More sites or fewer sites with more intensive studies?

Get a regional focus on one area where intensive focus can be placed.

Discussion 3: Plan implementation:

-How to manage expectations

-Crafting a coherent message about what we're trying to do

-Chapter concerns: it's not a matter of being able to do it, the TACF needs to work out a plan of how to do it
-It is still important to proceed with an organized plan, following the outline of adaptive management
-Problem of staffing in order to implement the plan: Bryan Burhans doesn't think we'll have problem
-Set up a testing structure rather than a roll-out structure
-Cell concept

Purpose of the cell was to break down the problem into something manageable

Compartmentalize for management

Manage the movement of genetic material, we would then be able to eventually build a set of local adaptations
-Partnerships and how they'll play into plan implementation, the cell problem may be that the small amount of active people in the state chapters felt they would be responsible for all of the work which seems insurmountable.
-What about dividing up into watersheds instead of man-made grid coordinates?
-Focus a huge amount of effort into a smaller amount of cells?
-This allows for genetic improvement to be rolled out into later cells,containment of -problems or fixing of "problems"
-Smaller amount of cells allows us to treat this rollout as an experiment, which it should be. Test a set of hypotheses in the original cells before moving into new cells.
-Establish a gradient of site qualities or cell qualities. Treat as a regression. Look at factors within the smaller scale as factors for an ANOVA type project.
-The number of cells focused on is then scale-based depending on how much the state chapters can put in.
-Smaller # of intensive plantings can then become a showcase, this allows momentum to build

Building interest, understanding

-Restoration landscapes?

-Finding people to get chestnuts into the ground is easy but getting data back is difficult

-How do we get data back? Who has the data?

-What about other nonprofits?
Natureserve? Can a partnership with these folks help? Basically, a web-based centralized database.
What do we have as an incentive to get people to get out and work?
The West Salem stand: how inspiring it's been
Can we create a series of West Salems?
Centralize research
How confident do we need to be in our data?
How do we deal with our volunteers? Do we get employees etc.
Standardization of data collection
-A set of standardized forms could be posted to the web site, apparently there might be?
List of all of the abiotic site characteristics conducted ahead of time
How does all of this get paid for?

Discussion 4: Adaptive Management:
Integrating the plan between planters, geneticists, etc.
Problems of not including enough American germplasm in the breeding program
-There might not be as much introgression going on as was originally thought
-Resistance level between anything hybridized between the hybrids and pure will not have sufficient blight resistance
-Bring in new lines of resistance, broaden the pool of American genetic material at the last stage of backcrossing
-May be done efficiently through genome assaying? Including more genetic diversity rather than replicating what we might already have
-Profiling individuals, you can't identify what the differences are but you can then intelligently attempt to include more genetic diversity than simply "a different tree."
-This is the sort of thing that could be studied at the "ecological" planting
Including greater diversity would allow for adaptability if not outright adaptation
-Need to increase the knowledge base about local adaptation to see if it's actually important, in short term this isn't terribly important but it might be interesting to look at over the long term, increased genetic diversity couldn't hurt
-A lot of differentiation could be found but is it important? Or is it just environmentally skewed?
-Selection can happen but the potentiality needs to be present
What metrics do we need to include to be integrated into the adaptive management process?
-Trees database data: how does the data going in get fed back into the breeding program?
-In the restoration plan: difficulty or subjectivity of each type of data collection
-What types of ecological questions will be asked?
-How will we be assessing "fitness" or "fitness components"?
# of burs, progeny, how to measure recruitment?
Size-based recruitment measurements
GM trees from NY: How will they affect what we do?
-They can be included in crossing with pure Americans but right now they're under strict FDA control
-Problems of structure being present in genetic variation, especially when you don't know what it is: differences exist between pops but the differences aren't known
-Push the idea of cryogenically preserving embryos for future introduction into the pool. What about pollen also?
-What about keeping a clone bank outside of the blight range?
-What about a set of progeny orchards to keep germplasm alive?
-Basically, we need to capture as much germplasm of Americans as possible
-Dr. Keiffer would like a cheap method of determining American vs. Chinese
-Benefit of preserving genetic material even if it's not pure American
-Importance of conserving existing American material as American by not planting hybrid material near those individuals
- Construct a decay curve, how long will genetic material hang around?
-Put pure American material on reclaimed minelands
-States can maintain pure or nearly pure orchards of American material

Restoration Plan as a big Hoagie:
-would it be better to refocus the document into "phases" in order to more carefully control the data
-ex: Phase 1 deals with sites, materials, that information then comes in to help structure phase 2, that info comes into phase 3
-Science vs. stakeholders
-This can allow a relaxation of the "phases" this also doesn't mean that volunteer plantings can't provide information
-"Intensive study" vs. "extensive study"
-Take information when material is given to stakeholders, use it as best as possible
-Pursue the avenues simultaneously
-Do we need to put a limit on the amount of B3F3 material. We need some sort of risk analysis. Is this a concern of getting material out that is not of good enough quality in that it only lives long enough to maybe be harmful or ultimately creates disinterest in planting.
-Are we risking something by planting this into a good quality site where it may in fact ultimately do some damage if there is a failure?
-Putting this risk and a possible contingency out front maw provide our stakeholders with a sense of security
-What do we do when we realize we have a problem? This is a good reason to keep the cells
-We need a description of what our product is supposed to look like? What are we going to have when we're done? We have a process but not a final product description? How will we know if our stuff is a success?
-What is American enough? How much Chinese-y is allowed?
-The New York material: considering biotechnology broadly, white paper stated that all methods should be considered as part of a solution.
-This is possibly a bogey-man that may or may not exist. We just need to use it wisely

Mike Saunders

[NB: Instead of meeting notes, Mike chose to submit an alternative strategy for the restoration plan entitled, "Integrating Chestnut Reintroduction with Ecological Research and Public Relationship Needs: A Workplan"]

Restoration of American chestnut onto the landscape has been a long-term goal of TACF. While the organization is enthusiastically waiting for resistant material, there is some danger that reintroduction at too rapid a pace may lead to unanticipated and undesirable ecological consequences. For this reason and for our relative lack of scientific information regarding the ecology of the species, we propose that the restoration effort should occur in phases that ramp up outplanting efforts slowly and in pace with our advances in ecological knowledge. Particularly within the intensive portions of Phases I and II below, these reintroduction efforts should proceed in concert with breeding efforts to create more locally adapted, resistant lines and with testing efforts to insure blight resistance in the field (Figure 1).

Phase I: Understand the ecology:

The goal of Phase I is to build our understanding of American chestnut ecology as quickly and efficiently as possible (the Intensive component) while simultaneously building public partnerships (the Extensive component). Both components are necessary to minimize the risk of adverse ecological consequences during later stages of the reintroduction, and to maximize the effectiveness of later reintroduction stages. Phase I is 10-15 years in length and should begin when locally-adapted seed is ready for outplanting on a state by state basis. In essence, this means some states may be in Phase II when other states are in Phase I. Spatial distribution of plantings during Phase I is not as important as the collection of information on the performance of resistant seedlings under diverse ecological conditions. Plantings should not necessarily be limited to one geographical area within a state, but chapters are encouraged to concentrate efforts in only 3-10 areas. During this period, there is strict control of the BC_3F_3 material in order to allow for destructive sampling, thinning, and other activities.

Phase 1: Intensive

- Purpose is publishable research results on chestnut's ecology, early growth, seed/seedling predator relationships, broader field-based testing of resistance, etc.

- Either large scale plantings (500 -2000+ BC_3F_3 trees) for longer-term (>5 year) multiple-factor tests (e.g., influence of light levels, understory competition, and soil characteristics on chestnut growth), or smaller-scale (250 – 500 BC_3F_3 trees) plantings for single-factor tests (e.g., influence of fertilization regimes on afforested plantings).[1]
- Goal over the entire period is 5-20 of these plantings per chapter (300 total); this is only 1-2 plantings per year.
- Strong site selection to assure best chances of seedlings survival. Sites should be owned by public agencies, universities, individuals and groups "strongly invested" in the effort, with long-term agreements in place to secure site for research.
- Plantation measurements are intensive both temporally (e.g., years 1, 3, 5, 8, 10, 13, 15, …) and characteristically (i.e., height, survival, diameter, …), and should be standardized to the greatest extent possible. All data should be archived with TACF in a centralized database to enable efficient, large-scale, cross-study analysis.[2]
- Should include both afforestation and reforestation plantings.

Phase 1: Extensive

- Purpose is for demonstration, public relations, and building partnerships for the long-term.
- Small-scale plantings with <250 BC_3F_3 trees. Many might be only 25-50 trees.
- No overarching goal for number of plantings by each chapter. Number installed is based strictly on opportunity.
- Weak site selection. Sites may be owned by private individuals, land trusts, etc.
- Landowners must agree to annual report of management and report survival, average height, and average diameter of plantation every year (landowner measured). Location of plantation (GPS coordinates) and contact information, at a minimum, must be registered with TACF.
- Plantings should be concentrated in afforestation and open canopy conditions.

Phase II: Plant the seeds and seedlings

This period is an additional 10-15 years in length, beginning after resistance is demonstrated in Phase I and preliminary management plans have been developed. Plantings should be strategically placed on appropriate sites and distributed across the range using results achieved in Phase I. Control of material may be relaxed to include only a "no profit" clause. The phase also has two components that roughly mirror those of Phase I, but with the following changes:

Phase II: Intensive

- Research focus should shift to community ecology, food web interactions, and testing restorative approaches. Some of this research should continue on Phase I sites, and with a broad range in tree sizes and site types allow for more gradient type analyses.
- Large scale to operation scale plantings (1000 -10000+ BC_3F_3 and other individuals) for long-term (>10 year) multiple-factor tests, or smaller-scale (250 – 1000 BC_4F_4 or similar next generation) plantings for single-factor tests.
- Should include both afforestation and reforestation plantings, but likely be concentrated on the latter.

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[1] Research efforts should be coordinated through either the TACF science cabinet or a special TACF reintroduction group. This structure will allow for the most efficient use of material and focus efforts upon those knowledge gaps most critical to the reintroduction effort.
[2] Although outside the scope of this document, data sharing agreements will need to be established with all researchers working with the resistant material. Obviously, intellectual property rights need to be maintained for researchers, but those rights could have an explicit expiration date.

Phase II: Extensive

- Purpose is to strategically place plantings across perceived range on appropriate sites that have been identified in Phase I. Phase I research should also be used to inform early stand management practices.
- Medium- to large-scale plantings with 250 – 1000+ BC_3F_3 and other individuals. Small scale plantings only on an ad-hoc basis.
- Goal of a minimum of 25 – 100 per chapter, or 5 – 15 per year, for a total of 1000 – 2000 plantings across range.
- Landowners must agree to annual report of management over first 3 years, or until plantation is known to be successful. Measurements are optional, but encouraged.

Phase III: Fill the voids

This period occurs after Year 30. At this stage, there is less focus on research and development, with the exception of breeding and testing of next generation material. It is assumed that by this stage enough intensive research sites have been established (likely 200 or more) that more effort can be placed by chapters on dispersed plantings within their respective territories. As BC_3F_3 material is no longer limiting, that material is released from TACF control completely. At this stage, chapters should be planting 5-15 plantings per year within areas without existing plantations, and across the range of appropriate site conditions identified through the Phase I and II research.

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