Final Report

Project title: Evaluation of Maclura Pomifera for fuels, chemicals and carbon sequestration (re-directed to Evaluation of massive reforestation/ propagation techniques to establish woody biomass)

NRCS Grant Number: 69-3A75-7-143

Completed Sept 23, 2011

Principle Investigator Alan W. Gravett MD MPH Hedgeapple Biotech (formerly Midwest Forestry and Biofuels)

Deliverables: (**These subjects were adjusted from original deliverable list after no cost extension of grant was allowed, focus retained on Maclura Pomifera)**

Evaluation of container tree practice for establishment of woody biomass crop

Evaluation of alternative watering/ irrigation techniques for woody biomass propagation

Evaluation of soil restoration in degraded central clay pan region

Evaluation of weed/grass/predator competition control techniques

Evaluation of indoor plant propagation with artificial light

Develop Value added product to facilitate economic viability

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Executive Summary: **NRCS priorities for the development of practices addressing climate change and biofuel/bio product production were addressed in this project**. This was done via **evaluation of establishment practices for woody biomass species with the introduction of several non-traditional species.** These included Osage Orange, Red Mulberry, and Silver Maple in addition to traditional biomass species Black locust, Black Walnut, multiple species of Oak and Cottonwood. We were able to establish 175,000-200,000 trees (best estimate…come count them!) by a combination of direct seeding, bare root propagation, container indoor/outdoor nursery practice and natural seeding on roughly 350 acres of central clay pan soil. This goal was accomplished ahead of revised schedule with the duration of time before Sept 23, 2011 deadline devoted to maintenance of plantings with water and weed control

(despite killer drought). Thanks to NRCS CIG staffs support allowing creative flexibility we were able to vastly exceed our original goal of 40,000 5 gallon container trees established at time of extension approval.

Customers that will benefit will include 1) NRCS and woody biomass propagators if they so choose to adopt our findings, 2) members of our developing rural cooperative, 3)people of the United States who benefit from economic development and 4) Planet earth via development of sustainable biomass/ tree propagation techniques. Funds were spent much as anticipated directly on tree propagation and maintenance. Deviations from original plan included obtaining necessary equipment for large scale materials handling and transport of container trees and establishment of indoor grow facility. The alternative technologies developed included 1) large scale adaption of drip irrigation; 2) large scale trenching to facilitate soil restoration, weed control and planting; 3) establishment of bare roots, direct and natural seeding and containers directly into said trenches; 4) establishment of indoor grow facility for winter propagation; 5) development of large scale materials handling system for container trees; 6) establishment of large scale logistics for obtaining, composting and utilizing urban woody waste and hay bales for mulch and compost; 7) utilization of feed wagons as large scale mulching units; 8) development of Value Added Product portfolio for selected woody biomass and; 9) alternative harvest techniques to facilitate product flow for VAP.

Quantifiable physical results include a large vigorous and sustainably produced biomass tree plantation, establishment of company capable of ongoing demonstration and production and development of rural cooperative base. We got roughly 2,376,000 of container growth medium established giving the equivalent of 475,000 5 gallon bags. This gives about 15 gallons of “in the ground” container growth medium for each of the 150,000 trees we planted this year.

Economically, we stimulated the local economy with as many as 17 individuals working at a time. We also created the birth of both a new biomass crop paradigm and new VAP industry. Getting trees to grow rapidly despite drought, flood and utilization of suboptimal “marginal land” with minimal utilization of chemicals will be a model for sustainable biomass production. There are multiple Federal, State and local biomass, rural economic development and tree planting initiatives that would benefit from lessons learned and which we will be interfacing with in the future to drive this project forward.

Our major recommendations include: 1) Adequate water supply for initiation of growth should be mandatory for all large scale tree planting attempts; 2) Adequate local soil restoration in degraded soil is mandatory for successful vigorous biomass crop development; 3) Aggressive large scale mulching with existing farm equipment is feasible and necessary at levels much higher that current NRCS recommendations (i.e. >>>2 ton/acre); 4) product development of VAP product line is mandatory to economically compete successfully with fossil fuels; 5) **Species investigated (Osage Orange, Mulberry, Black Locust and Silver Maple) are excellent biomass species and NRCS policy should be changed to stop current widespread destruction;** 6) large size (10,5, and 3 gallon) container trees although having significant advantages are logistically problematic for large scale propagation; 7) Indoor plant propagation with trees is a realistic and effective means of initiating container growth, , and finally; 8) **Trenching or (similar soil disruptive technology) may be the most effective means of bare root**

establishment and should be considered as a new NRCS practice for "in the ground" container practice.

Unrelated to project goals/ objectives we also conclude the following:

9) NRCS needs to clarify "consultant" parameters for payment; and 9) **NRCS needs to allow a waiver for USDA/ARS or other governmental agencies to participate in projects (as allowed by NIH, DOE and NSF)**

Introduction: This project initiated as collaboration between Iowa State University, the National Center for Agricultural Utilization and Research and a startup Agro-forestry/ Biotech company: Midwest Forestry and Biofuels which operates in the Tri-state Iowa/ Illinois and Missouri area). Dr. Alan Gravett MD MPH heads Midwest Forestry (now renamed Hedgeapple Biotech) and remains the principle investigator. We continue to receive significant input from NCAUR although they were excluded from funding participation by NRCS funding rules (this needs addressed). This collaboration has great promise into the future from the continued development of a bio products industry based on efforts within this project and rural cooperative development. Early on there appeared to be some conflict with lower echelon NRCS staffers who prevented any funds from flowing to consultants (specifically the Iowa State people). Subsequently, Iowa State dropped out of the project and with NCAUR unable to participate on a paid basis it severely hampered the original quantifiable goals of carbon sequestration and biomass growth. We greatly thank the current NRCS staff for their flexibility in allowing the project to morph into a "proof by numbers" project in which we evaluated current container nursery practice in relation to a goal of massive reforestation/ plantation development. **Our findings are both significant and extrapolatable to a wide spectrum of (tree) biomass species and farmland/ terrain scenarios**.

Background: This project was initiated with the current NRCS goals of addressing climate change (carbon sequestration) and bioenergy/ bio product production in mind. Our evaluation parameters were to look at NRCS practices relating to tree production (and subsequent c-sequestration) and evaluate a new biomass species (Osage Orange) for energy/ bio product usage.

Several previous attempts at looking at this have failed both from practical and political perspective Large scale popular and miscanthus/switchgrass production have failed form several reasons. 1) Lack for climate change legislation that levels the playing field for biomass to compete with coal; 2) Lack of value added product (VAP) in these species to make production cost competitive; 3) Especially in the case of popular in New York; failure to plan for a basic need in tree production startup...water and ; 4) erroneous thinking that adequate biomass can be produced on worn out CRP or other marginal land without massive soil restoration (hence 2-4 ton per acre on most switchgrass/ miscanthus stands).

The sole successful tree biomass plantings to date have been eucalytus plantings in Florida are based on content of value added product but these have been politically contentious due to water use issues and the fact that monoculture is usually a bad idea for many established reasons.

The sectors which benefit from findings in this study include any biomass project interested in maximizing sustainable production. Publication and promotion of these findings should catch the interest of environmental/ green groups interested in carbon sequestration and natural products

production. Additional interest should be generated in the rural development sector as we open the door to sustainable large scale Value added product production with rural cooperative and bio-refinery development.

The natural resource issues addressed include 1) sustainable biomass production (specifically large scale tree plantings), 2) water conservation for subsequent utilization and 3) soil restoration. There are no negative effects on the environment or community except for the need to control deer population during early tree growth. The significant start-up phase from initial seedling growth to the 4-8 years required for adequate secondary metabolite formation for adequate VAP yield must be factored in planning for biomass plantations. While currently we are able to address this issue by harvest of pre-existing biomass, adequate capitalization and government program planning will be necessary to facilitate project expansion.

Review of Methods:

Innovative aspects of this project include the following:

1) **Drip tape irrigation for field plantings:** When this grant was written the only option was expensive traditional traveling pipe irrigation. We have found that utilization of drip tape (commercially very cheap at 14$ an 800 ft. roll) provides excellent irrigation for large scale high density nursery production. Adequate provisos for water supply are essential as we drained 3 ponds over the course of a moderately severe drought in Iowa this past season. We used gas powered engines (obtained for ~750$ apiece) for pumping which worked well but burn moderate amounts of gas on a large scale. Provisos for windmills and elevated platforms (water towers) would make this even more doable on a large scale.

2) **Container nursery irrigation:** While decidedly low tech we found that readily available (Wal-Mart) lawn and garden hosing and sprinklers provided the most cost effective means of container nursery production. We used oscillating sweep type sprinklers supported on weighted 5 gallon buckets to excellent effect. We manually rotated flow via a fixed series of sprinklers and valves adjusted by staff prompted by timers on cell phones. Watering periods of 45 min to 1 hours provided nice breaks from mundane tasks of pot and bag filling, pallet construction, weeding and moving of plants.

3) **High volume mulching with farm machinery.** We found that current NRCS recommendations of 2 tons to the acre are totally inadequate to sustain good growth. Our initial hopes of adapting landscaping type/ mulch blowing equipment were dashed by several factors: 1) Excessive cost of most landscaping equipment; 2) Lack of adaptability of most landscaping equipment to the rigors of the field environment ; 3)ability to actually deliver high enough flow/tolerance on sometimes very dense mulch. and finally 4) lack of tolerance of small plants to high velocity deliverance of mulch.

Our solution was to use heavy duty feed equipment (example Kuhn manufacturing reel auger feeders. This has worked very well for the hand mulching we are currently engaged in. Potato forks, silage forks, hand scooping and simply kicking the mulch and compost around trees is necessary. A blower was evaluated but deemed too rough for mulching smaller trees. As we progress to larger trees we hope to design a silage blower type delivery unit capable of avoiding clogging with the heavier mix we use.

4) **Utilization of grass hay as alternative mulch:** Whilst using traditional tree bark/ woody waste is ideal, supply logistics for very large scale mulching mandate looking at alternatives. Big round bales or haylage from dump wagons provide a readily utilizable alternative with the following caveats 1) a 3:1 mix of compost or dirt is necessary to prevent plugging from most available mulching/feeding units; 2) Adding such compost or dirt is actually necessary from practical perspective as it keeps hay from blowing away and makes a type of "adobe mud" which makes excellent long lasting mulch which is highly effective in competition suppression. We have put on at least 200-250 tons of such mulch thus far with excellent results. Such a switch from traditional mulch was mandated by time/labor and diesel costs associated with hauling traditional mulch from our supply source in Illinois to the farm in Iowa.

5) **Trenching as initial means of competition control, soil tillage with soil restoration and facilitation of irrigation water retention** (with bare root, container, direct or natural seeding). After drilling about 2000 holes with a specifically designed “bobcat” auger system and hauling containerized bagged trees it became painfully obvious that large tree numbers would not be attainable without inordinate labor and fuel expenses. Advice from an engineering consultant interested in Biomass (Paul Weaver of Paul Weaver Construction Equipment) resulted in a trial of trenching to facilitate plantings. We trenched 2 ½ to 3 foot deep for about 24 miles total. The trencher we used (a 135 hp Veermer) had a 12 inch wide dig width and we ran it for 175 hrs. An 18 inch dig width (the largest available for conventional trenching) would appear to have worked even better.

Quantification of container “in ground” growth media:

Doing the math 24 miles * 5280 feet/ mile= 126720 feet of trench * 2.5 feet depth= 316800 cubic feet of dirt. As there is roughly 7.5 gallons of dirt in 1 cubic feet this gives the equivalent of 475,000 5 gallon bags or 792,000 3 gallon bags. We got about 150,000 trees total in the ground this year giving roughly 15 gallons of growth media per tree planted in 2011.

Advantages of this system include the following 1) allows “soil biopsy” to determine restorative needs at that location; 2) if trenching done ahead and displaced soil allowed to lay for couple of months get excellent competition control on either side of ditch; 3) returning soil to ditch allows bare root planting directly into this trenched system; 4) trench allows drip irrigation to preferentially go into ground rather than into surrounding competition.

Our most productive 2 days were 1) planting 15,500 bare roots in 1 day into trenched containers and 2) seeding several million silver maple seeds into container system resulting in roughly 40,000 trees. Heavy spring rains washed out our direct seed plantings or else our take of silver maple would have been even better.

5) **Styrofoam as large scale replacement for vermiculite/perlite.** We experimented with this and developed excellent container media based on urban woody waste compost. Compost/mulch placed into bags without adequate provision for drainage invariably ends up like concrete in the bottom of the bag. As nearly 100% of styrofoam is not recycled there is enormous potential for utilization of this in soil restoration. Toxicity testing is necessary however as the potential for styrene leakage into the environment is possible.

6) **Development of large scale container palletizing system:** The major drawback of larger container (3 and 5 gallon) tree propagation is the enormous materials handling necessary to do it. Multiple moves of the container are necessary and with compost growth media it becomes quite difficult manually. Tree containers must be moved 1) from filling machine into shade to prevent transplant shock if leaves are on seedling; 2) at 2-3 weeks movement from shade to sun; 3) loading onto truck; 4) unloading off truck and into field; 5) unloading bag into hole or trench. An additional 2 manual handling steps are necessary if taking off pallet to grow in nursery and then putting back on pallet to load out to truck giving total of 7 handlings of the container. With wood pallets this is necessary as they will rot if exposed to repetitive watering over several months. On a large scale this is whole labor prohibitive especially if those 5-10 gallon bags start weighing 50-70 lbs. with hydration. Wood pallets required constant maintenance and even the extremely heavy duty ones we obtained tended to be damaged frequently with constant movement.

Potential solutions include development of metal or plastic pallets to eliminate some of the moves. Frankly, the enormous difficulties with labor caused us to abandon traditional container planting about half way through our extension and birthed the concept of "container in the ground". (We still have about 8,000 10, 5 and 3 gallon containers to be planted at production facility in Bloomington)

7) **Indoor plant propagation of container plants**. NCAUR has been growing plants indoors in specialized grow boxes for years. Dr. Tisserat has shown that using 16 hours of UV light (cheap fluorescent bulbs are fine) with 8 hours of dark that it is possible to continuously grow Osage for at least 2 years. Extrapolating from the marijuana industry we developed an indoor grow facility utilizing ~120 ml and ~190ml Stuewe Cone-tainer tubes. This allowed us to produce ~19,000 tube trees twice before regular planting outside was possible. Brief experimentation with garlic showed it to do very well indoors. Pin Oaks also did extremely well and showed massive rooting when we initially failed to provide for adequate drainage. Osage did OK but our results were tainted in that we failed to use adequate styrofoam for these first 2 rounds. They had trouble overcoming tube clogging with straight compost which was not a problem with pin oak.

We did encounter difficulty transitioning trees to outdoor environment. We made 4 large "hot boxes" outside which held about 5,000 trees each. We insulated these with compost and placed a small electric heater in each for temperature drops. Covering these with styrofoam insulation allowed plant survival down to 0 degrees transiently. Our only mistake was initially using 50% shade cloth for transition to outdoors which killed about 10,000 trees. 70-80% shade cloth is necessary initially outdoors, further experimentation is necessary to determine the optimum intervals for transitioning shade cloths (50 to 30%) although intervals of a couple of months seemed to work usually. We kept most of this entire planting under 50% shade cloth the first year.

Overall we showed that 2 inch Styrofoam insulation with small electric heaters, UV bulbs, good growth media and adequate drainage can produce large numbers of trees. Our energy use for warming was less than a tradition greenhouse as heat loss was minimized by total enclosure. Whether this is cost competitive with direct seeding or bare root planting remains to be determined. It does keep nursery staff productive during normal downtime of winter.

8) **Utilization of urban woody waste** During this project we obtained roughly 75 90 cubic yard semi-loads of ground tree waste. We never paid for most of this except for paying a bounty of 10-15$ a load to small tree services to get them to bring their chips to us, a grinding fee for 19 loads and some trucking costs. It is increasingly clear that many municipalities have much more woody waste than they can handle and much of it gets burned or is simply left to rot. Developing relationships with communities, tree services and electric power line trimmers yields very big in having adequate material for large scale mulching, composting and growth medium production.

9) **Cooling units for on farm storage of bare roots** We utilized a portable cooling unit to facilitate bare root quality for planting. This improved logistics of getting trees from the state nursery and prolonged the time we could wait to get them in the ground if unfavorable planting conditions existed. Cooling units would be very helpful year round for seed collection, stratification and storage as well.

10) **Seed collection issues:** We developed means of very large scale collection of Osage, mulberry, black walnut and silver maple seeds. All 3 plant very well directly and are obtainable by the millions easily with a little manual labor. Placing plastic sheets out under Mulberry or Silver Maple when the seeds are falling yields very big. Alternatively, Silver Maple is easily collected by sweeping or leaf blowing on driveways, parking lots and porches. Parks, cemeteries, lawns or similar mowed areas are ideal for collecting Osage or Walnut although they can be collected anywhere. We experimented extensively with shaking/ percussion as a way of dealing with Black Locust and Honey locust seed coats with minimal success.

11) **Sod scalping evaluation:** Sod scalping deserves recognition as good techniques for first year competition control. It must be used with caution or aggressive soil replacement/ restoration in central clay pan soil to avoid getting into underlying clay or leaving such a minimal amount of topsoil that the trees do poorly. We were very discouraged early on in the project as most of our ground is central clay pan soil. Now that we understand what's needed for soil restoration we have selectively started using it again with aggressive composting.

12) **Soil restoration issues:** For biomass to be successful on marginal or wasteland it is crucial to realize that most of America's topsoil has been previously washed away long ago. Studies with NCAUR show that at least 3 to 4 feet of fertile growth medium is optimal for tree growth….indeed I got 15 feet growth in 1 year this year from container Osage placed into the thick 3-4 foot topsoil of my driveway. Given the enormous waste streams going into landfill nationally and the very poor utilization of urban woody waste we should be able to address this issue. Sand (readily available in creek and river beds) and compost can restore clay soil to full productivity. Our trenching techniques open the door to further development of this on an industrial scale. Clay soil actually has a density similar to coal and we envision potential utilization of similar mining technology to really industrialize the concept to soil restoration for biomass production.

Comparison to existing practices:

Our project differed from standard NRCS practice in the following aspects 1) We used no chemical. Previous plantings on our farm had very mixed results with herbicide application. Tillage techniques to

control competition couple with large scale mulching radically reduce the amount of chemical necessary. 2) We evaluated many sizes of containers including 112 ml, 190ml, 400 ml, 550 ml, 750 ml 1 gallon, 3 gallon, 5 gallon and 10 gallon. The more growth media a tree has at its disposal in a nurturing environment the better it will do. All these sizes actually work for different applications and requiring different amounts of labor. All of them work in a container nursery practice although materials handling becomes very problematic above 3 gallon. Our best results were "in the ground container" with bare root black locust which were characterized as the best 1 year growth our local conservationist had ever seen. 3) The true amount of mulch and compost needed is far above the standard NRCS recommendation of 2 tons per acre. FAO (the UN's group looking at world ag issues) suggests that 25 tons an acre is necessary to fully restore degraded soil. A realistic evaluation of quantifying this and providing cost effective techniques for doing it should be the focus for further eval. 4) Finally, aggressive water management especially in light of climate change and potential water shortages is mandatory and absent from many projects. We would have had very poor results this year without **many miles of drip tape irrigation and an actively running water wagon**. We have noted significant opportunity for water impounding created by old conservation practices of straightening streambeds. This has scoured very deep ditches in many areas facilitating water impoundment for ag and biomass production.

Alternative product development/ marketing: We have previously reported to NRCS and presented at SWCS society meetings the broad potential for bio-products. Further development of bio-refinery and bio product lines will be the focus of the remainder of the primary investigators life.

Differences to accommodate project: Admittedly this is a unique project as we have 1300 acres of Iowa pasture and farm ground dedicated to alternative biomass production through a conservation easement. Thus, we had to do nothing radically different than we would have had to anyway as total reforestation into an agroforestry project is our mantra. Developing a product line that will eclipse the current corn, cow and bean prices will be necessary to start using lots of traditional farm ground. We have generated much enthusiasm amongst our local cadre of low income and beginning farmers who have pre-existing trees on their farms.

Schedule of events:

February-May 2008: Initial 100 acres of Osage/ cottonwood planted into sod scalped CRP ground with the entire area seeded to Osage directly with a corn planter. No supplementary water supplied but due to combination of direct seed and bare root somewhere between 25,000-50,000 plants (we keep finding more) survive and some are actually doing very well after initial disappointingly slow growth.

Spring/ Summer 2009: Initial mulching with 19 loads of chipped woody waste and preliminary attempts at mulching with older model feed wagon. Went well until mechanical breakdown of machinery not up to the task. Initial attempts at hand filling of grow-bags resulted in about 2000 plants going into ground with 5 gallon containers. Initial problems with container to field materials handling encountered. Initial attempts at bagging trees for nursery with soil feeder.

Winter/Spring 2010: Concept of shifting grant to container nursery for duration of grant. Large scale bagging and container nursery effort initiated. Much effort given to 1) obtaining adequate flow of

mulch for composting and development of growth media and 2) Solving materials handling issues (We attempted multiple styles of pallets with experience/ consultation proving that too big was bad as too much weight). Materials handling problems appear to be solved by obtaining 200 heavy duty wood pallets (for 6 -8 dollars apiece). Current 56 bag pallet (7 by 8 3 gallons bags) with sides developed by late spring.

Summer/Fall 2010: Maximal production of large containers in range of 300 trees a day despite best efforts. Production of smaller 400 ml to 1 gallon containers augments production by 500-750 containers a day. Gearing up for truck transport with purchase of specialized tree container handling capability with max of 504 trees per load (not counting small containers). Initial attempts at drilling holes initiated with obtaining tree hole augers. Attempt/receive extension of grant time till Sept 23, 2011. Much effort to mulch in the 8,000 large containers and 17,000 small containers produced. Successful irrigation of container nursery with low cost materials. Transplant shock recognized as significant issue and initial shading/ shade cloth attempts utilized.

Winter 2010: Disappointingly slow progress/ logistics problems necessitate a re-thinking of plan. It became obvious that producing, transporting and planting large volumes of 3-5 gallon container trees would be a struggle and a new concept must be developed. Trenching for "container in ground" concept hit upon after consultation with Paul Weaver and associates. Geared up for "massive reforestation" by purchasing 39,000 bare roots and building indoor grow facility which ultimately produced just over 40,000 "cone-tainer" plants counting re-do's. Established outdoor "hot boxes" to facilitate transition to outdoors and maximize the ~20,000 plant capacity of the indoor grow facility.

Spring 2011: Trenching effort hampered by severe spring rains but mange to get roughly 24 miles of trench dug and all 39,000 bare roots into ground. Severe problems encountered with trenching in that initially we were placing trenches close together (4 to 6 feet) as would be classic for plantings with 2 tree rows separated by 16 foot alleyways. Bank collapse with backfilling and multiple episodes of getting stuck occurred until we placed trenches 16 feet apart. This disaster created a golden opportunity for innovation. We half filled the trenches we had dug 4-6 feet apart and were able to direct seed silver maple into several miles of trench line resulting in large number of plants (roughly 40,000 despite getting washed out). The trench in addition to small tufts of grass which overhung both sides of trench provided excellent shading for start-up Silver Maple production. Initial transplanting of small 400 to 1 gallon containers into "in the ground container" system facilitated by drip tape irrigation and large scale shade cloth. Production efforts continue at Bloomington container nursery facility resulting in roughly 10,000 additional small and large container trees. Surprising results from mulberry and Oak seeding from previous year with excellent results in small pots. Very large numbers of cottonwoods (at least 20,000) naturally seeded into trenches and several thousand direct seed Osage Orange come up.

Summer 2010: Large, small and "cone-tainer" plantings continue through end of grant with last 1000 hand planted end of August. Spring floods gave way to severe drought and major effort required re: irrigation. 2 large ponds drained almost completely and a 3rd 2/3 of way. Water wagon ran almost daily, not infrequently all day. Major effort of competition control with mechanical tillage with 2 tractor tillers. Attempts at smaller hand tillers and hand weeding necessary and productive but overwhelming.

Major efforts at chemical control fail (Post plus) and strong advisement for foresters not to try Round-up this year. Noted major wind problem with daily significant winds preventing spraying attempts. Mowing of all plantings to facilitate mulching and tillage attempts. Large scale mulching with classic woody mulch and compost and hay/dirt mix. This proved to be our best means of control.

Sept 23, 2011: End of project timeline. Work continues with ongoing seed collection, large scale composting and mulching. We will be adding water lines to initial 2008 plantings to catch them up.

Map of project (scale 1 inch equals 1500 feet)

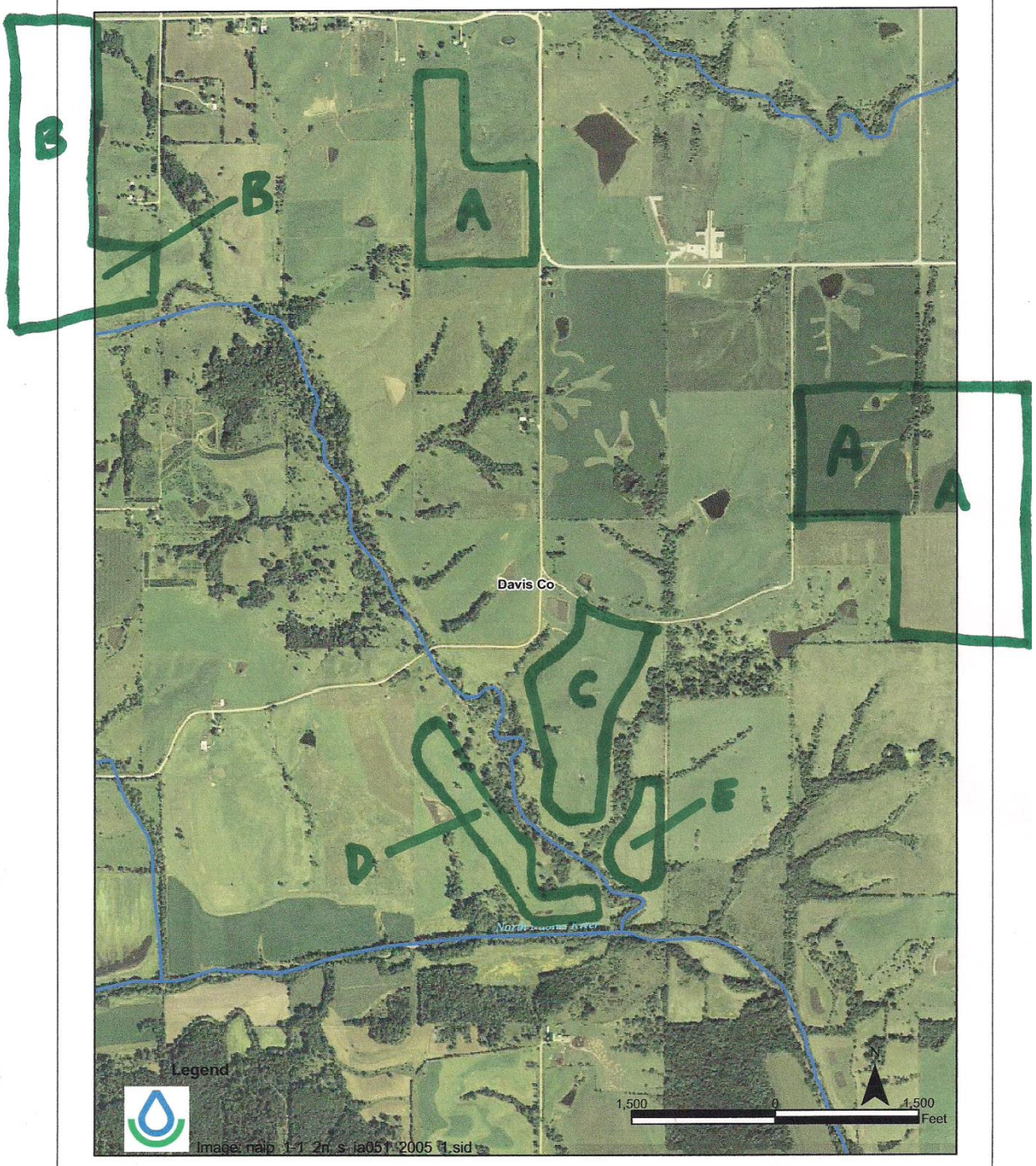
A) 100 acre 2008 plantings sod scalped on 12 foot rows following contour. 30,000 bare root Osage and 19,000 Cottonwood planted. Entire area direct seeded with 1.5 million Osage seeds. All cottonwoods are dead but large numbers of Osage remain.
B) 2010 plantings Site A. Mixed plantings into trenches with large and small containers, direct seed and bare roots into "container in ground"
C) 2010 plantings Site B. Mixed plantings with large number bare roots into "container in ground", direct and natural seeding and large and small containers.
D) 2010 plantings Site C Mixed plantings with large number bare roots into "container in ground", direct and natural seeding and large and small containers.
E) 2010 plantings Site D Marginal Black Walnut planting (bottom ground but flooded out with heavy spring rains) but enormous numbers of Cottonwood in natural seeding.

See next page for map.

Customer(s): ALAN GRAVETT **Conservation Plan Map** Field Office: BLOOMFIELD SERVICE CENTER

District: DAVIS SOIL & WATER CONSERVATION DISTRICT

Legal Description: 31,32,5 Wyacondah Agency: USDA-NRCS Land Units: Tract: 9707 Field:



Summary of successes and failures: Thanks to flexibility of NRCS staff which we were granted in the extension we were able to establish a large initial attempt at a woody biomass plantation/ in the ground container nursery by adjusting the plan when encountering problems. Our only real disappointments was poor growth on Black Walnut planted on bottom ground due to flood like conditions on bottoms in the spring and total failure of chemical weed control. If the project was to be done over again I'm not sure we'd do anything different except for 2 equipment issues. 1) A converted fertilizer wagon we purchase functioned very poorly to distribute san into trenches and 2) Despite purchasing a top of the line F-450 truck to haul mulch and trees with we got very poor gas mileage pulling loads (7-8 miles/gallon) contributing to our need to minimize hauling. We also would need clarification of payment criteria for any consultants.

Quality Assurance: As we lost all our initial consultants due to payment problems true quantifiable QA was somewhat limited. By holding regular management meetings and continuing to consult NCAUR and forestry professors (significant input from University of Missouri department of Agroforestry) we did produce a quality project.

Findings, Conclusions and Recommendations: These are summarized in the executive summary and are not reproduced here.

Appendices: None

Technology Review Criteria: Given the unique nature of this project, the loss of consultants and the large amount of production performed in the last 1 ½ years it might be prudent to re-evaluate this project in a year or two before making recommendations for technology change recommendations. As this project now represents my life's work I remain available for consultation for development of any requested criteria.