



Biochar

By Doug Cram – Extension Forestry and Fire Specialist at NMSU

Over the last four years the number of biochar inquiries that have come across my desk have increased. Biochar production and application is an emerging technology which is increasingly attracting the attention of investors, entrepreneurs, and researchers. Given my title, most of the questions I receive are related to forestry biomass, restoration incentives, and developing potential markets. However, outside of the woods, most of the today's biochar interest is focused on agriculture uses, "green" energy, and carbon sequestration. There remain numerous questions that science, technology, and industry are trying to answer. Given the relatively novel interest in modern biochar, below is a primer on biochar, mostly as it relates to forest biomass.

What is Biochar?

Simply stated, biochar is a form of charcoal produced as a byproduct of pyrolysis. Technically, you could sear your next steak on biochar if you ran out of BBQ briquettes. Biochar is typically associated with agricultural purposes most notably as a soil amendment. In fact, the technique of using charcoal to improve soil fertility originated in the Amazon basin 2500 years ago. We know this from research on the development of anthrosols (i.e., soils that have been significantly modified by human activities) such as terra preta in the Amazon. Natives in the region created charcoal and incorporated it into the soil on small plots of land. Terra preta, meaning black soil in Portuguese, remains highly fertile even today with little or no application of fertilizers. In fact, terra preta is often dug up and sold in Brazil, an area known for its highly infertile soils. Though far removed from North America, this represents a type of biochar market that entrepreneurs are looking to develop in the U.S.

Additional benefits of amending soil with biochar, even in the forest, include: (1) increasing soil capacity to sorb plant nutrients thereby reducing nutrient loss to leaching ; (2) decreasing soil bulk density

resulting in less-compacted soil conditions favorable for root growth and water permeability; (3) increasing soil cation exchange capacity; (4) increasing soil microbial activity and diversity; (5) increasing plant available water retention; (6) providing protection against particular foliar and soil-borne diseases; and (7) increasing crop yields (Zhang et al. 2016). As inferred from the terra preta research, biochar can persist in the soil for extended periods of time – hundreds to thousands of years – because its particulate form reduces microbial decomposition.

Beyond soil amendments, biochar has value including serving as a co-fuel alongside coal, filtering pyrolysis exhaust gases, serving as a base product for production of nitrogen fertilizer, and it can be treated with steam to generate activated carbon.

How is it Produced?

Biochar is produced by heating organic waste matter such as wood chips, crop residue, or even manure to temperatures between 572 and 1832°F (300 and 1000°C) in a low-oxygen environment – i.e., pyrolysis. In this application, pyrolysis produces biochar, liquids and gases the composition of which varies by feedstock and pyrolysis conditions. Typical yields are 60 to 75% by weight bio-oil, 15 to 25% by weight solid biochar, and 10 to 20% by weight non-condensable gases typically known syngas as well as minor quantities of methane, tars, organic acids and excess heat. The relative yield of products from pyrolysis varies according to the selected process temperature. Temperatures between 752–932°F (slow pyrolysis) produce more char while temperatures above 1,292°F (fast pyrolysis) favor a greater yield of liquid and gas components. No waste, other than flue gas and ash, is generated in the conversion process as the bio-oil and biochar can each be used as fuel and the syngas can be recycled back into the pyrolysis process, yielding a net energy output.

Forestry Applications

Forest and mill residues are a potential source of biomass feedstock for the production of bioenergy, biofuels, and bio-products such as biochar (residual pecan biomass is also a potential feedstock). Given the concerns for high fire severity across contiguous acres in New Mexico forests combined with the interest to reduce this threat using silvicultural treatments, land managers and entrepreneurs are seeking symbiotic partnerships. One of the considerable obstacles to forest restoration in New Mexico is a lack of economic incentives – particularly as it relates to small diameter material. One component of the solution might be innovative biochar technologies in combination with emerging markets.

In a New Mexico study, Brown et al. 2011 wanted to see if there was a model whereby businesses that harvested biomass could generate a commercially viable product through pyrolysis. Further, despite the increasing interest in forest biomass utilization, the cost of transporting material out of the woods to a central processing facility often exceeds its value. For example, a frequently cited economic rule of thumb for biomass transportation is less than 100 miles. As such, Brown et al. asked an interesting economic question: can on-site/mobile pyrolysis (which is a relative simple process) be a solution to this challenge?

One of the clearest findings from the Brown economic analysis as a whole was that economies of scale were important – small and mobile systems are not typically found to be cost-effective compared with larger systems. As such, the economies of scale arguments apply and suggest that the largest portable system that can be constructed will probably be the most cost-effective to operate. Another serious hurdle for implementing a regional biomass management model involving pyrolysis is the development of an emerging market.

In another study on mobile pyrolysis systems, Kim et al. (2015) reported there were clear opportunities for technical and operational improvements that could be expected to increase the financial viability of such a system (Kim et al. 2015). This is good news for Gordon West and his company Gila WoodNet, located just outside of Silver City. He invested in biochar technology with hopes to further develop equipment and markets. He was recently quoted as saying “A pound of woody biomass can produce a half pound of biochar and 60,000 BTUs of thermal energy. If the biochar is used in the soil, it may be sequestered for a thousand years or more. If the energy released during pyrolysis is utilized (displacing an equivalent amount of fossil fuel) and the biochar goes into the soil, for every pound of biomass used, 3.8 pounds of carbon dioxide will be removed from the atmosphere.” He also noted that biochar “has been shown to be effective at neutralizing acid mine tailings and absorbing toxic heavy metals.” (Silver City Daily Press – article by Gwyneth Jones). You can contact Gordon at gordon.west@rtnewmexico.com for more information or to discuss additional entrepreneurial ideas.

By the Numbers:

Badger et al. (2011) valued biochar at “a conservative” \$75 per ton.

Badger et al. (2011) valued pyrolysis oils at \$1.65 per gallon as a fuel oil substitute (based on a fast pyrolysis mobile unit).

Conversion rate in Chung et al. (2012) was 14% (i.e., 3.3 tons of biochar produced from 23.4 green-tons of feedstock).

100 miles is threshold for biomass transportation (Searcy et al. 2007).

Summary

Compared with other renewable biomass energy technologies, pyrolysis processes are proven but optimization still requires additional work. There remains a need for infrastructure on both the supply and demand side for pyrolysis byproducts to become a viable market product. Land managers and consumers may be wary of new technologies or departure from traditional management models, and may need to be educated on the benefits of the process before it is widely accepted.

Literature Cited:

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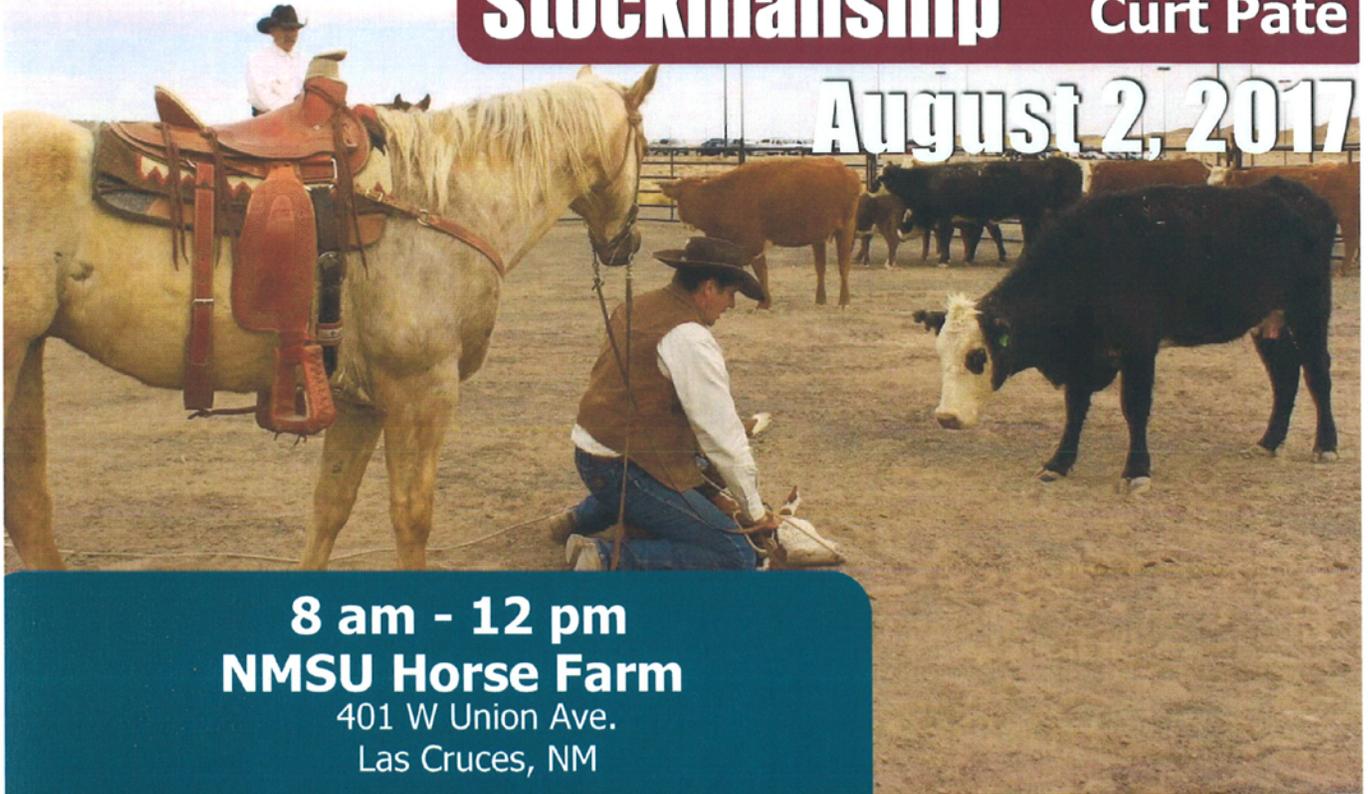


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