Main themes that were repeated throughout the sessions and the day.

Carbon markets need to be created to provide an incentive for reducing carbon from fossil fuels to the atmosphere and sequestering carbon in soils. But, carbon payments are predicted to be of limited value. These may make a project profitable but only on the margin. Alongside the PNW development of carbon market policy and mechanisms is adoption of a mechanism similar to California. This protocol needs review to assess whether it can be adapted to the PNW.

Biochar presents a method for many folks across a broad land base (cultivated agriculture, rangelands, forests and urban settings) and most segments of the economy to store carbon in soils. From urban to rural, and from private to public - almost any land footprint can actively store biochar carbon as well as compost in soils.

Standardized life cycle assessment (LCA) methods are needed to assess and verify carbon and energy savings. Business assessment models are needed to support financial "pro forma" analysis or pre-tax cash flow statements.

Biochar represents a range of products, from acid neutralizing to acid neutral and a range of biological stability depending on feedstock sources and pretreatment methods (particle size, moisture content), thermochemical conversion rates and technologies (gasification, pyrolysis, torrefaction), and conversion temperatures.

In most cases, the biochar value case must include by-product heat uses or bio-oil sales to make the economics work. Biochar as a large scale system may be economically viable at some point. But, current work suggests smaller distributed scale technology with heat recovery (at least) and electrical power generation as needed to make the business case possible.

While scientists and engineers would eagerly study the outcomes of biochar in a range of settings, funding has been limited and seemingly, ever decreasing. Even so, there is a great deal of flux in the demonstrated versus proven benefits of biochar in soils and in remediation applications. This one area is likely the biggest source of dispute about the utility of biochar to address a plethora of challenges. Claims are made and some demonstrated for improved soil productivity, and in

some environmental, stormwater and even drinking water remediation using biochar. What appears to be sure is that, no singular biochar will be able to match well with all applications.

Published and peer reviewed journal articles are broad spread on whether biochar provides certain benefits for improved soil productivity. On the other hand, critical reviews may lack true global representation from the cultures where biochar has been an historic practice that has been a matter of scientific scrutiny. This question may resolve itself by the sheer weight and magnitude of a move toward char production as it is realized that there are numerous other benefits such as combined heat and power (CHP) that can be attained and char may become an outcome of biomass resource uses.

Biochar provides a number of attributes, depending on source and process. The industry will need to step forward to fill the gap with well characterized biochar. And, biochar will need to match field soils and climatic conditions. Engineered char or designer char is on the horizon. Biochar designed to address a particular application is being investigated in university laboratories. The industry will need to provide clear demonstration of applicability to a given setting and set of challenges and intended outcomes.

Biomass feedstock resources are abundant in the PNW. The shutdown of the Kimberly Clark mill in Everett put 450,000 tons/yr of hog-fuel on the market which caused an immediate halving in prices, dramatically impacting businesses in biomass markets. As a corollary, many resources are already centralized in systems of collection transport and use or disposal at facilities in the waste sector of the Washington economy.

Forest biomass is broadly spread across the landscape. Systematic collection and pre-treatment was identified as a continuing challenge. Forest logging and thinning debris pile reduction methods are being developed and demonstrated. Equipment to bundle, load and transport branches and tops at the landing have been developed. Integration of these and additional technologies into practice are necessary.

Priority Projects:

This section is intended to provide a list of priority projects from the meeting notes by work group. These may or may not be the most optimized current priority for each work group. What is clear is that we must identify one or two projects on which to complete field demonstration and assessment. Each field project will require meeting the following level of activity.

- A well characterized biochar
- Field application (soils, remediation swails, rain water runoff, etc) characteristics with which to match biochar
- Biochar matched to field conditions to create a testable hypothesis
- A supplier that can provide consistent materials for the scale of the project
- Field application expertise
- Assessment methods
- Laboratory support
- Funding (if and when in-kind or matching services, equipment and materials) where necessary
- Schedule of activity
- Reporting

**Brief summaries of the Building Northwest Biochar Markets meeting (November 19th) work groups are provided further below.

Priority Projects for the Agriculture Work Group:

Best potential field application projects to carry forward include.

1. Greenhouse production of seedling trees and nursery plants. Use char to replace vermiculite, combined with compost to replace peat moss and heat from pyrolysis to heat greenhouse.
2. Apply biochar in production agriculture setting to address soil conditions for a commodity crop or to elicit higher produce quality from a high value crop.

Priority Projects for the Ecosystems Work Group:

Best potential field application projects to carry forward include.

1. Develop a carbon market and treading value mechanism.
2. Develop a broadly accepted LCA for business case.
3. Integrate Biochar into the current organics composting industry.

Priority Projects for the Forestry Work Group:

Best potential field application projects to carry forward include.

1. Integrate char into a logging practices strategy and implement/assess.
2. Apply char production to field sites with debris piles, use char in the forest, for soils reforestation applications and/or stream side applications.

Priority Projects for the Stormwater Remediation Work Group:

Best potential field application projects to carry forward include.

1. Elwha River Valley restoration project.
2. WSU Puyallup stormwater assessment basin
3. Work with states and municipalities to adopt biochar in standard methods for roadside vegetation, stormwater remediation, etc.

Priority Projects for the Biomass Work Group:

Best potential field application projects to carry forward include.

1. Recovery of wood waste organic wood to CHP, Fuel and char
2. Use char in treating stormwater prior to surface water discharge.

Building Northwest Biochar Markets meeting Top project ideas:

This is intended to distill and focus on project ideas.

Agriculture work group:

Short Term:

- Identify environmental problems in agriculture that specialized/customized chars may be able to address, e.g. Chesapeake Bay poultry runoff management, odor control in manure, reduce soil N2O emissions
- Develop a list of agricultural feedstocks where producing biochar on site could solve an environmental problem and also where heat is already needed; e.g. hops, mint oil; the heat utilization could be the critical economic link
- Identify places (geographical proximity) where synergistic opportunities exist to add biochar production (e.g. link an anaerobic digester, greenhouse, and biochar; pyrolysis heat goes to greenhouse, biochar goes to container mix and nutrient recovery from digester effluent, etc.). Might be an opportunity in the Mt Vernon area – dairies, flower greenhouses
    - NRCS CIG grant opportunity? Would need to be the national level funding to be a large enough grant

Long Term:

- Demonstration of closed-loop system (energy and nutrients) in dairy or poultry industry (Ohio has project underway)
    - Idaho, Westpoint Seattle digester, Farm power
- Develop greater understanding of biochar characteristics (effects of biochar aging, feedstock, process, particle size and post-production handling). Be able to generally understand what types of biochar elicit what sorts of responses.
- Develop actual end use specifications for different biochars similar to what the compost industry has done.

Ecosystems Work Group:

Priorities were categorized into private and public sector. In essence this group said let the private sector lead implementation and field applications, and assign the public sector the responsibility for developing strategies, markets and systems steps for analysis of value proposition to create further implementation opportunities.

Private sector priorities included:

- Brown-field cleanups and preparation for land redevelopment, and
- Advanced treatment processes with biochar for waste water and storm water point and non-point source cleanup, and use biochar for cleanup of surface water impacted wetlands, marshes, and shellfish production.

Public sector priorities included:

- Develop climate mitigation strategies and incentives (markets)
- Develop general LCA template that provides basic framework and support to development of best management practices for specific applications; includes development of characterization protocols and specifications.
- Develop resilient infrastructure to manage drought, reclaim/restore degraded lands, and manage waste.

Many long term projects were identified. Ideas included: sustainable agriculture, carbon farming, best use of biomass/biochar, grazing lands, eco-branded products, water quality, sanitation & waste, ocean acidification, wildlife habitat, nutrient trading/manure, compost, sustainable aviation fuel.

A plan was outlined for immediate and longer term biochar development. General goals were to educate policy makers and the public, fill gaps in knowledge, data and risk assumption, establish job and economic framework for biochar, and add value to the existing organic industry (compost).

The plan identified actions steps with work on a broad range of non-prioritized possible projects and partners. Near term focus was on developing an LCA

approach (SEI and PNNL partners), developing industry standards and management practices based on IBI standards for municipalities and agencies, and conducting demonstrations in a range of settings as follows.

- Wetland restoration (UWa, EPA)
- Drought mitigation on dryland wheat in the Palouse (WSU)
- Pipeline soil remediation
- Willapa Bay shellfish (Sustainable Seafood Initiative)
- Forest fuel reduction (DNR, USFS)
- Urban community gardens (Oregon Tilth)
- Renovation of older industrial parks (Tacoma smelter)
- Manure treatment (Tulalip Tribe, Sunnyside dairies)
- Compost odor control (North Plains, OR)
- Stream/shoreline restoration (SERF, Salmon, Tribes, BPA)

Forestry Work Group: OPPORTUNITIES/MARKETS

The Forestry Work Group focused on small landowners and woody biomass utilization opportunities within the forest and trucked out. The group noted that forest biomass collection is a challenging cost and technical issue, but observed that value added char could offset the high cost of burning and in particular fighting fires. Management practices that result in hazardous fuels build-up in the forest but don't allow for biomass harvest and use create conflicts that must be addressed.

An action item was noted that mobile pyrolysis units are needed for in-the-woods processing. Transportable units add complexity, but a scale unit should be built and tested. Mobil pyrolysis needs to be conceptually coupled with timber harvest. DNR noted that they will provide lead actions in the group.

Market questions that needed work included:

- How do we get carbon credits in the PNW states?
- Who are the customers for biochar?

- The California protocol needs review and consideration – can this protocol be adapted to the PNW?
- How do we establish a very competitive market?

Biochar as a means for water cleanup and purification on the reservation were noted as an area of high interest. Biochar could also support organic farms. Permamatrix (mixture of char, fiber and seed) soil stabilization was observed to have been used successfully to stabilize roadside and disturbed soils. Idaho and Oregon have standards that support biochar in surface soil stabilization but Washington has no use standards.

Heat is a co-product which could be used for greenhouses while biochar has been shown to be successful as a potting media in production nurseries. It was noted that biochar is a growing matrix which is complete with peat moss. It has been observed elsewhere that biochar substitutes well for vermiculite, and compost for peat moss in nursery media. These substitutions could substantially reduce the carbon footprint and cost outlay for production media.

In forest opportunities for biochar included water filtration on road systems, biochar in wattles, as a seed coating to improve post fire re-establishment, wildlife food plots for improving soils and food productivity, in restoring skid trails and in re-establishing forest on road surfaces. Biochar with chitosan is already used in Baker tank filters. Biochar could also be hydraulically applied for burned area recovery. But re-seeding products need to be certified by USDA which is in testing. The performance of biochar in these settings needs review and further work.

It was noted that an accepted set of production standards and some methods of analyzing the cost and benefits of various products are needed. Standards could be through a product certification process, or by testing through the IBI characterization standards with publically available test results. Standard laboratory methods and testing facilities need to be identified. Would this be a national standards program with regional variation or something more regional? The outcomes of biochar use over the long term need to be established.

Stormwater Work Group:

The Stormwater Work Group noted the following near term uses and markets. A large potential market for biochar exist for erosion control, site reclamation particularly at mine sites, restoration, and revegetation. The Elwha River valley restoration was discussed as a large and very current opportunity. Biochar combined with amendments and applied to the river valley sediments that collected behind the dam would be a dramatic project. Biochar could be incorporated in erosion control and revegetation products (e.g. Permamatrix). In order to support these, product specifications would need to be developed and adopted (Washdot Div 8-02, 8-02). Work needs to be taken with the PNW region resource and transportation agencies to standardize these approaches.

Biochar is being used in industrial filtration (zinc roof filters, drains, downspouts), stormwater, landscaping and remediation. This work needs to be tested and verified to measure actual concentrations (benchmark) and reported to agencies or jurisdictions (Zn in downspouts). Biochar uses in commercial and industrial settings must be tested and evaluated.

Municipal stormwater uses for biochar were identified. Testing is needed to demonstrate contaminant (TXX, Cu, ZN. Oil, grease (WA BMPT 7.30 Vol 5, and nutrients) removal and for final stormwater quality outcomes. Biochar combined with compost may be a potent filter. Biochar could also be used in Low Impact Development (LID) or bioretention media if it meets compost definitions.

Highway transportation routes could use biochar in bioswales, or for site restoration (WASHDOT Section 9.14). Several opportunities exist to incorporate biochar in Washington Department of Transportation (WASHDOT) standards. These include: WASHDOT Temporary Special Provision for specific projects, and within general specifications.

Short Term Actions included:

- Incorporate biochar (organic matter) in existing erosion control, site restoration and remediation projects.

- Sell biochar to industrial stormwater sites,
    - Demonstrate uses
    - Monitor results
- Laboratory studies of removal – column tests for Total Cu, Zn
- Fund collaborative monitoring and research (e.g. WSU Puyallup, TAPE)
- Identify collaborators - companies , City, State, Fed, ports
- Develop temporary special provision (WASHDOT), and general specifications that include biochar.

Long-term Markets and Actions included Low Impact Development (LID) facilities or structures which requires approval through demonstration and testing projects (TAPE, BMP). It is necessary to compare compost with biochar in column studies. These activities are begun at WSU, Puyallup's Bioretention stormwater testing facility. Multiyear testing is needed. Funding ($200K-$250K) is needed to fully build out the testing of biochar in these stormwater applications.

Remediation demonstration projects can easily be identified working with municipal, county and port district staff. Funding may come from collaborating with these entities or from state and federal sources. Networking is needed with groups like Washington Organics Recycling Council, US Compost Council or other compost organizations, and organics support organizations such as Biocycle. Biochar producers and users should consider becoming a member of WORC to build collaboration and field use opportunities. In addition, forestry organizations were identified as other collaborators.

Biomass Work Group:

The Biomass Work Group focused on centrally collected largely but not solely urban feedstocks as resources for biochar production. The work group identified and presented the research, demonstration, policy development and production model of technology/process development and steps to commercialization.

The focus was to use existing resources in a bio-refining approach that generates multiple revenue streams. Resources were seen as urban wood waste, mill waste

(pulp/paper, sawdust and bark), bioenergy facilities feedstocks and by-products, and advanced biofuels by-products.

Key direction were discussed.

- Markets dictated by unique characteristics of feedstocks and process technologies
- Integrate with other business synergies, match with appropriate energy needs
- Need robust inventory of thermal uses and opportunities to match feedstock sources for biochar production
- Adding biochar to an existing operation presents O&M challenges

Near-term market opportunities and action steps

- Inventory biochar industry and markets to identify current efforts and specific needs
- Build public/private partnerships to drive R&D efforts: expand field trials to prove long-term efficacy, develop regulatory approval, and adopt BMP requirements to support markets
- Informal advisory group to guide business planning (support through Extension?)
- Douglas fir bark char for stormwater, including field trials in Puyallup
- Nutrient capture (nitrates, phosphates)
- Activated carbon for filtration, e.g. Biogenic Reagents in Fife (feedstocks unknown)

Long-term market opportunity and action steps

- Only other source of predictable feedstock volumes, pricing and characteristics appears to be various forms of mill waste
- Need to identify process technologies and off-takes for char from inconsistent woody feedstocks, e.g. bioenergy facilities primarily producing syngas/biocrude