Extension Service

Corvallis Oregon 97331

THE GRAZIER

No. 334 **October 2008**

John C. Buckhouse
Rangeland Ecology and Management
Volunteer Extension Specialist
John.C.Buckhouse@oregonstate.edu
(541)737-1629

COMING EVENTS:

Oct. 28-30, 2008, Behavior-Based Management—Embracing Change from Genes to Landscapes. BEHAVE contact: www.behave.net

Oct. 28-29, 2008. Big Sky Carbon Sequestration Partnership. Spokane, WA. Contact: Kimi Nygaard; kimi.ngaard@montana.edu

Nov. 5-7, 2008. Watersheds & Climate Change Conference. OWEB. Eugene, OR. Contact: www.oregon.gov/OWEB

Dec. 2-4, 2008 Oregon Interagency Noxious Weed Symposium. Corvallis, OR. For directions contact: http://oregonstate.edu/lasells/gettinghere.html

Dec. 2-4, 2008. Strategy vs System: Grazing for Desired Outcomes. Fort Collins, CO. Contact timothy.steffens@co.usda.gov

Dec. 9-11, 2008. Wildfires and Invasive Plants in American Deserts. Reno, NV. Contact http://www.rangelands.org/deserts/

Agriculture, Family and Community Development, 4-H Youth, Forestry, Energy, and Extension Sea Grant programs. Oregon State University, United States Department of Agriculture, and Oregon counties cooperating. Oregon State University Extension Service offers educational programs, activities and materials without discrimination based on race, color, religion, sex, sexual orientation, national origin, age, marital status, disability, or disabled veteran or Vietnam era veteran status. Oregon State University Extension service is an Equal Opportunity Employer.

Feb. 9-12, 2009. Society for Range Management Annual Meeting. Albuquerque, NM. Contact: www.rangelands.org

Jun. 26, 2009. Department of Rangeland Ecology and Management Annual Field Day. Location TBA. Contact: Mike Borman at michael.borman@oregonstate.edu

Summer 2009. Pacific Northwest Section Society for Range Management Summer Meeting and Tour. John Day Area. Contact: Lynne Breese at jlbreese@crestviewcable.com

WELCOME

Dr. Michael Borman who has been serving as the interim Department Head for the past year has been named Department Head. Dr. Borman's job description includes state-wide Extension Specialist as well as Department Head responsibilities. It is a heavy load, but Michael seems to be holding up well.

Dr. Ricardo Mata-Gonzales has been hired to fill the tenure track ecologist position which the department has held open for the past several months. Dr. Mata Gonzales has spent the past year with the department teaching in a fixed-term position. We are pleased to have Ricardo as part of the Department of Rangeland Ecology and Management team!

SEARCH STATUS

The Department of Rangeland Ecology and Management has received authorization to search for a rangeland plant community and restoration ecology faculty position. This is a tenure-track Assistant Professor position. Details can be seen on the OSU webpage under employment opportunities. Job no. 0003364.

CARBON SEQUESTRATION AND CARBON CREDITS

Dr. Steven Sharrow, long-time faculty member at the Department of Rangeland Ecology and Management, has prepared a two-part series concerning the questions and issues germane to carbon sequestration and carbon trading on rangelands. It is a fascinating arena which has generated a lot of interest and curiosity within the rangeland community. I am sure you will find this series to be of interest and value.

Interest in Carbon Farming is Growing.

Steven H. Sharrow
Dept. of Rangeland Ecology and Management
Oregon State University

Hardly a week goes by now without several news stories about global climate change and the need to reduce the "human carbon footprint" on our environment. The link between rising atmospheric carbon dioxide (CO_2) levels, generally increasing temperatures and human activities is now sufficiently well accepted that legislation to reduce net CO_2 emissions in the U.S. seems inevitable. The European Economic Union has already established economic protocols to reduce their CO_2 emissions and individual states within the United States, including Oregon and California, appear to be following their lead. A formal carbon market, The Chicago Climate Exchange[1], and more recently, a carbon future's market, The NYMEX Green Exchange[2] have been established as brokers rush to secure positions in what appears to be the early stages of a "carbon rush" similar to past gold rushes familiar to us in the western U.S. Such well known corporate giants as Schlumberger[3], JP Morgan Chase[4], and Citigroup[5] have all entered the carbon trading business. Land owners are hearing anecdotal stories of people selling carbon sequestration rights to their lands. So, is land management designed to sequester carbon, carbon farming, a viable way for U.S. farmers, ranchers, agroforesters and foresters to gain income while helping the environment? To answer this question, we need to understand both the global carbon cycle, and how carbon markets are likely to operate.

The Global Carbon Cycle

Carbon is the basic building block of life on our planet. It is also a basic product of oxidation of organic matter to yield energy. This is equally true if the energy comes from you digesting a biscuit or from a power plant burning coal. As with all subjects, the carbon cycle can be as complicated or as simple as one chooses to make it. For our purposes, we can afford to take a rather simplistic view. This is good because much of what we actually "know" about carbon cycling is useful for making generalizations, but may not be entirely accurate for specific places and situations. As we will see later, this can pose some problems for selling carbon contracts on specific parcels of land. Many of the numbers presented in discussing carbon cycling are our best guess. Different people will often have slightly different numbers. The numbers are not meant to be literally true, but their relative size gives some idea of their importance in our discussion.

The total amount of carbon present on planet earth varies little over time. However, the chemical form that it is in can and has varied over time. Carbon occurs naturally both as a gas and as a solid, depending upon the compound that it is part of. Carbon dioxide (CO_2) is probably the most common gaseous form of carbon. Methane (CH^4) together with CO_2 are principle green house gases that trap the sun's energy beneath earth's atmosphere. In moderation, this "greenhouse effect" is critical to maintaining the warmth that makes life on earth possible. When CO_2 levels become too great, however, extra heat is retained and "global warning" may result. So, our discussion of carbon cycling will focus on CO_2. Although most CO_2 is an atmospheric gas, it is soluble in water and a considerable amount of it at any point in time is dissolved in our oceans where it moves with ocean currents. Since cold water can hold more dissolved gas than warm water (the fizzy beer can of warm beer effect), CO_2 generally moves south in cold water currents from the polar regions to lower latitudes where it is released as the water surfaces and warms[6].

Most solid carbon is found as either carbonates (rocks, sea shells), or as organic materials (from plants or animals). To understand mineral cycling, scientists like to look at where things are (storage compartments) and the rate at which they move from place to place or from state to state (transfers). A rough inventory of world carbon is given in Table 1. Several properties become immediately obvious from this inventory. Atmospheric CO_2 is actually a relatively small part of total world carbon. By far the greatest storage area for carbon is in carbonate rocks and sediments. Those of us who have lived in arid or semi-arid areas where the soil is underlain by a thick layer of caliche (calcium carbonate rock), can easily identify with this observation. The geologic processes which govern movement of carbon into and out of rock are relatively difficult for us to manage in a meaningful time frame. Organic matter, such as terrestrial plants and soil organic matter are much easier for us to manipulate. Organic matter is roughly half carbon. The other half is oxygen, hydrogen, and other elements. Together, ocean and terrestrial organic matter contains more carbon than does the atmosphere, giving us hope that we might really be able to effect atmospheric CO_2 levels by managing organic matter. In terrestrial systems, most organic matter is stored in soils rather than in plants or in animal tissue. Fossil fuels are just ancient organic matter. It is interesting to note that although much recent attention has been focused upon scarcity of oil and natural gas, most of the earth's fossil fuel energy is coal. Coal fired plants are major point source emitters of CO_2 and likely targets for carbon reduction or mitigation strategies. Because of its abundance of hydro-power, the Pacific Northwest gets relatively little of its energy from burning coal. Most of our fossil fuel use is natural gas and motor fuels (gasoline and diesel oil).

Table 1. World Carbon Storage

[Billions of Metric Tons]

Compartment		Amount
Atmosphere		766
Soil Organic Matter		1600
Ocean		40,000
Rocks		66,000,000
Terrestrial Plants		600
Fossil Fuels		5000
	Coal	4000
	Oil	500
	Natural gas	500

The amount of organic matter present at any moment in time is the net effect of processes that add vs. processes that remove it from that place. Photosynthesis is the single most important source of organic matter. Plants, ranging from simple ocean phytoplankton to large complex terrestrial vegetation, extract CO_2 from the air or water and combine it with water, using the sun's energy to produce chains of carbon (carbohydrates) that are then employed to build tissue and storage compounds (such as sugars and starches). The process of photosynthesis requires a considerable amount of energy. This stored chemical energy can be released by decomposing the organic matter through oxidation reactions. Two common oxidation reactions are respiration and fire. Both of these reactions essentially undo photosynthesis by converting organic materials back into CO_2, water, and energy along with any minerals present. Most animals derive their energy from respiration (oxidation of organic compounds) which releases previously stored CO_2. Animals are by their nature, therefore, generally sources of CO_2. Plants also get their energy from respiration. In the daytime, photosynthesis often exceeds respiration and we see a net increase in stored carbon, some of which is later consumed by respiration during the night. In balance, plants generally fix more carbon than they use and the surplus is either consumed by animals or is stored in plant tissue, soil organic matter, fossil fuels, or other organic matter (Figure 1).

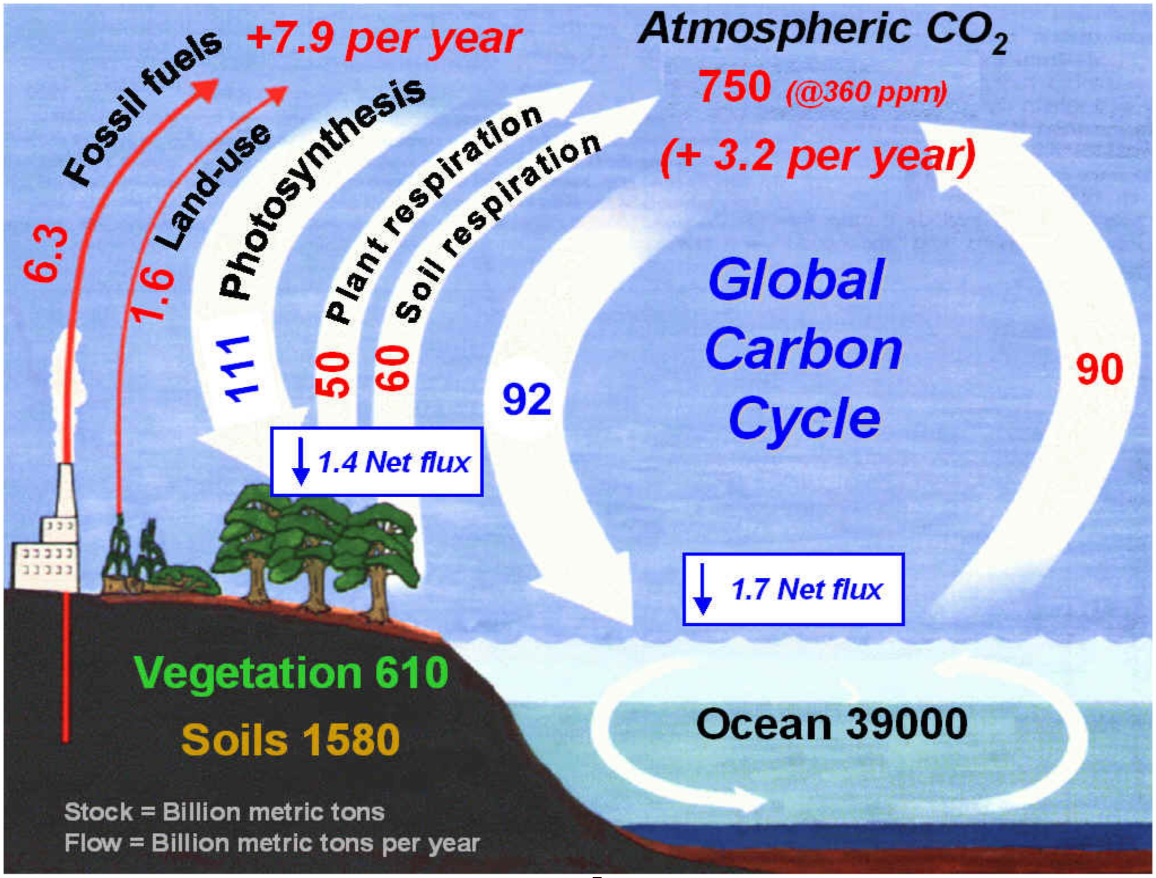

Figure 1. Global Carbon Storage and Flux.[7]

This stored surplus of "sequestered carbon" is about 3 billion tons per year, compared to about 8 billion tons released by human activities. So, the system seems to be out of balance by about 5 billion tons of carbon per year, and atmospheric CO_2 levels should continue to rise at about 3.2 ppm per year unless something changes. Logically, balance can be restored by reducing human-induced CO_2 release and by promoting net organic matter storage, through either increased photosynthesis or reduced respiration. It is unclear how rising atmospheric CO_2 levels and gradually increasing world temperatures will affect the balance of photosynthesis and respiration. Photosynthesis is often limited by CO_2 availability within the leaf, so increasing atmospheric CO_2 levels tends to increase photosynthesis. On the other hand, respiration rates increase with increasing temperature, so higher environmental temperatures tend to increase CO_2 released by respiration. Potential effects relating to vegetation change caused by climate shifts add another dimension of complexity. In any event, deforestation, soil erosion, plowing of agricultural fields and other human land use contributes only about 20% of global carbon release, compared to 80% by burning of fossil fuels. So, it will be difficult to use land use changes alone to offset fossil fuel use. Even if all net carbon release from land management ceased, net carbon surplus (photosynthesis – respiration) from ocean and land ecosystems would have to double to offset current fossil fuel burning. Changes in management of terrestrial and ocean ecosystems to favor increased net carbon storage are potentially very helpful. However, they are not seriously proposed by most experts as the sole solution to global carbon imbalance. Any practical solution will also have to address energy use and how energy is obtained (generated) in a more holistic way than merely trying to mitigate the emissions of current fossil fuel use.

Biological Carbon Sequestration Projects

Oceans cover approximately 70% of the planet's surface and have an important geologic carbon sequestering mechanism that terrestrial systems lack. They contain organisms such as corrals, mollusks, zooplankton, and other animals that extract carbon and combine it with calcium to form carbonates which ultimately contribute to sedimentary and metamorphic rocks such as limestone, marble, etc. The current and potential carbon sequestration of oceans is roughly equal to terrestrial systems in total. There have been some recent proposals to increase ocean carbon storage through ocean fertilization. However, most biological carbon sequestration projects have focused upon terrestrial systems, predominately forests.

Productive forests can accumulate considerable amounts of carbon in tree stems, woody roots, and duff (slowly decomposing needles, leaves, and shed bark). Removal of live trees, disturbance associated with harvest, and increased temperatures near the soil surface generally make newly logged stands or cleared forests net sources of carbon. As the stand regenerates and recaptures site resources, net photosynthesis generally exceeds respiration within 15 years, and rapidly growing tree stands become strong carbon sinks that sequester carbon[8]. This change from source to sink reflects the natural tendency of systems to return to balance after disturbance. The carbon lost following harvest is restored as the forest ages. There is some disagreement among ecologists about whether mature forests continue to accumulate carbon or if they gradually become carbon neutral as increased respiration catches up with photosynthesis in older forests. Since both respiration and photosynthesis strongly reflect site characteristics, the tendency for carbon accumulation to slow as the forest ages is very site specific. Silviculturalists sometimes argue that "decadent" mature forests could be replaced with younger rapidly growing forests that would be stronger carbon sinks. However, this argument generally focuses on the middle, carbon sink, portion of the timber rotation and often underrates the early carbon emission stage. Forest carbon inventories frequently also undervalue stored soil carbon. It is unclear if replacing old mature forests with new young forests will actually store more carbon over the entire timber rotation. Clearly, the length of time the forest is in place (timber rotation) will affect its carbon status. It is generally assumed that longer timber rotations will accumulate more carbon. There is often more total carbon present in old forests than young forests. Carbon accumulates over time as coarse wood debris in the form of dead logs on the forest floor, dead stumps, organic debris in the forest floor (duff), and soil organic matter, as well as standing woody stems in older forests. The more interesting question is whether the rate at which additional carbon is added to storage decreases over time as forests age. A recent study of forests around the world[8] estimated that forests over 200 years old continued to sequester approximately 2.4 tons/ha/year of carbon, of which about 1.1 tons was stored aboveground as vegetation and woody debris and 1.3 tons was belowground in roots and soil organic matter.

Afforestation is planting trees onto areas that recently did not support forest, such as crop and grazing lands). Reforestation is replacing trees that were recently harvested. Afforestation is more attractive as a carbon sequestering mechanism than is reforestation because it lacks the early carbon source stage of a recently harvested timber rotation. Afforestation projects such as agroforestry (producing crops or pasture together with trees) often involve converting croplands or pastures into open canopied forests. Since croplands are often net sources of carbon, agroforests can be very effective carbon sequestration projects.

Grasslands and planted pastures are widely underrated as carbon sinks compared to forests. This is probably because the accumulation of woody material in forests is easily seen and measured.

Although grasslands often store as much total carbon as forests do, they store less in aboveground vegetation and much more in the soil where it is less apparent. Many carbon inventories do not adequately consider soil organic matter. This bias makes forests and shrub lands appear to be more superior to grassland as carbon sinks than they really are. For example, a recent study near Corvallis, Oregon[9] compared carbon inventories for pastures, forests, and agroforests (pasture+forest) growing on the same site (Table 2).

Nitrogen Stored in System Compartments in August 2000 (kg/ha)
Corvallis, Oregon USA

Compartment*	Pasture	Agroforest	Forest	SE
Tree	0	83[a]	50[b]	7
Understory	54[a]	62[a]	59[b]	5.5
Soil	8,879[a]	8,097[a]	7,600[a]	635
TOTAL	8,933[a]	8,242[ab]	7,709[ab]	442

- Tree & understory include both above and belowground biomass
- Soil is the top 45 cm depth
- [ab] Means in a line differ (($p<05$)
- SE is standard error

After 11 years, pastures and forests had roughly the same total amount of stored carbon. However, carbon stored above ground was higher in forests while carbon stored belowground was higher in pastures. Agroforests had both forests' above ground storage plus grasslands belowground storage. So, they accumulated about 500 kg/ha/year more total carbon. Mixed grass and shrub communities, common on western rangelands, will probably have similar carbon storage patterns as agroforests. In all cases, most carbon was stored as soil organic matter. To a large extent, carbon management in terrestrial ecosystems is soil organic matter management! Besides containing carbon, soil organic matter is a primary storage site for soil nutrients, feeds useful soil organisms, holds soil water, and improves soil structure so that rainfall may more readily enter the soil. So, good soil carbon management leads to good soil quality that supports land productivity and stability. Managing for carbon sequestration can be quite compatible with other land management objectives. This appears to offer numerous opportunities to develop win-win land management options.

To be honest, it is very hard to predict how changing land management will affect net carbon storage on a particular site. For example, when grassland is plowed and planted to crops such as corn, the net productivity per hectare may increase because of fertilization and other farming practices. Relatively little of the crop biomass is removed as grain. So, it seems reasonable that soil organic matter should increase. However, we know from experience that it decreases because of increased soil respiration and oxidation of soil organic matter. That said, here is a brief list of some land practices that are likely to increase carbon storage[10]:

1. Rehabilitation of degraded pastures and rangelands
2. Riparian shelter belts
3. Windbreaks
4. Conservation tillage
5. Wetland restoration

6. Afforestation
7. Increased length of timber rotations

Obviously, the ability of any terrestrial ecosystem to accumulate carbon will be related to its climate, soils, and other factors that affect its ability to produce vegetation, as well as its present carbon status. Simply stated, more productive sites and carbon depleted sites have potentially greater carbon sequestration rates and storage capacity. Rangelands often occupy lower potential sites, but their large area makes them a potentially significant carbon sink in total. Grazing lands have been estimated to store approximately 10-30% of world's total soil carbon[11]. Rangeland productivity often varies substantially with weather from year to year. We do not have a lot of reliable site-specific carbon storage data from rangelands, but what we do have[12], clearly shows this variability with the same site often being a net source of carbon one year and a net sink for carbon the next year. Clearly, carbon credit trading on rangelands will have to take a long-term view of carbon storage and monitoring that averages over these yearly climate variations. Most current carbon credit projects use a 10-year-average project projection of carbon sequestered. It is unclear how longer-term systematic climate patterns such as periodic droughts will be dealt with in carbon accounting.

The actual amount paid for carbon sequestration services and the responsibilities of those selling carbon credits in the United States is largely dependent upon political and regulatory decisions that have yet to be made. It is possible, at this point however, to examine the European Economic Community as an example of an existing carbon credit trading system, to examine local western U.S. carbon sequestration projects, and to use current discussions underway in the U.S., to make some educated guesses about the nature of a US National trading system that is most likely to emerge and the price range that carbon credits are likely to trade within. This is the subject of a subsequent article to be published in the next issue of the Grazier.

References

[1] Chicago Climate Exchange Inc., Chicago Illinois. http://www.chicagoclimatex.com/

[2] Green Exchange, New York Mercantile Exchange Inc. http://nymex.greenfutures.com/news/news2.php

[3] Schlumberger Limited, Carbon Services. Houston, Texas. http://www.slb.com/content/services/additional/carbon/index.asp

[4] Gunther, Marc. August 12th, 2008. Cooking up carbon credits. Fortune Magazine, CNN Money.com. http://money.cnn.com/2008/08/11/technology/jpmorgan_carbon.fortune/index.htm?postversion=200808120

[5] Sacholu, Fareed. 5 December 2007. Citigroup hires carbon credit chief. Dow Jones Financial News Online. http://www.efinancialnews.com/usedition/index/content/2349333027

[6] Brewer, P.G., C. Goyet, and D. Dryssen. 1989. Carbon dioxide transport by ocean currents at 25N latitude in the Atlantic Ocean. Science 246(4929):477-479. http://www.sciencemag.org/cgi/content/abstract/246/4929/477

[7] Introduction to global climate change. University of Michigan. 2004. The global carbon cycle. http://www.globalchange.umich.edu/globalchange1/current/lectures/kling/carbon_cycle/carbon_cycle_new.html

[8] Luyssaert et al. 2008. Old-growth forests as global carbon sinks. Nature 455:213-215.

[9] Sharrow and Ismail 2004. Carbon and nitrogen storage in agroforests, tree plantations and pastures in western Oregon, USA. Agroforestry Systems 69:123-130.

[10] U.S. Environmental Protection Agency. 2006. Agricultural practices that sequester carbon and/or reduce emissions of other greenhouse gases. http://www.epa.gov/sequestration/ag.html

[11] Schuman, G.E., H.H. Janzen, and J.E. Herrick. 2002. Soil carbon dynamics and carbon sequestration by rangelands. Environmental Pollution 116:391-396.

[12] Gilmanov, Tagir G. et al. 2006. Long term dynamics of production, respiration, and net CO_2 exchange in two sagebrush-steppe ecosystems. Rangeland Ecology and Management 59:585-599.

If you would like to receive "The Grazier" in electronic format via email instead of a paper copy please contact Connie Davis at Connie.L.Davis@oregonstate.edu This document will need Adobe Acrobat to be read. You can download your free copy of Adobe Acrobat Reader at: http://www.adobe.com/products/acrobat/readstep2.html

Department of Rangeland Ecology and Management
Oregon State University
202 Strand Agriculture Hall
Corvallis, OR 97331-2218