

What Do Landslides Have To Do With Carbon Sequestration

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The development of carbon markets as one tool to reduce greenhouse gases and their role in global climate change has raised society's interest in carbon sequestration and release. Much current research is now focused on changes in carbon storage through forest harvest and regeneration. Redwood National and State Parks may play a role in carbon storage through management of its second-growth forests (see *A 30 Year Retrospective on Restoration of Second Growth Forests* in this issue).

But seemingly unrelated human activities that alter erosion, sediment dispersal, and deposition on the physical landscape underlying the forest may also affect the release and sequestration of carbon in the environment. For example, timber harvest and road construction change the cycling of carbon by accelerating hillslope erosion that increases vegetation loss. Landslides, both natural and human induced, strip soil and carbon-rich vegetation off a hillslope and deliver that carbon to streams.

Widespread landslide activity in the redwood region presumably affects carbon fluxes, but such fluxes have not yet been measured. A quarter of the Redwood Creek watershed shows evidence of earthflows, rock slides, shallow debris slides, and debris torrents. An additional 19% of the watershed exhibits disrupted ground and hummocky topography related to past mass wasting.

In some environments, floodplains help to sequester soil carbon that is exported to rivers from landslides. However, in the steep forested terrain of northwestern California, channels and hillslopes are tightly linked and floodplains are very narrow, if they are present at all. So in this region, landslides are probably more effective at exporting carbon than in sequestration.

A carbon budget can be developed to quantify the amount of carbon inputs, storage, and exports (what is leaving the system) and include carbon stored in vegetation and soil.

Carbon removal by landslides can be roughly calculated using information on soils and vegetative biomass. Landslides in this region typically strip the soil and regolith down to bedrock.

The Natural Resources Conservation Service (NRCS) (<http://soildatamart.nrcs.usda.gov/Manuscripts/CA605/0/Redwood.pdf>) recently estimated the carbon content of the major soil types on park lands.



Regolith is a layer of loose rock fragments covering solid bedrock. The term is a combination of two Greek words: *rhēgos* which means blanket, and *Lithos* which means rock.

For soils on hillslopes where landslides are common, soil carbon content is about 100 Mg per hectare.

A second-growth redwood forest typically has a carbon mass of:

- 100 Mg/ha in soil carbon content (NRCS)
- 290 Mg/ha in live standing trees*
- 24 Mg/ha in snags*
- 17 Mg/ha in dead wood*

(*from Christensen et al. 2008)

Units of Measure

Megagram equals about 2200 pounds.

A hectare is about 2.4 acres.

An acre is about the size of a football field.

Total biogenic carbon for second-growth redwood forests is estimated at 430 Mg/ha. Estimates of carbon mass are currently being refined by more field work in RNSP by the USGS Redwood Field Station.

Using these estimates, the January 1997 storm that initiated landslides covering 45.4 ha in the Redwood Creek watershed removed roughly 20,000 Mg of carbon from the hillslopes and delivered it to Redwood Creek and its tributaries. Larger storms in 1964, 1972 and 1975 resulted in more than 1800 streamside landslides encompassing 630 ha of forested terrain, which would have contributed roughly 280,000 Mg of carbon to the river network. Old-growth redwood forests have significantly more standing biomass (3,500 Mg/ha) than second-growth forests, but no landslides were detected in old-growth redwoods in the landslide surveys. To put our carbon numbers in perspective, a temperate wetland accumulates about 1.4 Mg of carbon per hectare per year.

Perhaps we should consider a reduction in landslide risk as a type of carbon sequestration.

Not all carbon delivered to streams from landslides gets transferred out of the watershed. In-channel storage of wood sequesters some carbon. The fate of trees that enter streams and rivers from mass movements depends on the size and steepness of the channels. Commonly, headwater streams lack sufficient power to mobilize large organic debris, so debris tends to remain in the

channel until it decays or is transported by subsequent debris flows. Farther down the channel network, large woody debris is mobilized more frequently and can form log jams.

In larger streams, where channels are wider than the length of woody debris, log jams become less frequent and debris is found more commonly along channel margins or at the heads of gravel bars. To calculate a full budget for carbon stored within a watershed, much more work is needed to quantify landslides, in-channel wood storage, and how carbon in wood and soil moves from hillslopes to the ocean. The effects of timber harvest, replanting, road construction, road decommissioning, channel excavation and placing wood in excavated road crossings can all be evaluated in light of carbon budgets as well. As we search for ways to reduce, eliminate, or reverse our carbon input into the atmosphere, studies of “carbon geomorphology” will become more common.

References:

Christensen, G. A., S. J. Campbell, and J. S. Fried, eds. 2008. California's forest resources, 2001-2005: Five-year forest inventory and analysis report. Gen. Tech. Rep. PNW-GTR-763. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 183 p.

<http://www.fs.fed.us/pnw/publications/gtr763/>

The Role of the NPS in Carbon Sequestration and Carbon Credits/Offsets

A series of short white papers are being developed by Terry Hofstra, Chief of Resource Management and Sciences Division and Leonel Argeullo, Vegetation Management Branch Chief at the request of Regional Director Jon Jarvis. The goal of these white papers is to explore this topic—in a brief and straightforward format—and add clarity to what is often a confusing topic.

Check out the latest paper on Carbon Sequestration

http://classicinside.nps.gov/documents/2_CarbonSequestration.pdf