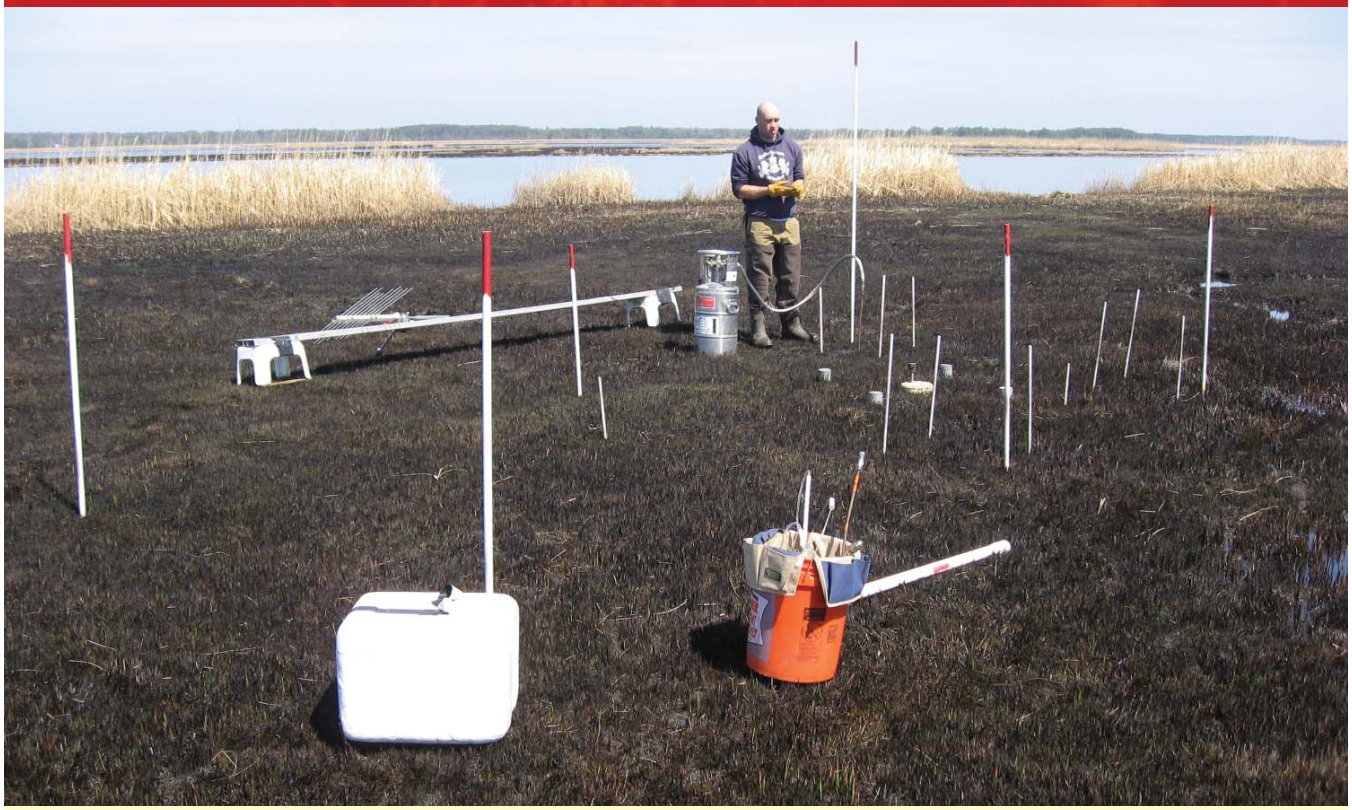
Joint Fire Science Program
Fire Science Brief
RESEARCH SUPPORTING SOUND DECISIONS



A burned marsh plot in Blackwater National Wildlife Refuge, Maryland, with equipment for collecting an accretion core from a marker horizon.

Thumbs Up or Down to Annual Burning of a Tidal Marsh in Maryland?

Summary

Currently land managers at Blackwater National Wildlife Refuge on the Eastern Shore of Maryland annually burn most of the marsh as a way to enhance wildlife habitat, promote habitat for rare and threatened plant species, and avoid hazardous buildups of fuel. However, it was unclear how this regimen affects the elevation of the marsh and marsh sustainability. This research attempted to answer those questions, which are critical in light of expected future sea-level rise. The method used allowed the scientists to measure marsh surface accretion (building) and elevation trends, and to determine the separate influence of surface and subsurface processes on marsh elevation change. Annual burning proved to have a less negative effect on factors influencing marsh vertical development than did no burning, a 3–5 year burn cycle, or a 7–10 year burn cycle. The scientists caution that these results are not transferable to other places because of the unique hydrology of the area. They note that in the adjacent state-owned marsh, the results would likely be vastly different. They also note that this is a short-term study covering only three fire seasons and two growing seasons, and that the long-term results of the longer burn cycles will not be clear for another 30 years or so.

Key Findings

- The rate of surface accretion was higher than expected—about 6 to 7 millimeters per year, which is greater than local relative sea-level rise of about 3.5 millimeters per year.
- Annual burning has a positive effect on plant production both above- and below ground.
- Plant growth in the root zone played a greater role in marsh elevation on the annually burned area than in the no-burn, 3–5 year burn, and 7–10 year burn areas.

Annual burning: Does it make sense?

Prescribed burning is a common practice in marshes. It was developed in the Gulf Coast, where it's typically done every 2–4 years. It's used in Blackwater National Wildlife Refuge (NWR), Maryland, to knock back the perennial saltmarsh cordgrass (*Spartina patens*) and to encourage annual wildlife food plants such as Olney 3-square (*Schoenoplectus americanus*) to grow and increase in density. About 3,000 acres of marshland are burned annually at Blackwater.

Blackwater includes more than 27,000 acres of tidal marsh in the Chesapeake Bay system. The refuge is an important stopover point for migratory waterfowl on the Atlantic Flyway and is home to several threatened species, including the Delmarva fox squirrel.

Some people wonder if prescribed fire in marshes may contribute to their demise. More than 5,000 acres of marshland have already been lost at Blackwater over the last 100 years. Blackwater has the highest rate of wetland loss in the Chesapeake Bay system. Concern over marsh loss arises because of the potential for sea-level rise with global climate change, and also because of possible effects on secretive marsh birds and other sensitive wildlife.

"There was a concern that if you burn it every year, what effect does that have on the ability of the marsh to accrete, or build, vertically?" says Donald Cahoon, research ecologist with the U.S. Geological Survey, Patuxent Wildlife Research Center. "If you use an analogy of an automobile, are you just holding the gas pedal down to the floor and burning up all of the fuel in the system?" By cranking up the plant growth, as we know fire does, is the refuge using up all of the basic minerals and sending them off into the atmosphere via burning?

"Our most critical science need is to know if an annual return fire interval adversely or positively affects marsh elevation, and whether fire is contributing to or slowing the loss of marsh habitats."

Suzanne Baird, refuge manager at Blackwater, has stated, "Our most critical science need is to know if an annual return fire interval adversely or positively affects marsh elevation, and whether fire is contributing to or slowing the loss of marsh habitats." These questions became the research objectives for this project.

Refuge managers wish to identify the reasons for marsh loss so they can attempt to mitigate them, if possible. "Understanding the relationship between fire, organic matter accumulation, and marsh sustainability is important in recognizing the limits and consequences of fire as a management tool in these coastal wetlands," Cahoon notes.

"From the very beginning," admits Cahoon, "I was one of the skeptics. I was right there with most people—almost everybody I know was highly skeptical of an annual burn program." Studies Cahoon had done on burns in the Gulf Coast gave him this gut feeling, but there were no data to prove it.

First steps toward answers

In 1998, the refuge set up a network of sampling stations with four different treatment levels. From the 1970s up until 1998, managers had burned these marshes annually. So in 1998 they stopped burning the control plots. They just kept burning the annual plots annually. They stopped burning two other sets of plots annually and put them on a return fire frequency of 3–5 years or 7–10 years.

Prescribed burns are conducted between January 1 and March 15. The dates are chosen based on a formula that accounts for temperature, winds, soil moisture, and humidity. The same formula has been used since 1970. The goal of the prescribed burns is to "ensure a surface burn with 1–2 inches of vegetative stubble remaining."

Burned marsh at Blackwater NWR.

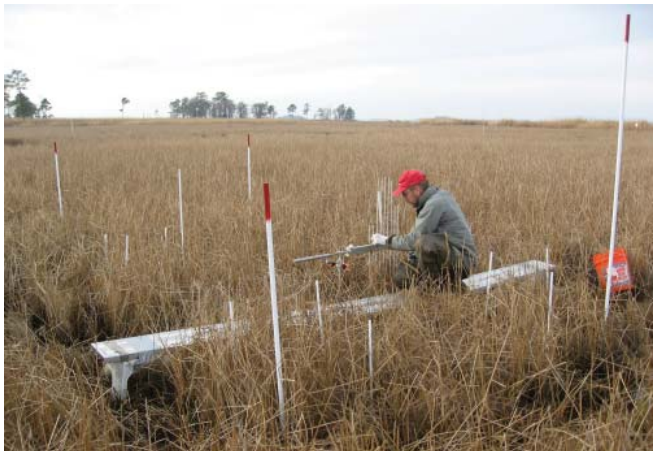
A scientific review in 2003 revealed that the data being collected were not addressing the question of whether the marsh was gaining material faster than sea level was rising. So the refuge managers asked Cahoon and his colleagues to set up a more elaborate study to determine this. With Joint

Fire Science Program (JFSP) funding in hand by 2006, the project began.

Complex methods required

Cahoon's crew used the surface elevation table-marker horizon (SET-MH) method to "measure surface accretion processes with a marker horizon and measure elevation change of the marsh surface relative to the base of the SET benchmark," which is a stainless steel rod driven into the ground up to 60 feet in these marshes. The method allows simultaneous data gathering on both surface deposition and total elevation change. The latter reflects surface deposition and any changes below ground to the base of the SET benchmark. These changes could include surface erosion, root growth, root decomposition, shrink-swell of soils from variations in water level, and auto-compaction of peat.

Surveying marsh plot elevations in a *Schoenoplectus americanus* marsh is an important step in establishing a SET-MH study site.



Collaborator Jim Lynch collecting baseline SET data in 2006.

The method allows the scientists to tease apart the effects of fire on organic matter accumulation both above and below ground. By subtracting the elevation data from the marker horizon accretion data, Cahoon notes, you can determine what part of the elevation change comes from surface and subsurface processes. This is important to know because the Blackwater marsh system receives virtually no incoming sediment from rivers. So that leaves accumulation of organic matter below ground—root growth—to build the marsh vertically. The changes are tiny every year, but it's critical to be able to distinguish building processes if we are to accurately determine the effect of prescribed fires.

An additional benchmark at 30 centimeters—the bottom of the rooting zone—allowed the team to separate out the contribution to marsh elevation in the rooting zone from deeper processes such as compaction. The critical measures here are how did fire affect the thickness and elevation of the root zone and did different fire return frequencies affect these measures differently.

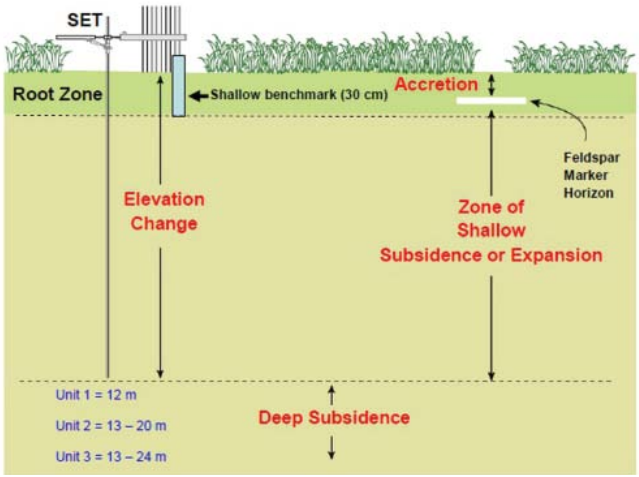


Diagram showing the portions of the soil profile measured by deep and shallow surface elevation table benchmarks and marker horizon techniques. Credit: Donald Cahoon.

Cahoon developed the SET-marker horizon method himself, and says that it is necessary to be able to tease apart the various processes occurring in the marsh. "If you know what the key process is controlling elevation, then you know what to manage," he says. For example, there's not much you can do to remediate physical compaction or shrink-swell of the peat layer caused by fluctuating river levels. "But if it's biologically driven—mostly a root zone component—then do whatever you can to maximize root growth," he adds.

In addition to the SET protocol, the research team also measured litter accumulation, root production, soil organic matter/ash, soil carbon/nitrogen, soil bulk density, biomass and community structure, and other variables.

Annual burning is the best option for Blackwater

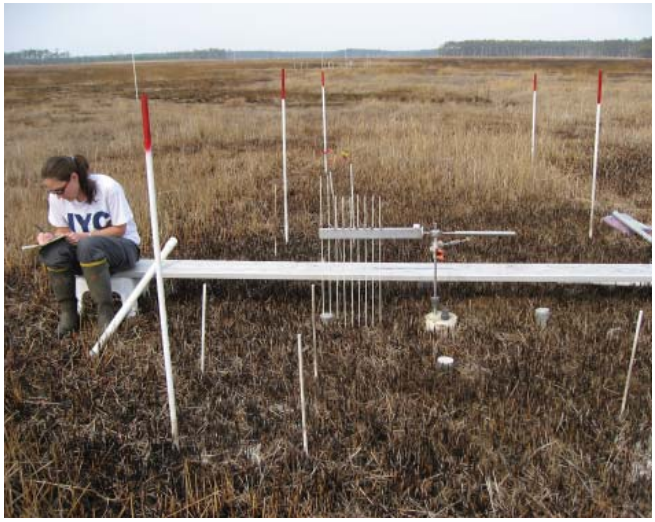
The measurements revealed "surprisingly high rates of surface accretion: 5–6 millimeters a year, 7–8 millimeters a year in some places," Cahoon says. These are greater than the local rate of sea-level rise of 3.5 millimeters per year.

Cahoon explains: "Basically the marsh is falling apart. So material that's being released as it falls apart is just being redeposited on the marsh surface. That's very typical. You see that everywhere that marshes start to disintegrate."

As to the main question of the research, Cahoon says, "At the moment, the no burn, 3–5, and 7–10 year burn areas

are responding the same," with no statistically significant differences among them. There was, however, a strong significant difference in many variables for the annual burn plots. He says it would take at least another 30 years to accurately distinguish any differences among the treatments.

"Annual burning had a strong positive effect on plant production above ground and below ground and on stem density," Cahoon states. "So clearly burning was having a positive effect on plant productivity, which in this system is essential because we're not getting any mineral sediment in, so you've got to get your vertical development through the plant growth."



Recording data at a SET-MH sampling station after a prescribed fire.

The annually burned areas had up to 100 percent greater stem density and root production than the other three treatments. The relative proportion of *Spartina patens* and *Schoenoplectus americanus* did not change significantly. Cahoon notes that annual burning could produce positive effects on plant growth via some combination of a fertilization effect, less shading, and higher soil temperatures.

There were, of course, also significant reductions in fuel loads in the annual burn plots versus the other three treatments because with fire you're burning up the litter from the plants.

Another key finding was that root zone subsidence (sinking) was smallest in the annual burn plots. The trend in elevation contribution from the root zone was not statistically significant (not significantly different from zero) in any treatment, but Cahoon notes that evidence of root zone collapse was smallest in the annual burn plot.

"The bottom line is that since there were no statistically significant effects of annual burning in terms of elevation trends," says Cahoon, "we couldn't say that annual burning significantly influenced elevation trends and therefore was something you should keep doing. But what we could say was it certainly isn't doing any harm compared to the other three treatments."

The authors explain in their final JFSP project report that "in this mineral sediment–poor estuary, marsh vertical development is driven primarily by the accumulation of plant matter in the soil (roots and rhizomes). Thus any activity that affects plant productivity can affect the ability of these marshes to keep pace with sea-level rise."

Cahoon's crew did not make specific recommendations for refuge management, but he does acknowledge that "annual burning is the best situation you've got out there. I think it's pretty clear that they can keep using annual burning, because it has either a positive effect or a less negative effect" than the other three treatments.

Cahoon cautions, however, that the work is "as much a study of the effects of a release from annual burning as it is an evaluation of the effects of annual burning," because the longest burn-free period is only 11 years, just more than the longest previous burn cycle.

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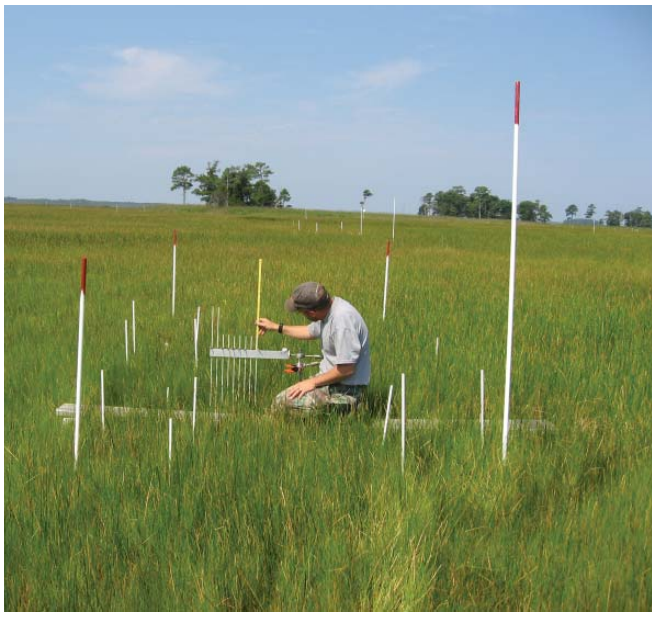
Site-specific results

Cahoon notes that the results obtained for this marsh in Maryland can't be generalized to anywhere else. "What we're finding in all the work we've done all over the world with this methodology," says Cahoon, "is that everything is very site-specific. You can't take what we're finding here at Blackwater and apply it to Long Island or wherever, because differences in tidal range, differences in sediment supply, differences in geomorphic setting—they all have a huge influence on these dynamic processes that go on within a marsh. So I think it's very important that people try not to jump to conclusions and apply this to other places. That's clearly a dangerous thing to do."

He notes that Blackwater, particularly the inner part of the refuge, where marsh loss is occurring and the study treatments are located, has an unusually small tidal range—the difference between high and low tide—only about 5 to 7 centimeters. This is because it's a ways up into the bay estuary and because a road crosses the marsh and partially impounds the marsh water, thereby limiting the inflow of water and sediment to the marsh. The road was installed at least 100 years ago for a commercial shipping operation.

Funding for long-term monitoring?

Because of costs, full-scale monitoring is not currently continuing despite the potential long-term value of the data. Cahoon's group is just continuing to read the surface elevation tables annually. The refuge and its partners are seeking funding for further monitoring at these and other locations throughout the refuge and in the adjacent Fishing Bay Wildlife Management Area, Maryland's largest wildlife management area. They want to determine the elevation across the entire marsh and develop trajectories of elevation in the future. Refuge managers also want to know how the various fire return intervals affect wildlife populations and habitat value.



Reading the SET in a *Schoenoplectus americanus* marsh in summer.

Cahoon and his colleagues would like to repeat the study in Blackwater and establish monitoring sites in Fishing Bay, which has approximately 60 centimeters in metric scale tidal range and receives much more sediment input, making the marshes there 20–30 centimeters higher and more stable and healthy. Cahoon emphasizes that literally 1 kilometer away from Blackwater, marsh hydrology is an entirely different story, so you really can't generalize the results to anywhere else.

Management Implications

- Surface accretion, root zone subsidence, and shrink-swell of sediments are the main forces behind marsh elevation change at Blackwater.
- Annual burning affects marsh elevation both positively and negatively. It significantly stimulates plant growth, which enhances elevation gain, but reduces litter accumulation, which lowers surface sediment deposition. Its effect on marsh vertical development is not statistically significant. The decision of whether or not to continue annual burning requires consideration of tradeoffs.
- Annual burning does not pose a risk to long-term sustainability of the marsh at Blackwater.

Further Information: Publications and Web Resources

Cahoon, D.R., G. Guntenspargen, and S. Baird. 2010. Do Annual Prescribed Fires Enhance or Slow the Loss of Coastal Marsh Habitat at Blackwater National Wildlife Refuge? Final report to JFSP. http://www.firescience.gov/projects/06-2-1-35/project/06-2-1-35_blackwater_burn_final_report_mar_31_2010.pdf

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