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ABSTRACT


I comment on Olea and Coleman’s (2014) conclusion that subsidence was the primary cause of the dramatic rise in Louisiana’s coastal land losses in the last 100 years. The focus on subsidence combined with the omission of context for factors not related to subsidence (e.g., dredged canals), leaves the reader with the incorrect conclusion that anthropogenic factors observed to date are insignificant, and that coastal wetland losses are only driven by subsidence. I address this omission by discussing two points about anthropogenic influences: (1) dredged canals and (2) changes in sediment load from the watershed and its distribution. They omit quantitative inclusion of two signature symptoms of the cause-and-effect relationships at temporal and spatial scales. To wit, there are: direct relationships between canal density and land loss over decades and shorter intervals for the whole coast and individual estuaries, instances of indirect losses immediately after canal construction, an increase in ponding near dredged canals but not further away, and, evidence of effective hydrologic barriers created by the spoil bank above- and belowground. The view that geological subsidence exerts a top-down control on the net adjustment to changes in vertical space leads to the narrow view of restoration being modeled using the mineral soils for wetland soils comprised mostly of organics. Further, the decline in suspended sediment concentrations since the 1950s (from dam construction) needs to be put within the context of the landscape changes occurring when European colonization resulted in much higher rates of erosion. The restriction of exclusively geological factors driving land loss is, therefore, an incomplete view of what causes land loss in modern times—and a perhaps dangerously naïve basis for management decisions on this coast. I agree with their conclusions that (1) geological subsidence has not changed significantly in the last 100 years, (2) fluid withdrawal is an unlikely and unproven large enough force to cause the patterns in land loss across the deltaic plain, and (3) acceleration in sea level rise will rise to problematic levels in the near future.

ADDITIONAL INDEX WORDS: Coastal wetland loss, Louisiana, dredging, subsidence, sediment supply.
years with better records. Other factors seem to have had a
more local or temporary influence” (p. 13). This leads to the
conclusion that subsidence is directly related to land loss
(“...complete elimination of this form of subsidence will likely
result in no more than a 5% reduction of subsidence and coastal
land loss”). The focus on subsidence from these four factors
(lithosphere flexure, sediment loading, faulting, and compac-
tion) and on sediment supply, combined with the omission of
context for factors not related to subsidence (e.g., dredged
canals), leaves the reader with the incorrect conclusion that
anthropogenic factors observed to date are insignificant and
that it is only a matter of how much subsidence occurs. I
address this omission herein by discussing two points about
anthropogenic influences: (1) dredged canals, and (2) changes
in sediment load from the watershed and its distribution.

DREDGED CANAL IMPACTS

Canals and the spoil banks created by disposal of the dredged
materials cause wetland loss by the direct replacement of one
habitat with another and the indirect consequences on local
wetland hydrology. Examples of these features are shown in
Figure 1. The total length of spoil banks in 1978 was about
17,894 km (Turner and Streever, 2002, Table 4.1), which is
about twice the distance from Los Angeles, California, to

The total direct effects can be significant. A typical oil and gas
canal is dredged to be about 4 to 5 m deep and 41 to 45 m wide,
which is much wider and deeper than a natural channel in
coastal wetlands. Baumann and Turner (1990) estimated that
approximately 16.1% and 6.3% of the wetland loss in coastal
Louisiana from 1955/56–78 was from the combined effect of
canals and spoil banks, or canals alone, respectively. Britsch
and Dunbar (1993) estimated that the 45,866 ha of constructed
channels dredged from the 1930s to 1990 (in slightly different
mapping units from Baumann and Turner, 1990) accounted for
12% of the total land loss during that interval.

The remaining 84% of wetland loss is from other causes,
including the indirect impacts of canals. The specific mecha-
nisms to explain these effects are not fully understood in each
type of wetland or estuary, but changes in wetland hydrology
are usually the key agent of change because the spoil bank and
channel alter the patterns of water flow, e.g., frequency of flooding
and drying. Spoil banks, for example, are initially at least 1 m
higher than the average tide, which changes the aboveground
movements of water. The spoil weight compacts the soil
beneath it (Nichols, 1959), thereby reducing belowground
water flows (Swenson and Turner, 1987). One of the indirect
impacts of this damming effect of spoil banks above- and
belowground is waterlogging. Longer wetting cycles (waterlog-
ging) may lead to toxic sulfide accumulations and may reduce
the accumulation of soil organic matter; the same damming
effect causes longer drying cycles, which leads to soil oxidation.
Spoil banks can inhibit sedimentation rates (Cahoon and
Turner, 1989). The combined effects of canals and spoil banks
leads to pond formation within 2 km of the canal. More and
larger ponds form with increases in the local density of spoil

Regional or site-specific instances of these spatial and
temporal relationships are available at many scales. One
example involves a canal dredged on the south side of Jug Lake,
west of Houma, Louisiana. The area of adjacent wetland went
from around 15% open water to 85% open water within 2 y

Figure 1. Photographs of dredged canals and their spoil bank in south
Louisiana wetlands. The spoil bank has shrubs and trees on it. The
individual wellhead is in the enlarged area at the end of the canal (called a
keyhole). (Color for this figure is available in the online version of this paper.)

Figure 2. Land loss at one location occurring after a canal was dredged on
the south side of Jug Lake, west of Houma, Louisiana. The area of adjacent
wetland went from around 15% open water to 85% open water within 2 y

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There are several estimates of these indirect losses of land or wetland at an estuary scale, including the following four estimates.

A consensus estimate by 13 coastal scientists who were involved in a landmark study of the topic was that, from 1955/6 to 1978, the combined direct and indirect impacts of canals caused at least 30%–59% of the total coastal land loss in Louisiana (Turner and Cahoon, 1997).

Scaife, Turner, and Costanza (1983) used data on the density of canals vs. land loss in 7.5-minute quadrangle maps of estuarine wetlands of similar geology to estimate the background rate of land loss from all other factors in the absence of canals. Their estimate of the land loss from canals could then be calculated as the difference in the loss rates minus that background rate. Their resulting estimate for the deltaic plain was that 89% of the land loss was due to the direct and indirect effects of canals and the associated spoil banks.

Penland et al. (1996; an unpublished report) provided a subjective estimate that canals were the cause of 35% of the wetland losses for the Louisiana coast.

Turner (1997) presented an analysis suggesting that the best explanation among four competing hypotheses explaining the wetland loss in coastal Louisiana was that the combined effects of the direct and indirect impacts of canals and spoil banks were the more likely cause of these land losses (and not subsidence, river levees, salinity stress, or sediment starvation).

Although these estimates are not in complete agreement, it is clear that a significant amount of wetland area lost along this coast is attributable to the combined direct and indirect impacts of canals and spoil banks.

Two grand patterns are particularly striking, I think, and cannot be ignored in these discussions. The first is the relationship between canal density and land loss for the entire deltaic plain from the 1930s to 1990. The loss rates are directly related to land loss in a dose–response manner, and there is a zero intercept (Figure 3). The second is that there is a temporal coherence between dredging and land loss for the Louisiana coast from the 1930s to 2001 (Figure 4).

It seems to me, therefore, that Olea and Coleman (2014) omit a quantitative inclusion of a signature symptom in the cause-and-effect relationships at temporal (Figure 4) and spatial (Figure 3) scales. I agree with their conclusion that geological subsidence has not changed significantly in the past 100 years and that fluid withdrawal is an unlikely cause of the patterns of land loss across the deltaic plain and whether its force would be sufficient to do so remains unproven. How could the spatial variation, however, not be due to the dredging of canals if the subsidence is unchanged in time and space? If subsidence from fluid withdrawal is not the driver of land loss, then what other factor explains the observed land loss, the absence of loss a few kilometers away from a canal, the losses within 1 km of a canal, and the higher losses where the canals intersect and impound wetlands?

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The rosy picture given by Olea and Coleman (2014) of significant reduction in impacts from dredged canals is a misrepresentation of the actual case. Canal construction may be less than it was in the 1960s, but the reasons have little to do with management. Simply put, the recoverable mineral reserves are dwindling, and the canals already in place are able to reach the wellhead locations using the same drilling-access methods.

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accumulated over centuries and millennia and the modern-day living plant?

This discussion is not to ignore the essential limiting role of sediments comprising the geological structure upon which emergent coastal vegetation has anchored itself, grown, and accumulated soil organics over millennia. The inorganic volume in those surficial sediments is less than 4% (Turner, Swenson, and Milan, 2000). It is the dredging of canals that has affected the green “toupee” overlying the sediments, not the geological structure beneath the emergent vegetation. It is this organic layer that can be compromised when nutrient supply increases sufficiently to stimulate its decomposition and reduce live, belowground biomass, reducing soil strength and making it susceptible to storm-induced erosion (Deegan et al., 2012; Swarzenski et al., 2008). The health of the plants may become compromised with a higher rate of sea-level rise this century, erode at the edge, and migrate inland. I agree completely with the conclusion that acceleration in sea-level rise will become a driving force if it becomes greater than the presently observed limit in vertical accretion (Kearney and Turner, 2014).

**SEDIMENT LOADING DEPLETES**

The second point is related to the “sediment deficit” view of wetland loss and the overstated role of sediment loading from the Mississippi River in controlling wetland gain and loss in the past 100 years. The picture painted is that sediment loading decreased with engineering features (e.g., dams), and its distribution was constrained by flood-protection levees. Yes, sediment loading decreased from the 1880s to present, but the sediment load was higher after the expansion of Europeans into the watershed for 200 years and was so much higher then that the present load is about equal to the precolonization era after dams had been constructed and trapped 50% of the sediment flux upstream (Tweed and Turner, 2012). These culturally induced erosion and coastal accumulations are well known (Bruckner, 1986; Hughes, 1996). The precolonial shape at the river’s terminus has grown and shrunk over decades as this loading fluctuated, but that is not the case for the deltaic plain to the north (Tweed and Turner, 2012). Further, the amount of sediments flowing overbank before flood-protection levees were built was about 2% of the river’s load (Kesel, 1988), and its accumulation would be concentrated no more than a few kilometers from the riverbank (hence the formation of the riverbank levees). Hurricanes, in contrast, bring a larger amount of sediment, which is spread across the coast in a more democratic manner (Tweed and Turner, 2014).

Most of the deltaic plain soils are composed of organic matter, not mineral matter (Tweed and Turner, 2012). Omitting the role of belowground organic matter ignores an admittedly difficult complexity for the geologic-centric view of wetland loss; however, belowground organic matter hosts the consequential set of interactions driving the canal–wetland loss cause-and-effect relationships shown in Figures 3 and 4. Indeed, the view that geological subsidence exerts a top–down control on the net adjustment to changes in vertical space (i.e. from sea level rise above, or soil oxidation within) is an insufficient model for restoration. It leads to the narrow view of restoration being modeled on the basis of sediment flux, and acceptance of using the mineral soils of the receiving basin at the end of the Atchafalaya River and Mississippi River deltas as a legitimate model for restoration success (or failure) in organic soils. The restriction of exclusively geological factors driving land loss is, therefore, an incomplete view of what causes land loss in modern times—and a, perhaps dangerously, naïve basis for management decisions on this coast.

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**LITERATURE CITED**


