The Voluntary Carbon Market: The Next Stage of Non-Structural Engineering

By Jim Blackburn and Elizabeth Winston-Jones

When Hurricane Ike hit in 2008, it marked a wake-up call for Houston and the Texas coast. Ike came ashore at Galveston Bay, meaning that most of the surge, which was higher than the normal Category 2 storm, went east into the relatively undeveloped low-lying lands of Chambers and Jefferson Counties. And although significant inundation occurred as can be seen from Figure 1, damage to the built environment in this area was minimal and recovery quite rapid compared to the western side of Galveston Bay, Galveston Island and the Bolivar Peninsula which suffered $25 billion plus in damage.

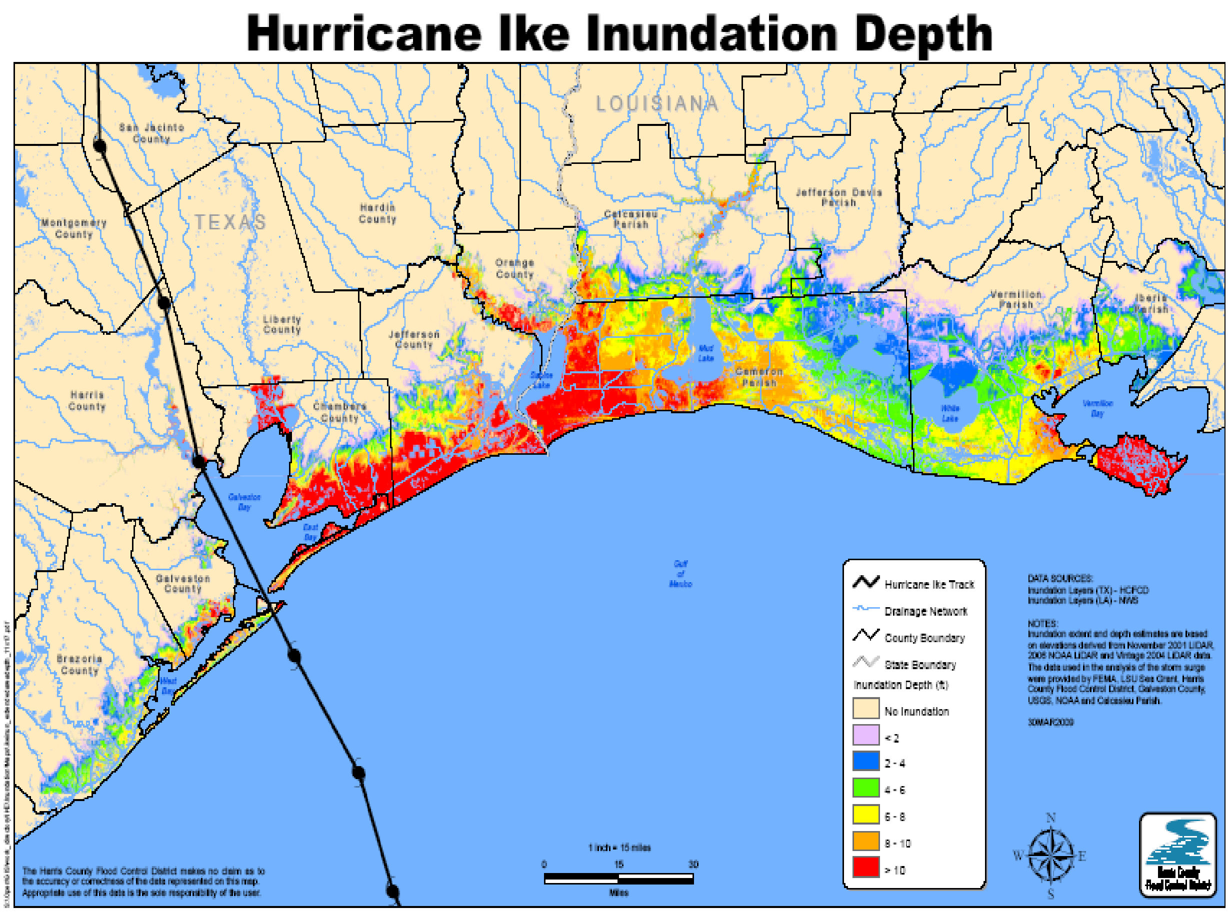


Figure 1. Hurricane Ike inundation depth as compiled by the Harris County Flood Control District. Source: HCFCD.

After Ike, the Severe Storm (SSPEED) Center at Rice University received a grant from The Houston Endowment to study lessons learned from Hurricane Ike. Among the key lessons was the fact that undeveloped low-lying lands survived the storm surge extremely well, relative to the built environment. Interestingly, much of the Texas coast is undeveloped, and much of it is low-lying. Only about 12% of the land area in our coastal counties is developed. This makes sense as almost 45% of the 10 million acres of coastal county land is either extremely vulnerable to hurricane surge flooding or is in the 100-year flood plain as shown in figure 2. Notwithstanding these factors, because of population growth and rising land values, Texas coastal lands are also among the most rapidly fragmenting in the country.

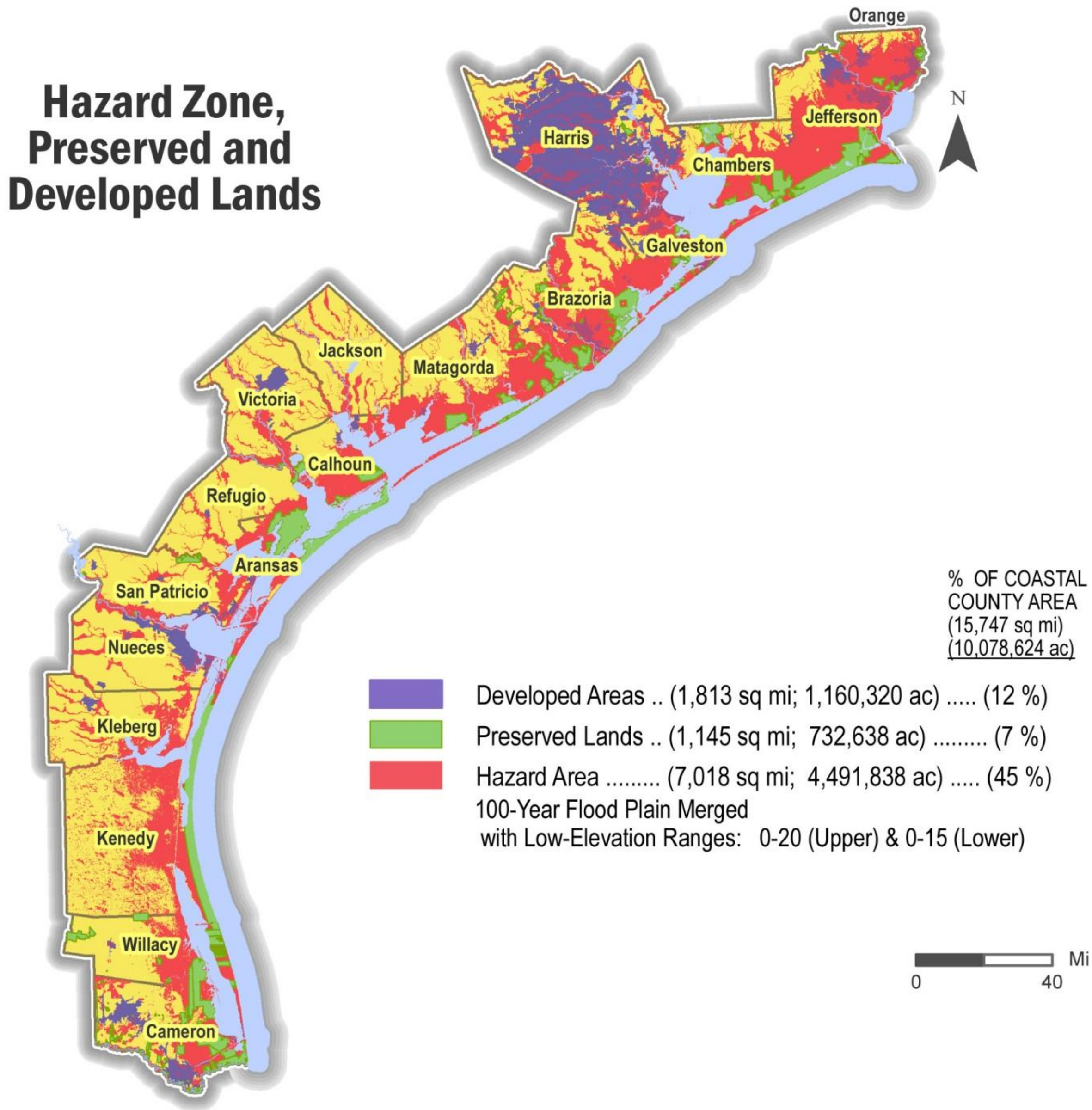


Figure 2. Map of the hazard areas of the Texas coast including lands lying below 20 feet in the upper coast, lands lying below 15 feet in the lower coast and mapped flood plain lands. Source: Blackburn, *A Texan Plan for the Texas Coast,* Texas A&M Press, 2017.

As part of the research, the project team investigated non-structural alternatives to minimize future flood damages in and around Galveston Bay as well as the coast generally. Regulation is one form of non-structural flood control, but regulation is not popular in Texas. On the other hand, money is very popular in Texas, including in the ranching and farming community where landowners are often land-rich and cash-poor. As a result, the project team searched for ways to compensate landowners for protecting their working lands and the ecological services provided by those lands to the community at large, many of which are world-class. In short, we aimed to make open space economically competitive with developed space.

A key idea that emerged from this work was payment for ecological services, a concept popularized in 1997 when Dr. Robert Costanza and a group of environmental economists published a paper titled "The Value of the World's Ecosystem Services and Natural Capital" in *Nature* (Vol. 387, 15 May 1997). Dr. Costanza and his co-authors identified a number of services provided by wetlands, prairies, forests and flood plains, among others, and identified a range of values from $2,000 to $10,000 per acre per year. And while there was no current commodity market for many of these services, such as nutrient removal or flood storage, the SSPEED project team homed in on carbon sequestration as an ecological service that individuals and local industries might be willing to purchase as climate change was emerging as a risk and reducing or eliminating carbon footprint was becoming top of mind for many.

The basic idea is quite straightforward. The plants in coastal prairies, forests and marshes grow using a process called photosynthesis, which draws carbon dioxide (CO2) out of the air and stores it in the plants and soil. In exchange for managing their farms and ranches to optimize the capture of carbon dioxide for 15 to 20 years, landowners would be paid by emitters that wanted to have their carbon dioxide emissions captured and stored. At the time, pressure had been growing on industry to begin to address climate change, and with the signing of the Paris Accord in 2015, many industries began to make public commitments to reduce or eliminate their carbon footprint. As such, a symbiotic relationship was sketched out by the project team where industry paid rural landowners for removing their carbon emissions from the atmosphere and storing it as shown in Figure 3. In the process, the land was also conserved for flood storage.

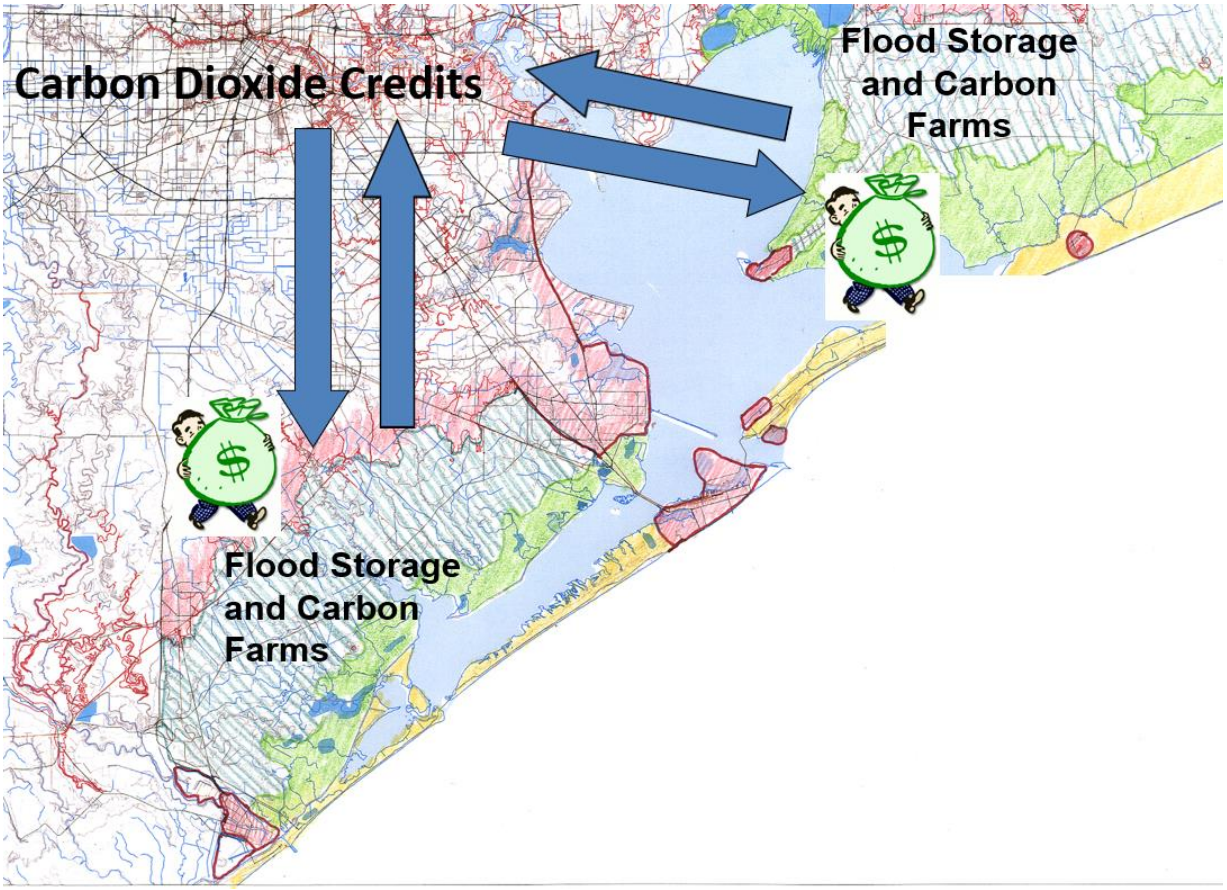


Figure 3. Conceptual diagram of the symbiotic relationship between carbon emitters and rural landowners who manage their lands to store carbon (and floodwaters). Diagram courtesy of SSPEED Center.

The next stage of the SSPEED Center work was to study the carbon credit market in detail. Numerous registries existed at the time and all worked on the same framework. For each ton of carbon dioxide removed and stored, a credit is issued. That credit could then be purchased by the emitter to help bring their emissions to net zero, which is an international goal for 2050, if not sooner.

However, to turn carbon collection and storage into a commodity, a structure with participants and processes needed to be created. As can be seen in Figure 4, there are many pieces to the carbon trading process. There must be a registry that sets standards and protocols. There is also the project developer who works with a landowner to develop a plan that meets the registry's protocol which they then submit to the registry. The registry then confirms through verification and validation that the registry's standards are met and, if so, issues credits to the developer who then sells to a buyer, who is likely meeting the needs of their own shareholders and stakeholders.

After reviewing the existing carbon credit registries, the SSPEED Center team, with the assistance of a stakeholder group formed at the Baker Institute at Rice, determined that these existing registries would not work for Texas landowners. With the assistance of the stakeholders, we created the independent non-profit registry, BCarbon.

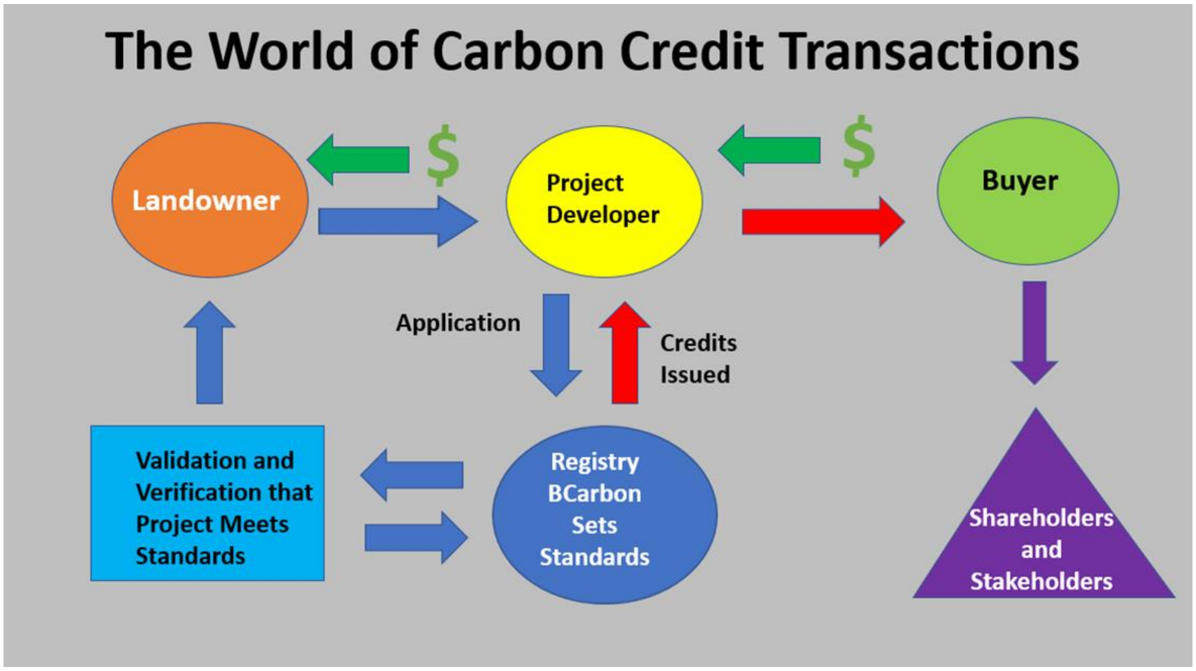
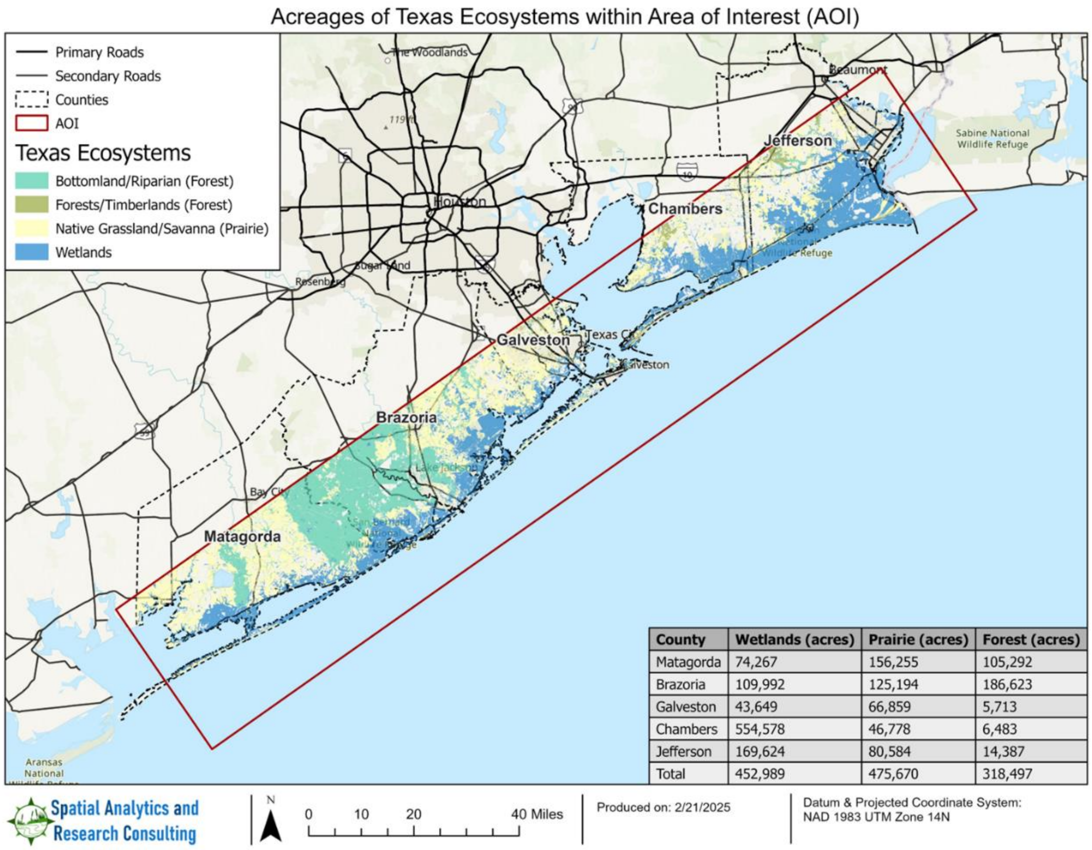


Figure 4. The world of carbon credit transactions showing relationship between the project developer, the landowner, the registry and the buyer with the verification/validation process included along with the buyer reporting to shareholders and stakeholders. Image by author.

Coastal Flood Protection and Carbon Credits

Keeping open spaces open as a means of coastal flood protection can include soil, forest or saltwater wetland carbon credits, and depends on the physical characteristics of the land area. As shown in Figure 5, in the five counties of the Upper Texas coast – Matagorda, Brazoria, Galveston, Chambers and Jefferson - there are 1.2 million acres subject to surge flooding. Of this, 475,670 acres are prairies, 318,497 acres are forested, and 452,989 acres are saltwater wetlands.



County	Wetlands (acres)	Prairie (acres)	Forest (acres)
Matagorda	74,267	156,255	105,292
Brazoria	109,992	125,194	186,623
Galveston	43,649	66,859	5,713
Chambers	554,578	46,778	6,483
Jefferson	169,624	80,584	14,387
Total	452,989	475,670	318,497

Figure 5. Five coastal Texas counties showing ecological resources within the coastal surge hazard zone. Image by Spatial Analytics and Research Consulting (SPAARC) for the author.

Consequently, BCarbon developed protocols for these three ecosystems. For soil carbon, the methodology requires measuring the carbon in the soil at the outset to establish a baseline, then measuring again at year 5, with carbon credits being issued for the difference between the baseline and year 5. Similarly, the forest carbon is measured to establish the baseline and then measured again after five years. For coastal blue carbon, an initial protection credit will be issued following the construction of a living shoreline to protect the coastal wetland from loss due to erosion from wave action or inundation by sea level rise. Following that, annual drawdown credits will be issued and measured on a 5-year cycle like prairie and forest. For the annual credits, in addition to meeting the protocol standards, the landowner commits to a 15-to-20-year term during which the ecosystem will not be disturbed in a manner that releases the carbon, and efforts may be made to enhance carbon uptake.

Although testing is required every 5 years, literature and on-site, real-time observations and data exist for both soil and forest carbon that provide a basis for estimating carbon dioxide removal rates. In the Upper Texas coastal region, reasonable estimates for annual carbon uptake are: one ton per acre per year for prairies, three tons per acre per year for hardwood bottom land forests, and two tons per acre per year for saltwater marshes. Additionally, approximately 50% of protected saltwater marsh will be eligible for protection credits associated with construction of living shorelines, and a reasonable estimate for the avoided release due to that protection is about 400 tons per acre as a one-time award.

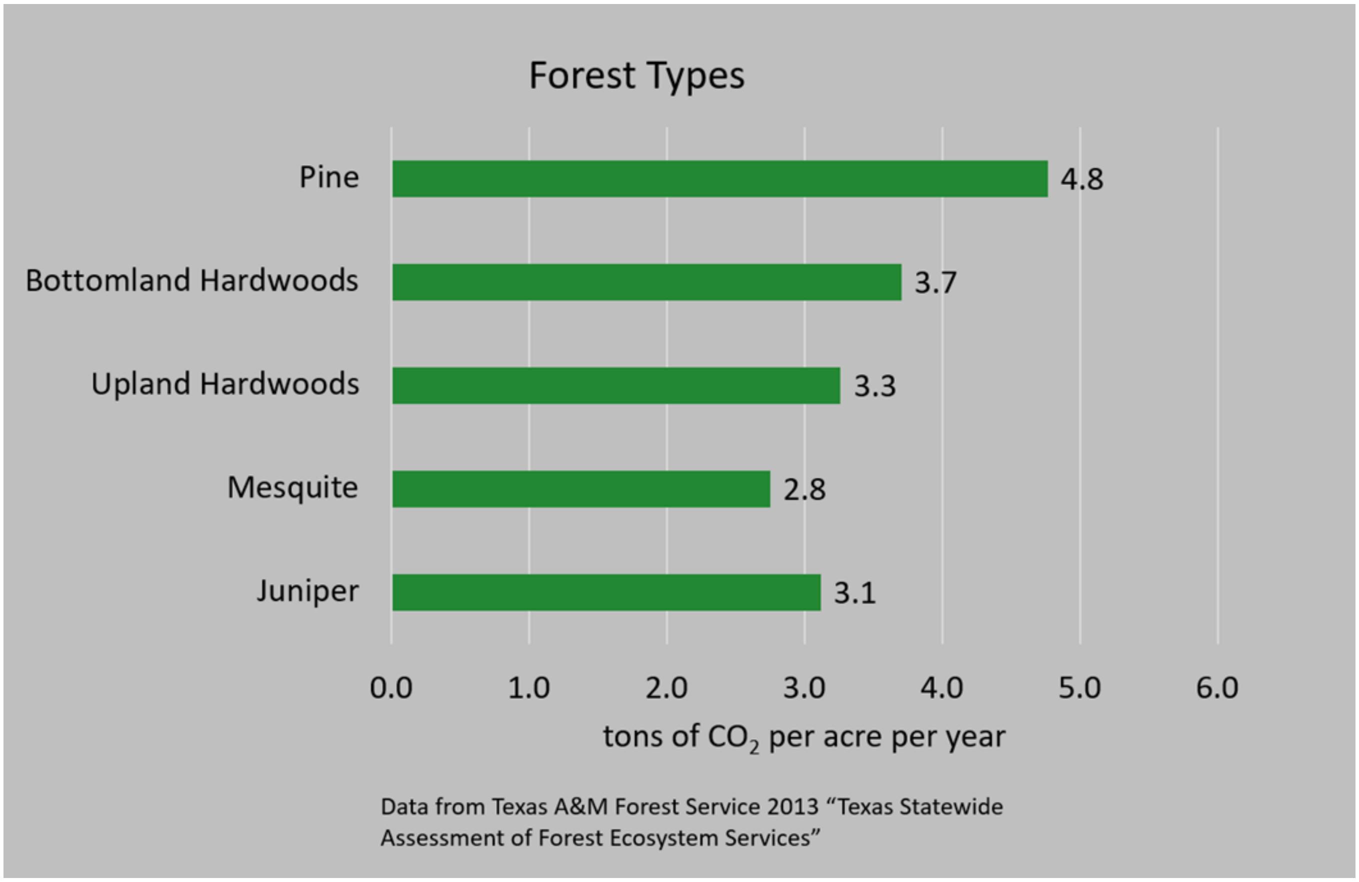


Figure 6. Estimated carbon sequestration for various Texas forest types. Source: Texas A&M Forest Service, 2013, "Texas Statewide Assessment of Forest Ecosystem Services".

Assuming the sequestration rates set out above, and based on current market values, it is possible to estimate the potential economic value of this carbon-based, non-structural flood mitigation approach to landowners in this low lying area. If all prairie acreage were committed to carbon management, the potential income at one ton per acre and $50 per ton would be about $23.8 million per year. Similarly, the forest income at three tons per acre and $15 per ton would be $14.3 million per year. For the saltwater wetlands at two tons per acre and $50 per ton the annual income would be $22.6 million per year. Additionally for the wetlands, the one-time protection payment at $20 per ton for 400 tons per acre for 50% of the acreage would be $1.81 billion, and the cost of building an estimated 200 miles of living shoreline would be about $400 million. Whether one is a private investor or a business needing a tool to help meet their net zero commitment, the economic return on this investment is real. Additionally, it is an investment that energizes rural communities and is a significant flood risk mitigation strategy that saves billions in taxpayer dollars.

Inland Flood Protection, Water Supply and Carbon Credits

During this process the SSPEED Center team also learned about significant co-benefits of carbon sequestration, including, but not limited to, the value of native prairie and other ecosystems to absorb, hold and filter water. Anecdotal evidence clearly shows that restoring prairie enhances the water baselines in the area restored. The same deep root systems that capture carbon also serve to act as reservoirs for water. Project Meadowlark and the Dixon Water Foundation both see this result on the tens of thousands of prairie acres they have restored. When prairies are restored, seeps and springs return, grasses stay greener and ponds maintain their water longer in times of drought, and in a deluge, water does not run off the land but instead is held by it. For these reasons, carbon credits could be a valuable non-structural tool for addressing water challenges.

Inland Flood Protection and Carbon Credits

In this context, the thinking is that downstream flooding could be reduced by increasing upstream prairie carbon absorption, which would increase upstream water absorption.

To test this concept, the SSPEED Center is conducting research on the Brazos River watershed, west of Houston, shown in Figure 7. In the lower portion of the watershed near Sugarland, about 30 miles of earthen levees have been constructed for flood protection, primarily on the eastern bank of the Brazos. Increasing rainfall projections, mean that the 100-year rainfall and 100-year flood will be rising, and the existing levee system will need to be made higher, perhaps as much as three feet. Three feet of levee height added across 30 miles of levees will cost a significant amount of money although no estimate exists yet. However, the important question is – can increasing carbon sequestration increase water infiltration upstream and lower the flood levels downstream, thus reducing or eliminating the need to increase levee height? At this time, computer modeling is being conducted by the SSPEED Center to predict existing runoff from the increased 100-year rain and to determine how many acres of prairie would be needed in order to reduce downstream flood levels. Other significant benefits of the prairie approach is that it supports biodiversity and quality of life in the region. This research should be complete by fall, 2025.

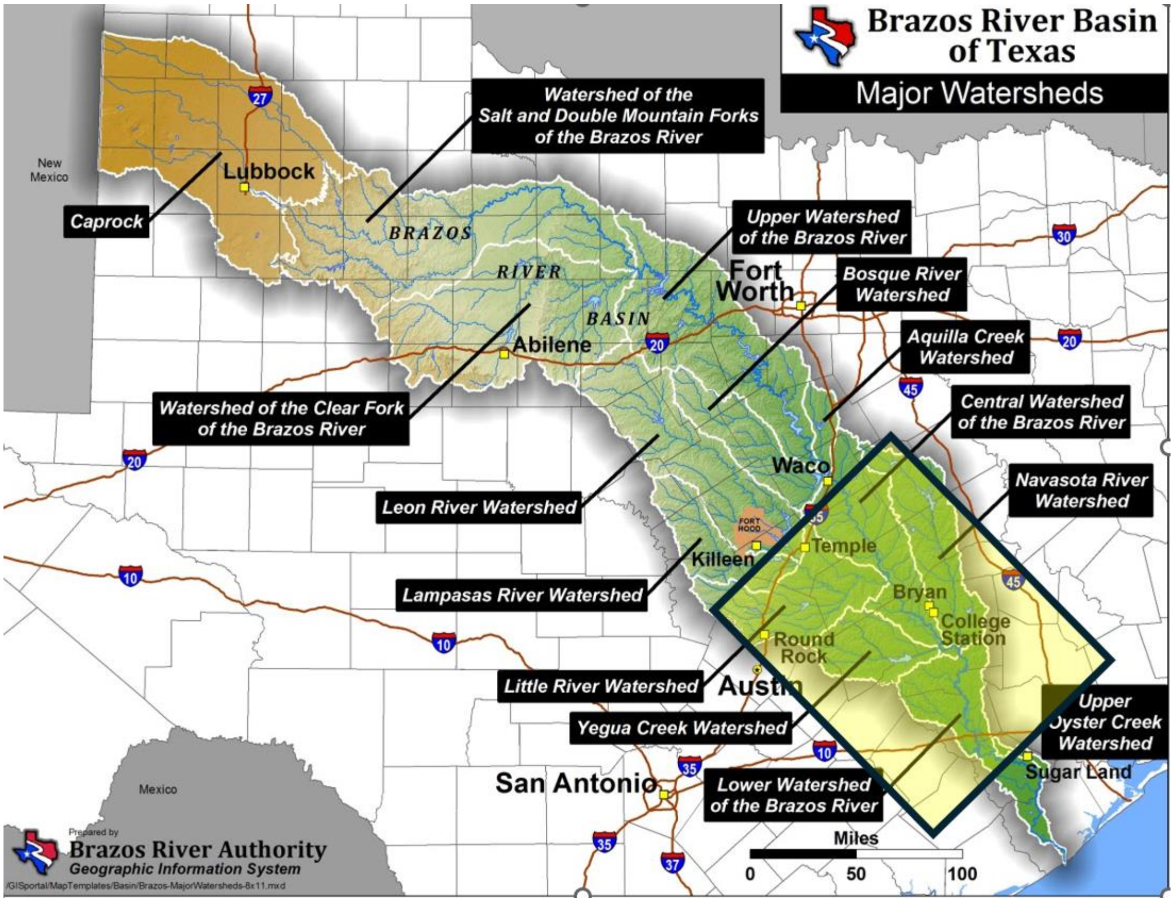


Figure 7. Identification of the critical section of the Brazos River watershed for determining the impact of carbon sequestration and increased infiltration on downstream flood levels. Map from Brazos River Authority with additions made by the authors.

Water Supply and Carbon Credits

There are several ways that water supplies can be protected and enhanced using carbon credits, three of which will be discussed here. The first is the protection of springs in the Texas Hill Country. The second is the protection of water supplies such as Lake Livingston on the Trinity River. And third is the enhancement of seeps and springs using the Guadalupe River as an example.

In the Texas Hill Country, springs are a critical aspect of water supply and, therefore, life and living things. Throughout this landscape, springs feed the headwaters of most central and south Texas rivers including the Colorado, the Guadalupe, the San Antonio, the Nueces, the Sabinal and the Rio Grande. The location of these springs is shown in figure 8. Today groundwater is being taken in greater and greater quantities as population growth extends westward from the Austin to San Antonio corridor. This is exacerbated by the fact that Texas water law is governed by the Rule of Capture. This law dictates that whatever the landowner can bring to the surface, the landowner owns. This applies to oil, and it applies to water. Consequently, all springs are at risk of being dewatered, whether from population growth or pumping-to-sell, such as has happened with Jacobs Well near Wimberley, and carbon credits offer a solution to this problem.

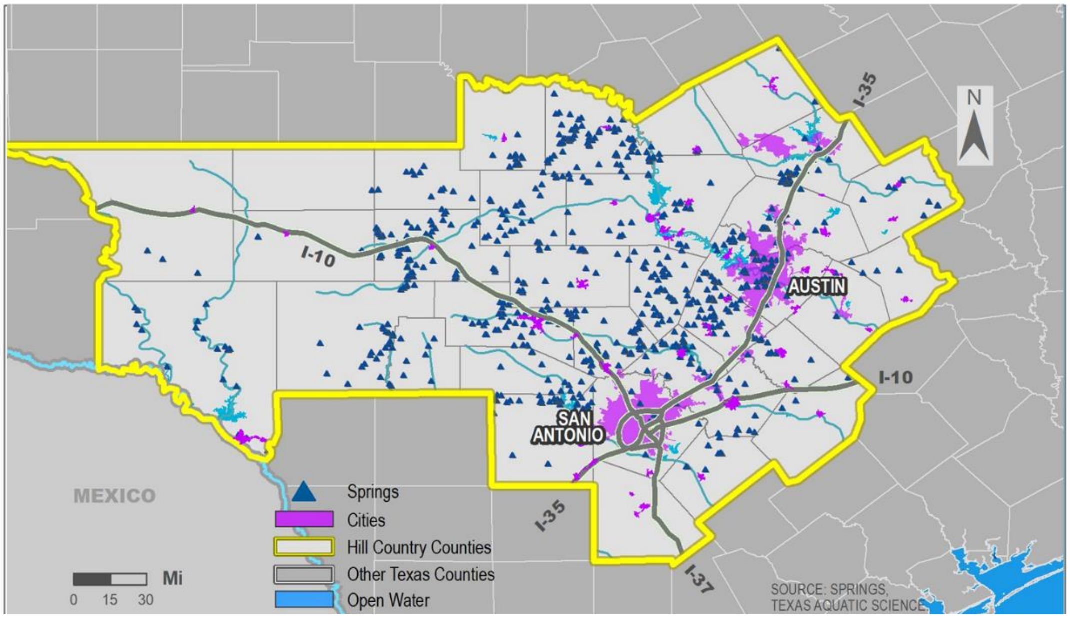


Figure 8. The springs of the Texas Hill Country. Map prepared by Christina Walsh for the Trinity Edwards Springs Protection Association (TESPA).

The key to maintaining the productivity of these springs is to conserve the land surrounding these springs. If the land is conserved, much of the pressure to remove ever increasing volumes of water will be diminished. As an example, consider the area surrounding Jacobs Well shown in Figure 9. Here, a two-mile radius circle has been drawn with Jacobs Well at the center and the surrounding land uses depicted. As can be seen, a significant amount of the undeveloped land is oak-juniper with the remainder of the undeveloped land being grasslands. Here, the potential exists to create carbon credits for the oak juniper forest, which is shown in Figure 6 to drawdown about three tons of carbon dioxide per year.

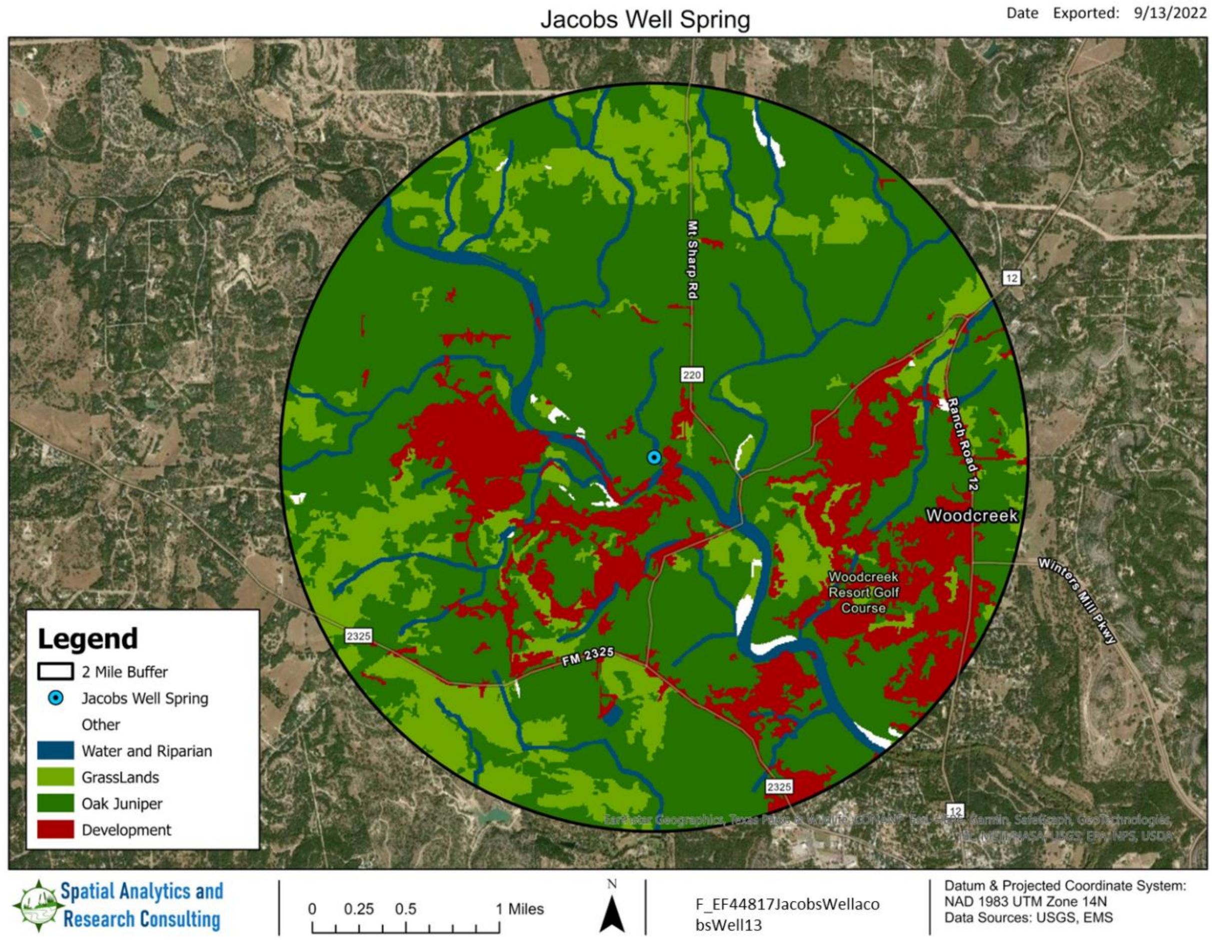


Figure 9. Two-mile circle of land uses surrounding Jacobs Well. Image by Spatial Analytics and Research Consulting (SPAARC) for the author.

Unfortunately, the critical mass of open space does not exist to make carbon credits a viable option in the instance of Jacobs Well. However, further west in the Hill Country there is plenty of opportunity to pay landowners for the carbon their oak juniper and prairie are sequestering. A distinction on these credits is that the landowners would also agree only to drill and use water for their own domestic and agricultural usage, thus mitigating the opportunity for future depletion.

Another potential use of carbon credits would be to protect the water quality of municipal water supplies much like the City of New York did in the 1870s as shown in Figure 10. New York City, either through fee simple purchase or easement purchase, conserved large watershed acreages to protect the quality of runoff, which makes up a large portion of their water supply. As also shown in Figure 10, carbon credits could be used to protect the rural watershed of Lake Livingston (the principal water supply source for the City of Houston) south of Dallas and north of the lake. In the carbon credit contract, the landowner commits to maintaining the land it its current state for a minimum of 15 to 20 years, making it unnecessary to purchase either fee simple or easement rights to the land, and would be likely to continue doing so for as long as the carbon market remains viable, which should be for most of the 21st Century.

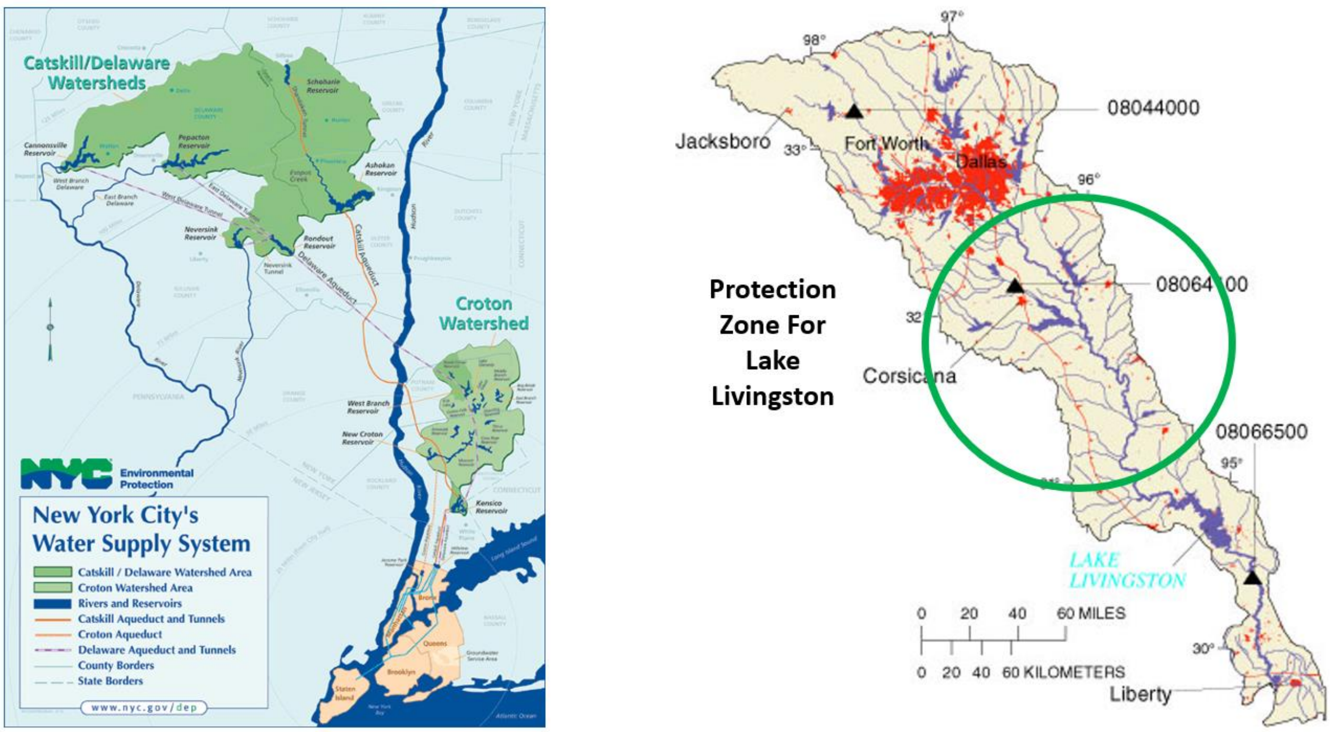


Figure 10. Diagram showing the two major watershed protection areas established by the City of New York to protect its waters supply as well as the area above Lake Livingston, the water supply for the City of Houston, that could be protected like NYC but with carbon credits rather than fee simple or easement purchase. Source: City of New York.

A third potential non-structural water supply enhancement is related to supply enhancement for the middle watershed of the Guadalupe River, shown in Figure 11. This approach leverages another benefit of the downstream flood mitigation approach discussed previously for the Brazos River. Prairie restoration has the potential to reduce flooding downstream because the water is held in the soil instead of hitting the waterway all at once in a deluge. The follow-on to this is that the water held in the soil is released over time. For the middle Guadalupe, this absorption and slowing down delivers more water over time to the uppermost aquifer, enhancing seeps and springs in this portion of the watershed. In this manner, in other places, flow during drought conditions has been increased. When this approach is combined with approaches to enhancing spring productivity as previously discussed in the upper portion of the Guadalupe River watershed, significant increases in water supplies within the Guadalupe River system could occur.

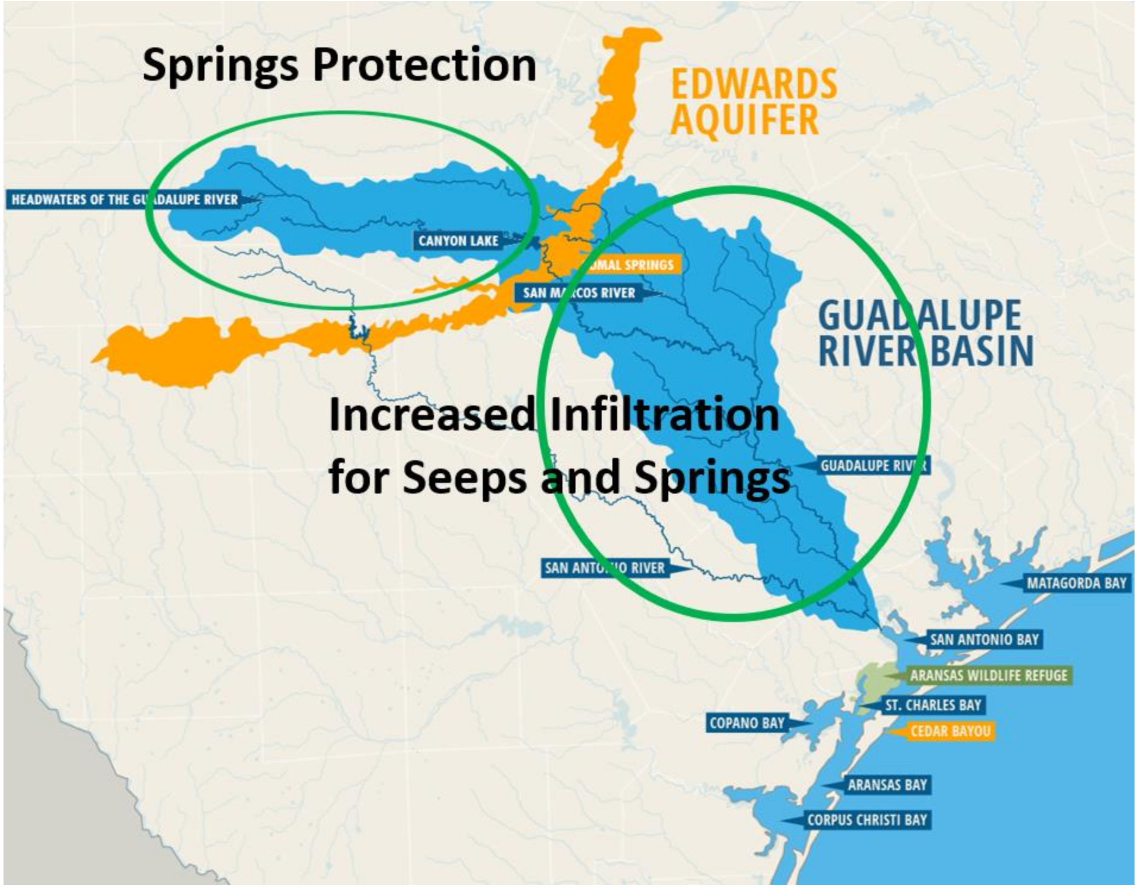


Figure 11. Two methods for increasing water supply on the Guadalupe River using carbon credits. Image provided by Guadalupe Blanco River Authority as modified by the authors.

Conclusion

Carbon credits are relatively new. To date, their utilization for non-structural engineering solutions for both flood protection and water supply has not been explored to any meaningful extent. The potential of carbon credits to provide supplemental sources of funding for non-structural solutions is significant. This should become a tool in the portfolio of every municipality and state in the United States as well as other countries of the world.

It is also important to note that, because of the work of the SSPEED Center, work is now underway to implement non-structural flood surge-mitigation potential through carbon credit purchase. At this time, three non-profit entities formed out of the early SSPEED Center research exist and are working together to implement carbon credit programs in Matagorda, Brazoria, Galveston, Chambers and Jefferson Counties. As shown in Figure 12, the idea for these three entities dates back to our early work at Houston Wilderness. This work was continued at SSPEED Center, and it led to the formation of the Texas Coastal Exchange, BCarbon and the Lone Star Coastal Alliance.

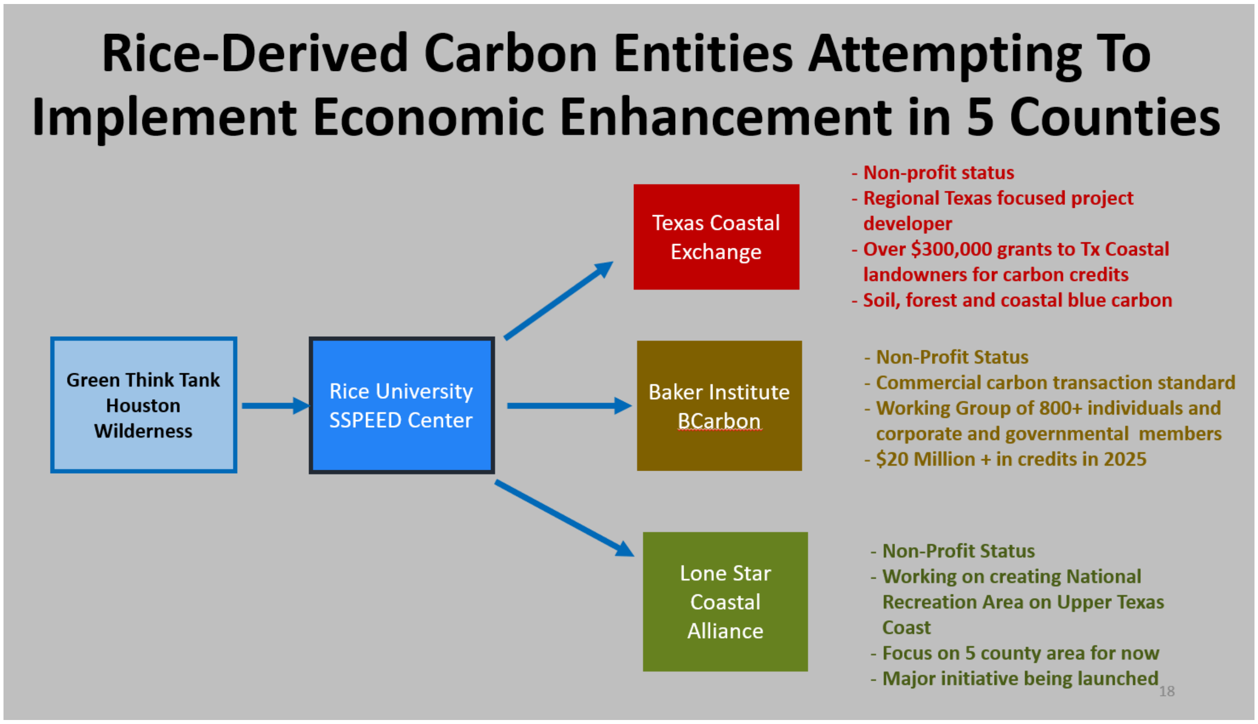


Figure 12. Three entities formed out of work at the SSPEED Center are now working to implement flood mitigation through non-structural solutions and nature-based economics in five coastal counties. Diagram by author.

The Texas Coastal Exchange was formed in 2017 and has provided over $300,000 in funding from carbon transactions for coastal landowners. Currently, it is transitioning into a project developer role. BCarbon was formed in 2021 from a stakeholder group at the Baker Institute that started in 2019 and now has over 800 members. BCarbon is a soil carbon registry with four separate protocols, and which is projected to issue from 2 to 4 million tons of carbon credits around the world in 2025. The Lone Star Coastal Alliance was formed in 2015 and has been working to implement an ecotourism-focused economic development plan for the ecological resources of the Texas coast. All three are actively involved in attempting to monetize ecological services to the benefit of the ecosystems and the communities along the coast.

This marketplace for ecological services is very much a part of the ongoing energy transition. Indeed, the circular economy will be the economy of the future and nature-based, non-structural engineering solutions are simply waiting to be discovered as this circular economic system unfolds.