REINVENTING THE WORLD WHITE PAPER SERIES · NO. 4

From Debris to a New Industry

Reinventing the forest and farm economy of North Carolina

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November 2026

ABOUT THIS SERIES

In my book *Reinventing the World*, I argue that four trends (climate change, demographic shifts, a fractured world, and technological disruption) have combined into a single tidal wave, and that meeting it requires us to challenge the assumptions on which we have run the world.

Earlier papers in this series looked at countries and at the university. This one looks at an industry, forestry and the farms it can serve, in the region where I live and where I have put my own money to work. It is the most personal paper in the series.

DISCLOSURE

I have a direct financial interest in the ideas in this paper, and readers should know it.

I am a co-owner of Heritage Tree Recycling, a debris-recovery and biochar business in Yancey County, North Carolina, which I started with my partner Sam after Hurricane Helene. I personally own a Tigercat carbonizer that the company rents from me. The company leases a Takachar machine and is a pilot site for Takachar's North American equipment. Heritage sells biochar and expects to take part in North Carolina's biochar cost-share program and in carbon removal markets.

We are a small business, and the idea at the heart of this paper is not to grow one company but to build a network of many businesses like ours across the state. That is also its strength. When a single large mill closes, as Canton did, a whole regional economy can collapse with it. A network of dozens of small and midsize operators is far more resilient: no single firm's failure can bring the system down.

Several of the policies this paper recommends, including clearer permits for carbonizers, disaster contracts that favour biochar, and public support for biochar markets, would benefit my business along with others like it. The operating figures in this paper come from our own experience and projections. I will publish our actual results after the first six months of Takachar operation, whatever they show.

Executive Summary

North Carolina's forest economy, especially in the mountains, is losing its foundation at the very moment the region has more wood to deal with than ever before.

For generations, paper mills bought the low-grade wood that sawmills could not use: thinnings, tops, and limbs, known in the trade as pulpwood and toppings. That market kept loggers working and landowners managing their forests. It is disappearing. The Canton mill closed in 2023 after 115 years, and eleven pulp mills across the South have closed since 2022. Pulpwood standing in the forest now sells for about $6 a ton, while cutting and hauling it costs about $25. Then Hurricane Helene damaged some 822,000 acres of North Carolina timberland and left millions of cubic yards of debris across the west.

These two problems contain each other's solution. By converting wood into biochar, a stable form of carbon that rebuilds soil and cleans water, North Carolina can build a new forest-based industry:

1. **Clear storm debris** faster and at less than half the cost of grinding and hauling, using carbonizers for bulk debris and Takachar machines to turn mulch and chips into biochar.
2. **Shift to pulpwood and toppings** once the debris is gone, giving the wood the paper mills no longer buy a new market.
3. **Redeploy the same equipment** to the next disaster, rotating between storm recovery and forest work.
4. **Put a carbonizer at every landfill that has room for one,** saving landfill space and money, and potentially cutting methane and odour.
5. **Send the biochar to farms and rivers,** from the flood-damaged fields of the mountains to the sandy soils of eastern North Carolina.

The result would be a network of small and midsize businesses across the state, far more resilient than any single mill. The state's new $10 million biochar cost-share can launch it; the private market must sustain it. This paper draws on what my partner and I have learned running such a business in Yancey County since Helene.

1. A Forest Economy Losing Its Foundation

Forests cover about 60% of North Carolina. A forest pays for itself in layers: the best logs go to sawmills, but every harvest also yields large volumes of smaller, lower-quality wood, and for a century paper mills bought it. That market made it

worthwhile to thin a forest, clear a damaged stand, or harvest at all. It is now collapsing.

Exhibit 1: The Squeeze on the Southern Forest Economy

Indicator	What the data show
Pulp mill closures	Eleven pulp mills in the U.S. South closed between 2022 and 2025, removing about 16% of the region's pulp capacity and about 25 million tons a year of wood demand (Forisk, 2025)
Pulpwood prices	Southern pine pulpwood stumpage averaged about $5.96 per ton in late 2025, down 46% from its 2022 peak, and in some places fell to zero (Timber Mart-South, 2025)
Cost of getting wood out	Logging and hauling run about $25 per ton, about 70% of pulpwood's delivered cost (Forisk, 2021)
Sawtimber prices	About $23 per ton in late 2025, roughly flat since 2019, even through record lumber prices
Hardwood exports	China bought more than $1 billion a year in U.S. hardwood before the 2018 trade war. Retaliatory tariffs and a 2025 suspension of U.S. log imports have cost the industry an estimated $9 billion since then, and many Appalachian sawmills have closed or cut shifts (U.S. Department of Agriculture, 2025; Tennessee Lookout, 2025)

The squeeze runs from both sides. For decades, logging and hauling costs rose more slowly than inflation, but that changed after 2020. Wages, equipment, insurance, and repairs have risen faster than the rates loggers are paid (Forisk, n.d.), and diesel reached a record of about $6.29 a gallon in September 2026, up 68% in a year (Bureau of Transportation Statistics, 2026). Meanwhile, what the forest earns has stalled. Sawtimber has been roughly flat since 2019, and lumber prices have fallen over the past year despite tariffs. Even the best logs have lost ground: China, once the largest buyer of Appalachian hardwood, has been an unreliable market since the 2018 trade war. In the mountains, timber must also compete with another use of the same land: sale for second homes and recreation, often worth far more than the trees. At $6 a ton standing and $25 or more to cut and haul, there is little reason to keep managing forest land as forest. Loggers retire, equipment is sold, and unmanaged forests become more vulnerable to fire, pests, and storms.

The mountains have been hit hardest. The Canton mill, Haywood County's largest employer for more than a century, closed in June 2023, affecting more than 1,000 workers and the loggers and truckers who supplied it (WRI, 2024). It once drew about two million tons of pulpwood a year from four states; by U.S. Forest Service figures, the region now produces on the order of 24,000 tons. When the next disaster comes, the people and machines needed to respond may no longer be there.

2. Then Came Helene

Hurricane Helene, in late September 2024, delivered the problem the region was least prepared for: an enormous volume of wood, all at once, in steep terrain. The NC Forest Service estimated that about 822,000 acres of timberland were damaged, with losses of about $214 million (NC Forest Service, 2024). By April 2025, about 6.7 million cubic yards of debris had been removed across 22 counties, with an estimated $1–2 billion more needed to finish the job (Carolina Journal, 2025). Much of the downed timber in the forests themselves has never been touched. It is a fire hazard with no economic way out, because the mills that might have taken it are gone.

The traditional response is to grind debris into mulch, haul it, grind it again, and then sell what the market can absorb and bury, rot, or burn the rest. Rotting and burning return the trees' carbon to the atmosphere, and the mountains need only so much mulch. Meanwhile, landfills never designed for it are being forced to take tree debris. Buncombe County had to accelerate a landfill expansion because Helene "collapsed" its timeline for disposal capacity (WFAE, 2025).

3. What We Learned Clearing Helene's Debris

After Helene, I asked people in the mountains what I could do to help beyond charity. The answer was almost always the same: deal with the tree waste. My partner Sam, a lifelong local with a track hoe and a reputation for honesty, and I started what is now Heritage Tree Recycling in Yancey County. We planned to grind wood and sell mulch. On our second day, a disaster-recovery contractor asked us to take fifteen truckloads a day, more than 300,000 cubic yards over nine months. We said yes, and then had to work out what to do with it all. Local rules require stored wood waste to shrink by at least 70% a year, so the choices were to let it rot, burn it, or find something better. That led us to biochar and to two machines that do different jobs:

- **The Tigercat Carbonizer 6040,** made by a Canadian forestry-equipment company, is a volume-reduction tool. It adapts an air-curtain burner so that biochar falls through a grate before it turns to ash, processing about 20 tons of wood an hour and shrinking it more than fourteen-fold. It converts only about 5–7% of its input into biochar, but it handles huge volumes of large, unsorted debris, at about a tenth the cost of earlier biochar systems. Two now operate in western North Carolina, in Haywood and Yancey counties.
- **Takachar's oxygen-lean torrefaction system** is a biochar-production tool. It cooks biomass at about 300°C rather than the 800°C of conventional pyrolysis, cutting cost and complexity, and its process is approved by Puro.earth, the leading verifier of carbon removal. Fed with mulch and chips,

it converts about 30–35% of its input into biochar, roughly five times the carbonizer's yield, which makes it the more profitable machine. We are a pilot site for its North American model. Our first unit, leased for about $5,000 a month, begins operating in November 2026, rated at about 4.5 cubic yards of biochar an hour.

The right model uses both: **carbonizers for large-scale debris, and Takachar for producing biochar** from the mulch and chips that debris and forest work generate.

Exhibit 2: Traditional Debris Recovery Versus Biochar

	Traditional model	Biochar model
Steps	Collect, haul, grind, haul to storage, regrind or compost, distribute	Collect, convert to biochar on or near site, distribute
Volume reduction	About 5 times	About 14 times with the carbonizer
Cost	Baseline	Less than half
Carbon	Released as mulch decays or is burned	Stored for centuries
End product	Mulch, in a saturated local market	Biochar, valuable enough to ship to distant markets

We were in the black within three months. The business is small, but the model can be repeated wherever there is wood to deal with, by people of ordinary means.

4. The Rotation Model

The central idea of this paper is simple. The equipment, skills, and businesses built to clear storm debris do not have to disappear when the debris is gone. They can rotate.

Exhibit 3: Rotating Between Disaster and Forest Work

Phase	Feedstock	What happens
1. Storm recovery	Debris from roads, rivers, properties, and damaged forests	Carbonizers reduce bulk debris on site; the rest is ground into mulch and chips for Takachar machines
2. Forest work	Pulpwood and toppings from public and private forests	Wood is chipped in the forest and turned into biochar; biochar and mulch go to farms and markets by truck and rail
3. The next disaster	New storm, flood, or fire debris anywhere in the region	Equipment and crews redeploy, then return to forest work

The rotation solves two problems at once. It gives the wood the paper mills no longer buy a new market, which keeps loggers working and forests managed. And

it keeps a trained workforce and fleet ready for the next storm instead of rebuilding that capacity from scratch every time.

Making the numbers work

Pulpwood alone does not pay: a chip mill needs roughly $32 a ton in sales, and delivered pulpwood barely covers its own logging and hauling. Biochar changes the equation by earning several kinds of revenue from the same wood:

- **Farm programs and product sales.** North Carolina has added biochar to its Agriculture Cost Share Program, with $10 million set aside, paying up to $120 per cubic yard applied to farmland, a 75% share of a $160 unit cost (NC Division of Soil and Water Conservation, 2026). We sell biochar at about $120 a cubic yard, a biochar-compost blend at about $90, and mulch at about $30, prices high enough to justify shipping biochar to farm markets across the Southeast and Midwest.
- **Carbon removal credits.** Biochar has supplied about 86% of all durable carbon-removal credits delivered since 2022 (CDR.fyi, 2025). U.S. biochar credits traded at about $150 per tonne of CO_2 in late 2025, with buyers such as Microsoft and Google (CarbonCredits.com, 2025). A tonne of wood biochar typically earns a little over two tonnes of credits, very roughly $40–60 per cubic yard after fees.
- **Avoided costs.** Fewer handling steps, less hauling, and no mulch piles to store or burn.

Exhibit 4: The Projected Economics of One Takachar Machine

Item	Projection (to be tested from November 2026)
Output	About 315 cubic yards of biochar a month running days only, or about 750 around the clock, at a conservative 35% capacity factor
Revenue per cubic yard	About $120 from the state cost-share program, plus about $40–60 in carbon credits once verified
Main costs	A lease of about $5,000 a month, plus power, wear parts, testing, insurance, verification, and night labour if run around the clock
Break-even	Roughly 15% of planned output

These are projections built on placeholder assumptions that we will replace with real data. The biggest unknowns are how many hours the machine actually runs, how long the state program lasts, and how quickly carbon credits are paid.

What a ton of pulpwood becomes

Follow a single ton of low-grade wood. A green ton of pulpwood is roughly half water. Dried to about 20% moisture and converted at Takachar's 35% yield by weight, it becomes roughly 200 kilograms of biochar, about one cubic yard.

Exhibit 5: What One Green Ton of Pulpwood Becomes

	Approximate value
As standing timber today	About $6
Cost to cut and haul it	About $25
As biochar, at the state program rate of $120 per cubic yard	About $125
As biochar, at low-end commodity prices of about $75 per cubic yard	About $80
Plus carbon removal credits, after fees	About $40–45

These figures come before the costs of chipping, drying, and running the machine, and they will vary with the wood. But the direction is unmistakable: wood worth almost nothing to a landowner today can become a product worth several times what it costs to bring out of the forest. That is what makes the forest half of the rotation pay.

After the first $10 million

The cost-share is a launching pad, not a business model. At $120 per cubic yard, $10 million buys about 83,000 cubic yards, roughly nine machine-years of round-the-clock Takachar output: enough to launch a network, not sustain one. The industry has to stand on the private market.

That market exists, though prices vary widely. In the state's own survey of seven woody biochar suppliers, delivered prices ran from about $66 to $300 per cubic yard, with a median of $200. Biochar from forest residues and mill residuals sat at the low end, about $66–84; certified and hardwood biochar sold for $200–300; bagged biochar for small users, $450 or more (NC Division of Soil and Water Conservation, 2026). The U.S. biochar market roughly tripled in value between 2023 and 2025, to about $157 million (American Biochar Institute, 2026).

Our projections test the low end. Even at $60 a cubic yard, half the program rate, one Takachar machine running around the clock would remain comfortably profitable, because carbon credits and cheap feedstock carry much of the weight. The business does not depend on the subsidy lasting forever. It depends on building enough buyers among farmers, landscapers, restoration projects, and out-of-state markets, and on earning from several revenue streams rather than one.

5. A Carbonizer at Every Landfill

North Carolina keeps yard waste out of ordinary municipal landfills, sending it to land-clearing debris sites, mulching operations, or burn piles. After a storm those sites fill quickly. I would put a carbonizer at every landfill and debris site with

room for one, to handle the bulk volume, and pair it with Takachar machines wherever there is enough mulch and chips to make biochar production pay. Every such site also becomes a pre-positioned disaster-recovery site.

Why landfills would save money

Landfills already charge to take wood: typically about $22–62 per ton for yard waste and land-clearing debris, and $43–64 per ton for construction and demolition waste.

Exhibit 6: Typical North Carolina Tipping Fees

Landfill	Yard waste or land-clearing debris	Construction and demolition
Buncombe County	$30 per ton (mulchable wood and yard waste)	By quote
Orange County	$30 per ton (yard waste); $45 per ton (stumps and land clearing)	$45 per ton
Wilson County	$22 per ton	$43 per ton
Nash County	$62 per ton	$64 per ton

Those fees rarely cover the full cost. Loose wood debris runs about four cubic yards to the ton (NC DEQ, 2012). Grinding it typically costs around $7 per cubic yard in disaster-debris contracts (Lake County, FL, 2023). Burying the result consumes landfill space that costs roughly $6–13 per cubic yard to build and could otherwise hold waste that pays higher fees (Waste Today, n.d.).

Exhibit 7: A Rough Illustration for 10,000 Tons of Wood Debris

	Traditional handling	With a carbonizer
Loose volume received	About 40,000 cubic yards	About 40,000 cubic yards
Tipping fees collected (at about $30 per ton)	About $300,000	About $300,000
Grinding (at about $7 per cubic yard)	About $280,000	Little or none for large debris
What is left	About 10,000 cubic yards of mulch to sell, store, or bury	About 2,900 cubic yards of biochar to sell or use on site
Landfill space used if buried	Up to about 10,000 cubic yards, costing roughly $60,000–130,000 to build	None, if the biochar is sold or used

These are rough figures, and every landfill differs, but the pattern holds. The carbonizer removes the largest handling cost, frees landfill space, and leaves a product instead of a pile, while the landfill keeps its tipping fees. In effect, the machine can be paid for out of space the county no longer has to build. Counties should run these numbers with their own data.

From disposal site to treatment site

Biochar may also help solve some of a landfill's hardest problems. The evidence is early but promising:

- **Methane.** Landfills are among the largest human-caused sources of methane in the United States, much of it escaping through cover soil. Bacteria in that soil consume methane, and biochar gives them a far better home. In laboratory tests at the University of Illinois Chicago, biochar-amended cover soil oxidized methane at roughly 30 to 60 times the rate of a conventional barrier soil (Chetri et al., 2022).
- **Odour.** The same tests found the biochar cover removed hydrogen sulfide, the rotten-egg gas behind many neighbours' complaints.
- **Leachate and runoff.** Biochar can capture ammonia, heavy metals, and some organic compounds. Some engineered biochars also adsorb PFAS, the so-called forever chemicals, though activated carbon generally does better; biochar may help as one part of treatment, not as a cure.

That opens the possibility of a closed loop: wood arrives, is carbonized on site, and the biochar goes back into cover soil, closure caps, leachate pretreatment, and stormwater controls, reducing the soil the landfill must buy. Questions remain. On-site use will need approval from DEQ's solid waste regulators; it is unclear whether it qualifies for carbon credits; biochar from mixed debris must be tested; and every cubic yard used on site is one not sold. A North Carolina field trial would answer most of them.

The permitting question

The main barrier is air permitting, which North Carolina is still working out. Takachar's enclosed system tests well below the applicable emission standards and is expected to be approved. Carbonizers, a variant of the open air-curtain burners regulators already know, face a less certain path. Clear standard permits for both, with limits matched to each technology, would let counties move quickly, especially in the weeks after a storm.

6. From Forest to Farm and River

In the book I argue that we must reinvent how we feed ourselves, and that some of the best solutions are rediscoveries. Biochar is one. Centuries ago, Indigenous peoples in the Amazon built remarkably fertile "dark earths" by working charcoal into their soils, and those soils are still productive today.

Biochar and regenerative agriculture

Regenerative agriculture rebuilds soil rather than depleting it. NC State Extension summarizes its core principles as minimal soil disturbance, diverse crops, constant

soil cover, living roots for much of the year, and integrated livestock, with organic amendments favoured over heavy synthetic inputs (NC State Extension, n.d.).

Biochar adds something those practices do not: permanence. Compost and cover crops break down within a few years; biochar persists for centuries, giving soil a lasting porous structure that holds water and nutrients. That structure is also a home for soil life. Each particle is riddled with tiny pores that shelter bacteria and fungi from drying out and from predators, while holding the water and nutrients they live on. Biochar works best in combination, mixed with compost so that it is "charged" with nutrients and used alongside cover crops and reduced tillage, which is why we sell a biochar-compost blend.

What the evidence shows, and what it does not

Biochar has attracted its share of exaggerated claims, and farmers are right to be sceptical. The best evidence comes from meta-analyses that combine many studies:

Exhibit 8: What Biochar Does for Soil and Water

Benefit	What the research finds
Water held in the soil	Plant-available water rose about 45% in coarse, sandy soils, 21% in medium soils, and 14% in fine soils (Edeh et al., 2020)
Nitrogen kept on the field	Nitrate leaching fell about 13% on average and 26% in longer experiments; nitrous oxide emissions fell about 38%, mostly in the first year (Borchard et al., 2019)
Crop yields	Up about 25% on average in the tropics, where soils are acidic and poor; no average change on fertile, well-fertilized temperate farmland (Jeffery et al., 2017)
A home for soil life	Microbial biomass rose about 21% on average, and key nutrient-cycling enzymes about 20–25% (Kumar et al., 2025; Pokharel et al., 2020)
Carbon storage	Stable for centuries, which is why biochar qualifies for durable carbon removal credits
Cleaner runoff	In field stormwater filters, biochar retained metals such as zinc better than sand; results for bacteria vary with how it is made (University of Minnesota Water Resources Center, n.d.)

The honest reading: biochar is not a miracle fertilizer for healthy temperate farmland. Its value is greatest where soil is sandy, degraded, low in organic matter, or losing nutrients to the water, which describes exactly what Helene left behind.

Repairing Helene's farms

Helene caused an estimated $4.9 billion in damage to North Carolina agriculture (Grist, 2025). In the mountains it damaged the land itself. Some fields were buried under several feet of river sand; others were stripped to bedrock, their topsoil carried downstream. As one soil scientist put it, "the clock has been reset."

Extension agents advise farmers to expect at least three years of cover cropping before the soil recovers.

Farmers are already rebuilding with compost, lime, cover crops, and biochar. One vegetable grower near Asheville whose fields were buried in sand added biochar and compost and had an unusually productive season on four of her six acres (Grist, 2025). In Yancey County, a field study run by an NC Cooperative Extension team, using biochar from our operation, is showing early evidence that biochar helps both repair damaged soil and improve plant growth. The results are not yet published, and because the biochar is ours, they should be judged on their own merits once they are.

The cost-share makes this affordable. At a typical four tons per acre, about 24 cubic yards, the program covers about $2,880 an acre, putting a real soil rebuild within reach of a small mountain farm.

Beyond the mountains: eastern North Carolina

The largest long-term farm market may be the Coastal Plain. Eastern North Carolina's soils are mostly sandy, acidic, and poor at holding nutrients, leached by heavy rainfall over millennia (NC State Extension, n.d.). In those respects they resemble the weathered tropical soils where biochar shows its biggest gains. In a USDA study of Norfolk loamy sand, a typical Coastal Plain soil, biochar raised pH from 4.8 to 6.4, increased organic carbon by about 70%, and cut phosphorus leaching by roughly 40% (Novak et al., 2009). It was a short laboratory study, but it points the right way.

The east has every reason to want those benefits. It is the heart of the state's farm economy and the nation's leading sweet potato producer, with large swine and poultry industries whose manure must be managed, rivers such as the Neuse and Tar-Pamlico long burdened by nutrient pollution, and, in 2024, the worst drought in the state's recorded history (Carolina Public Press, 2024). Researchers are now testing whether biochar mixed with poultry litter reduces nutrient runoff (Advanced Carbons Council, 2026). With its own pine plantations needing a market for low-grade wood, the east makes the model statewide.

Water and rivers

Nutrients and sediment that wash off fields end up in the French Broad, the Pigeon, and the other rivers the region depends on for drinking water and tourism. Biochar in the soil keeps more nutrients where crops can use them, and biochar built into stormwater filters, bioretention areas, and buffer strips catches runoff before it reaches a stream. Biochar meant for water treatment should be produced and tested for that purpose.

Helene also tore away riverbanks across the region. NC DEQ has awarded $2 million to the Haywood Waterways Association for streambank restoration in the

Pigeon River watershed (NC DEQ, 2025). Biochar can be worked into the soil of rebuilt banks and riparian plantings to help vegetation take hold and filter runoff, though the field evidence is young and demonstration reaches should be monitored. Not all debris should become biochar: whole logs and root wads are valuable in stream restoration. Part of this industry is sorting wood to its best use.

A network, not a mill

The result is a new ecosystem of the kind I describe in the book: foresters, loggers, carbonizer and Takachar operators, truckers, composters, processors, sales and logistics firms, and the farms, landscapers, contractors, and agencies that buy the product. Beyond agriculture, biochar is being developed for concrete and asphalt, filtration, animal feed, and consumer products. One industry estimate puts the global biochar market at about $2.5 billion in 2025, growing about 11% a year to roughly $6.3 billion by 2034 (IMARC Group, 2025), and the value of biochar carbon-removal credits rose from about $15 million in 2022 to about $180 million in 2024 (CDR.fyi, 2025).

7. Why North Carolina, and Why Now

North Carolina has the largest volume of Helene debris, a clear gap in its western forest economy after Canton, and state leaders who have made forest use a priority. The ecosystem is already forming. Two carbonizers operate in Haywood and Yancey counties. NC DEQ has awarded $1 million to pilot mobile biochar equipment on Helene-damaged farmland; the U.S. Forest Service's Southern Research Station is field-testing mobile units; a former Haywood County chip mill now processes storm debris; and farm groups are lending small kilns to rural operators (NC DEQ, 2025; Biochar Today, 2025). The new $10 million cost-share gives farmers a direct reason to buy, though early feedback from conservation districts shows that demand will have to be built through demonstration and outreach.

North Carolina could also build the equipment, not just use it. Takachar will need a home to manufacture its North American machine, and a state with a forest industry in transition, skilled manufacturing workers, and a ready market would be a natural choice. That would make North Carolina a maker of this technology, not just a buyer, in line with the book's argument for real things. In time, the model applies well beyond the state, to neighbours that took Helene's floods, to the Gulf Coast, and to the fire-damaged forests of the West.

8. What Could Go Wrong

A paper that argues for a new industry owes its readers an honest account of the risks.

Exhibit 9: Risks and Responses

Risk	Why it matters	What reduces it
Air quality and community concern	Any process that heats wood produces emissions, and neighbours who lived through Helene's burn piles will be wary	Takachar tests well below emission standards; carbonizers burn far cleaner than open piles; clear permits, careful siting, monitoring, and early engagement with neighbours
Farmers don't buy	Many farmers have not heard of biochar, and conservation districts report limited interest so far	Demonstration farms, published results, extension support, and other buyers such as restoration, stormwater, and landfills
Public funding ends	The $10 million cost-share is finite	Multi-year commitments and business models built on several revenue streams
The carbon market weakens	Demand is concentrated among a few large buyers	Treat credits as upside, not the base case; pool small producers to cut certification costs
Our projections prove optimistic	The Takachar economics are untested	A low break-even, published results, and scaling only after the data are in
Dependence on new equipment	The technology is young and has few makers	Two complementary technologies, and recruiting more manufacturers to the region
Taking too much from the forest	Over-harvesting harms soil and habitat; mixed debris can contaminate biochar	Sustainable-harvest guidelines and testing of feedstock and biochar
Gaps between storms	If forest work does not pay, crews and equipment drift away	The rotation model, backed by stable markets for pulpwood biochar

None of these is a reason not to act. They are reasons to start where the evidence is strongest, measure everything, and scale as the results come in.

9. What Should Happen Now

1. **Settle the permits and put carbonizers at landfills and debris sites.** Finish North Carolina's air-permitting rules with clear standard permits for enclosed systems such as Takachar and for carbonizers, and help counties finance equipment, starting in the Helene-affected west.
2. **Pre-position the rotation.** Write disaster debris contracts that favour biochar over grinding and burning, and line up regional operators who can move between forest work and disaster recovery.

3. **Build the market for biochar.** Sustain the farm cost-share beyond its first $10 million and commit to it for several years. Fund demonstration farms in the mountains and on the Coastal Plain, and demonstrations in streambank restoration and stormwater control. Pilot biochar at one western landfill, with a university partner and DEQ measuring methane and odour. Have state agencies buy biochar for roadside, stormwater, and restoration work, and support processing facilities and rail links to larger markets.
4. **Keep the forest workforce.** Help loggers, truckers, and equipment operators move into the new industry, with training at community colleges.
5. **Bring the equipment makers here.** Recruit Takachar's North American manufacturing plant, and other biochar equipment makers, to North Carolina.
6. **Make carbon pay.** Help small operators measure, verify, and sell carbon removal, for example through cooperatives that share the cost of certification.

Conclusion

Western North Carolina has lost textiles, furniture, and now paper, and each loss was treated as the end of something. Helene added a catastrophe on top. But the same storm that buried the region in wood has shown what that wood could become.

This is reinvention at its most practical: not a grand national program but thousands of small decisions by landowners, loggers, county managers, and farmers, made easier by a few good policies. It turns debris into soil, waste into stored carbon, and a dying forest economy into a new one, and it leaves the region more ready for the next storm than it was for the last.

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