A Fresh Look at Stream Restoration

Upper Midwest
Stream Restoration Symposium
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Streams can self-restore from human-generated harm – if we haven't destroyed landscape resilience.

Here is a trout creek in Central Wisconsin in 1956, just 3 years after cessation of cattle grazing that had kept its banks bare for decades. We see excellent self-restoration in progress. This contrasts with the highly artificial structures often built as trout habitat.

A bend of the same creek on the same morning. Flow toward left. Vegetation alone is healing the formerly “raw” current-bearing bank. Why is it that many people feel the urge to fix things artificially?

Impulses in us that lead to various approaches

In each person lies some of the following:

Farmer, Grazier – Produce biological tissue (plant fish)

Carpenter, Mason – Build, fix (construct habitat)

Engineer – Find solutions, build, fix, invent

Physician – Diagnose, promote healing, fix, and recently evidence-based medicine

Adding a fifth source of restoration impulse

Farmer, Grazier – Nurture (plant fish)

Carpenter, Mason – Build, fix (construct habitat)

Engineer – Find solutions, build, fix, invent

Physician – Diagnose, promote healing, fix, and recently evidence-based medicine

Hydrogeomorphic Ecologist – Understand natural systems, diagnose, conduct evidence-based healing in concert with natural processes (as no one person can do all this, every project requires a multi-profession team)

Scientists provide excellent information and ideas but communicate poorly to practitioners.

The key publication at right has boring format and appeared in a journal accessible to few.

The author committee of 22 may have been ungainly—and had any of them ever served as a practitioner?

"Standards for ecologically successful river restoration" M. A. Palmer and 21 others, *Journal of Applied Ecology, Vol. 42* (2005)

Journal of Applied Ecology 2005
42, 208–217

FORUM

Standards for ecologically successful river restoration

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Summary

1. Increasingly, river managers are turning from hard engineering solutions to ecologically based restoration activities in order to improve degraded waterways. River restoration projects aim to maintain or increase ecosystem goods and services while protecting downstream and coastal ecosystems. There is growing interest in applying river restoration techniques to solve environmental problems, yet little agreement exists on what constitutes a successful river restoration effort.

2. We propose five criteria for measuring success, with emphasis on an ecological perspective. First, the design of an ecological river restoration project should be based on a specified guiding image of a more dynamic, healthy river that could exist at the site. Secondly, the river's ecological condition must be measurably improved. Thirdly, the river system must be more self-sustaining and resilient to external perturbations so that only minimal follow-up maintenance is needed. Fourthly, during the construction phase, no lasting harm should be inflicted on the ecosystem. Fifthly, both pre- and post-assessment must be completed and data made publicly available.

3. Determining if these five criteria have been met for a particular project requires development of an assessment protocol. We suggest standards of evaluation for each of the five criteria and provide examples of suitable indicators.

4. *Synthesis and applications.* Billions of dollars are currently spent restoring streams and rivers, yet to date there are no agreed upon standards for what constitutes ecologically beneficial stream and river restoration. We propose five criteria that must be met for a river restoration project to be considered ecologically successful. It is critical that the broad restoration community, including funding agencies, practitioners and citizen restoration groups, adopt criteria for defining and assessing ecological success in restoration. Standards are needed because progress in the science and practice of river restoration has been hampered by the lack of agreed upon criteria for judging ecological success. Without well-accepted criteria that are ultimately supported by funding and implementing agencies, there is little incentive for practitioners to assess and report restoration outcomes. Improving methods and weighing the ecological benefits of various restoration approaches require organized national-level reporting systems.

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Buried in that publication is an important statement:

"While other objectives have value in their own right, river restoration connotes 'ecological' and should be distinguished from other types of improvement."

Few practitioners or management organizations will see it – including government agencies responsible for natural resources.

A practitioner puts it this way:

"If the restoration design is not based on natural channel morphology and ecology, it is NOT stream restoration!"

L. Aadland (Minnesota DNR)

Upper Midwest Stream Restoration Symposium 2012

The publication’s important statements of 5 criteria for measuring ecological success:

A guiding image exists: a dynamic ecological endpoint is identified a priori and used to guide the restoration. [Have a reference site.]

Ecosystems are improved: the ecological conditions of the river are measurably enhanced.

Resilience is increased: the river ecosystem is more self-sustaining than prior to the restoration.

No lasting harm is done: implementing the restoration does not inflict irreparable harm.

Ecological assessment is completed: some level of both pre- and post-project assessment is conducted and the information made available.

Wordy!

The 5 criteria can be condensed:

Aim for specific dynamic ecological outcomes. (Use reference sites; diagnose.)

Measurably improve the stream’s ecological functions.

Increase resilience for a self-sustaining ecosystem.

Do no irreparable harm.

Reveal results via pre- and post-project measurements and analyses.

Many projects, such as this one, probably meet none of the criteria. The harm being done in the name of “restoration” may be reparable only at great expense.

Criteria for ecological success	Traditional habitat work
Aim for dynamic ecological outcomes (ref site; diagnose)	Simplify; create a few kinds of in-channel habitat features for trout
Measurably improve the stream’s ecological functions	Little considered
Increase resilience for a self-sustaining ecosystem	Build structures that need artificial maintenance for on-going function
Do no irreparable harm	Destroy various stream features needed for full ecosystem function
Pre- and post-project measurements and analyses	Seldom (“too expensive”)

Success criteria	Past habitat work	Some solutions
Aim for dynamic ecological outcomes	Create few kinds of in-channel habitat for trout	Devise diagnostic methods; adopt broader perspective*
Improve ecological functions	Little considered	Ditto*
Increase ecosystem resilience	Build structures that need artificial maintenance	Enable self-healing (geomorph analysis; manage riparian veg)*
Do no irreparable harm.	Destroy, inhibit features for restored ecosystem function	Minimize artificial restructuring*
Pre-, post-project measurements and analyses	Seldom (“too expensive”)	Sample feasible numbers of similar projects; measure more variables*

*For all criteria, promote ecological perceptivity in practitioners; use multi-profession teams.

The Wisconsin Conservation Dept. (WCD) began a statewide **watershed program** in 1949-50.

The needs were obvious.

Impetus came from trout fishers, from newly hired biologists, and from Aldo Leopold.

Prof. Leopold, the father of wildlife management, had helped start Coon Valley's watershed project, the nation's first big soil conservation effort, and he held a seat on the Wisconsin Conservation Commission.

Unfortunately, Leopold died in 1948, and the WCD program got off to a bad start.

Aldo Leopold's Wisdom - 1939

A wildlife professional has:

Conviction of need for science in accomplishing conservation

Ability to diagnose the landscape to discern trends in its biotic community and modify them where necessary for conservation

Knowledge of plants, animals, soil and water

Familiarity with other professions and their influence on the landscape

This was inadequately followed in WCD's watershed program.

The program was organized as construction crews. A desk-bound biologist in Madison headed it administratively. The crew foremen, called "watershed managers," had little or no scientific training.

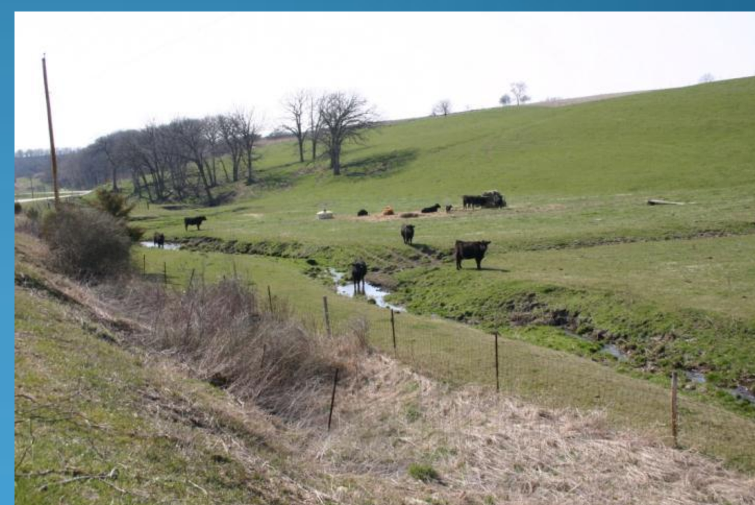
The program soon lost its watershed aspect, largely because few upslope farmers would cooperate.

It became a trout stream improvement program. The foremen became "habitat managers."

Biological surveys identified streams that had potential. Otherwise, there was little guidance from biologists.

Valley bottom farmers often granted narrow riparian easements. The crews built stream channel structures and fenced banks to exclude livestock. The latter practice did a world of long-term good.

“America’s Dairyland”

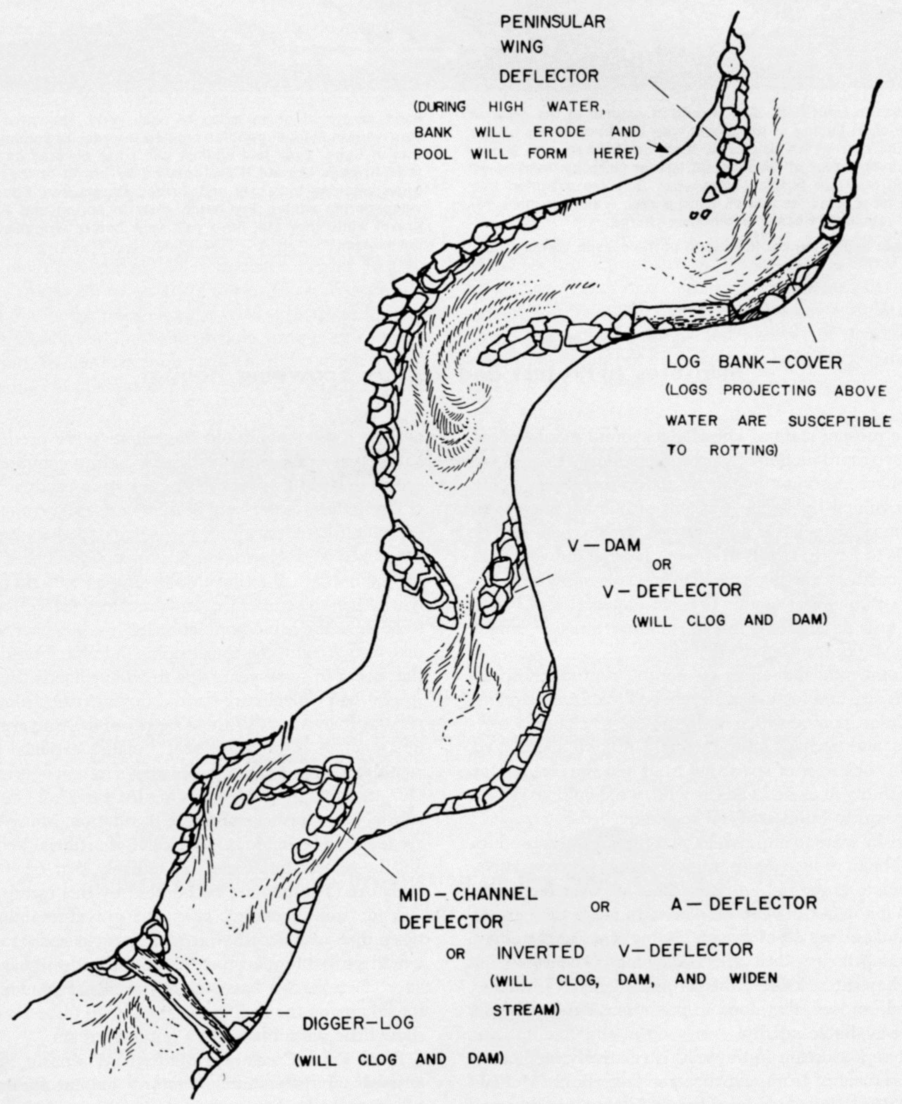


Streams were in such bad shape that we thought we had to built habitat. We didn’t know what vegetation could do, once protected.

The program built many structures of the types shown at right.

Guidelines eventually published for the program in1967 recommended against such devices, advocated some other kinds of structures, and emphasized management of riparian vegetation.

Note that riprap is one of the non-recommended methods.



Some nonrecommended or improperly constructed devices.

Basic mistakes (mainly techno-fix)

within a primarily beneficial program

Much like the hatchery mistake, in which we tried to manipulate fish instead of dealing with the difficult human issues of over-fishing and habitat destruction, stream habitat projects have often manipulated channels instead of reducing human-generated harm to the land- and waterscape.

We have tended to:

- Ignore root causes of problems
- Manage where convenient but not needed
- Not work in concert with dynamic physical and ecological processes
- Emphasize artificial structures to stabilize channels
- Lack multi-profession, science-based teamwork

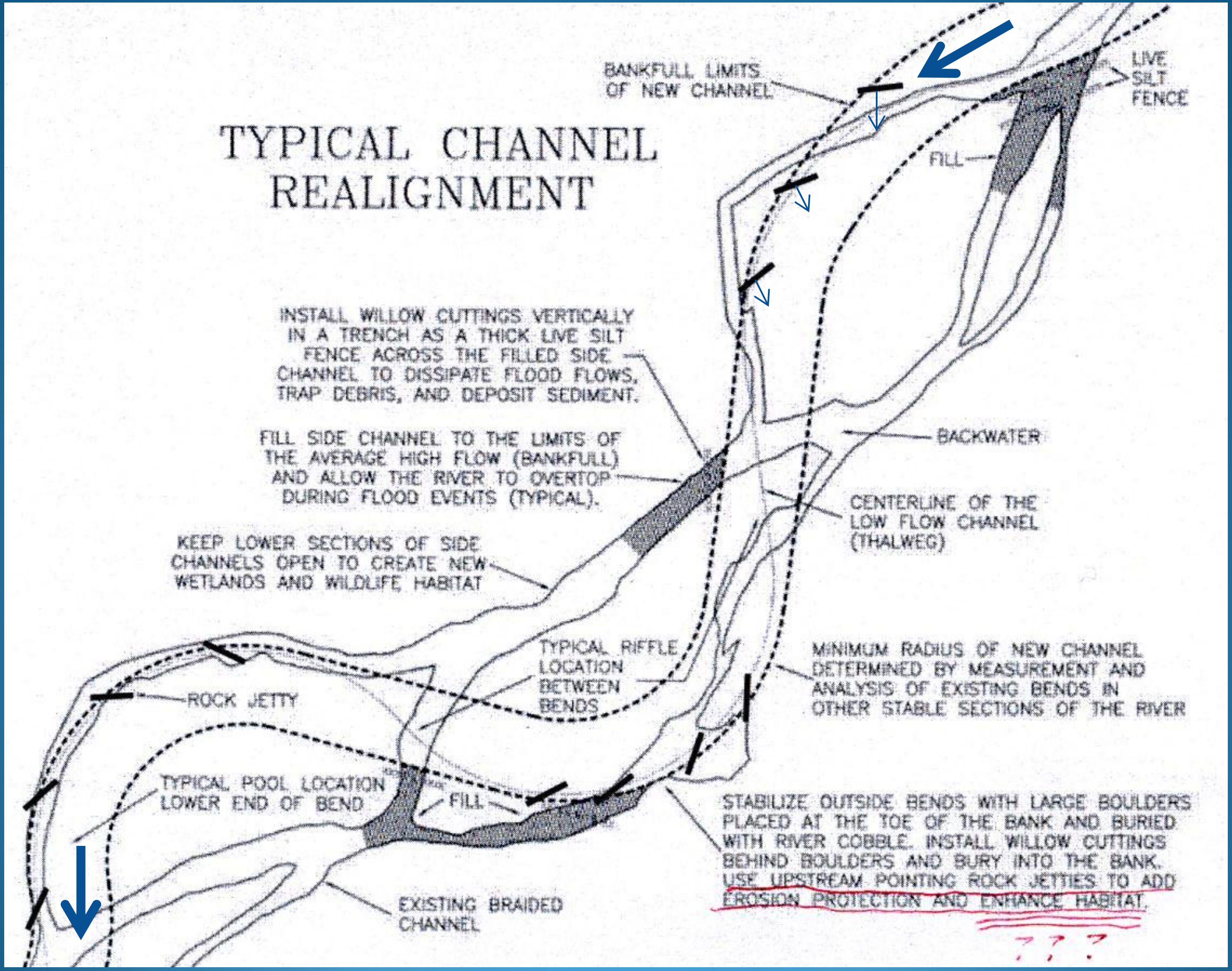
Confusion about the term “habitat” causes problems

Habitat = the spatial structure of the environment, which allows a species to live, reproduce, feed, and move.

The term “habitat” has little meaning without mentioning the type of organism to which it applies.

Examples: brook trout habitat, snapping turtle habitat

A nonsense use of the term "habitat," underlined at lower right. The jetties mimic no natural form and enhance no known habitat.



The term "restoration" also is commonly misused.

People apply it to many kinds of stream work nowadays – but **restore** means "to bring back to an original state."

Toward an original state is more realistic because even if we can determine what a stream's and landscape's original state was, "legacy effects" of past harm and social realities of the present often hinder full restoration.

The best definition of restoration I've found is this one:
Restoration = relaxing human constraints on natural development of patterns of diversity. Restoration measures should NOT focus on directly recreating natural structures or states but on reestablishing the conditions under which natural states create themselves.

Modified from Minnesota DNR and other sources

“Manage for the mess!” – a restoration slogan

But it should be natural diversity. Just any old kind of diversity won’t do.

Too often, instead of reestablishing the conditions under which naturally protective stream banks can develop, we build structures like this – a type I used to advocate.

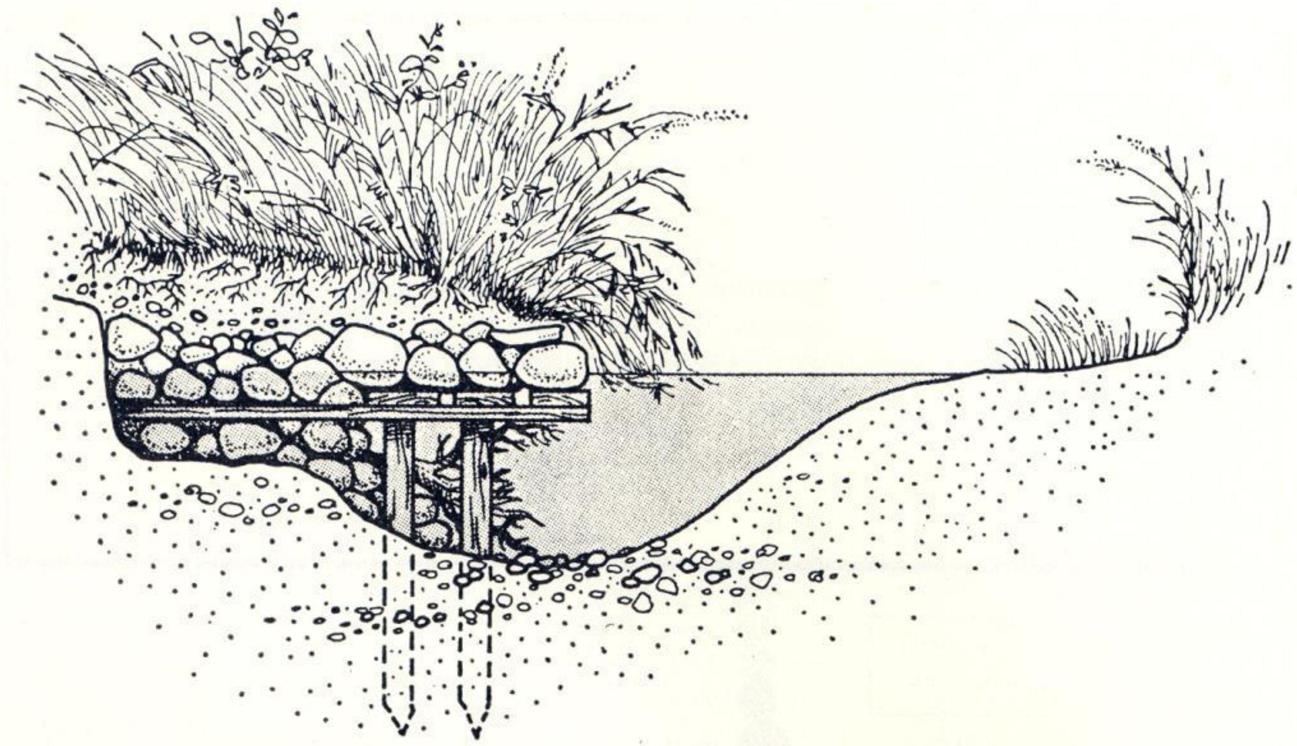


Fig. 4. Cross-section of deflector and bank cover construction. Pilings usually longer than shown. (From WHITE 1968, copyright, Verlag Paul Parey, Hamburg and Berlin.)

Here’s one being built in 2011. “Creek carpentry” on a Central Wisconsin stream that’s perfectly capable of self-restoration.

A well built bank-cover structure – but unneeded in a creek's meadow section that had been excellent habitat and provided superb trout fishing for decades. Beneficial management of riparian vegetation has been preserving the meadow habitat.

Riparian brush cutting in the same county prevents excessive streambank shading which would cause the channel's habitat for trout to deteriorate. Regrowth of grasses and tree foliage will quickly change the bleak appearance of this early spring scene.

Project X

The riparian vegetation along this brook looks favorable, but deep silt covers the bed, and trout are scarce. Much of the brook had once been channelized.

A local citizen-conservation group promoted a restoration project to be done by the state.

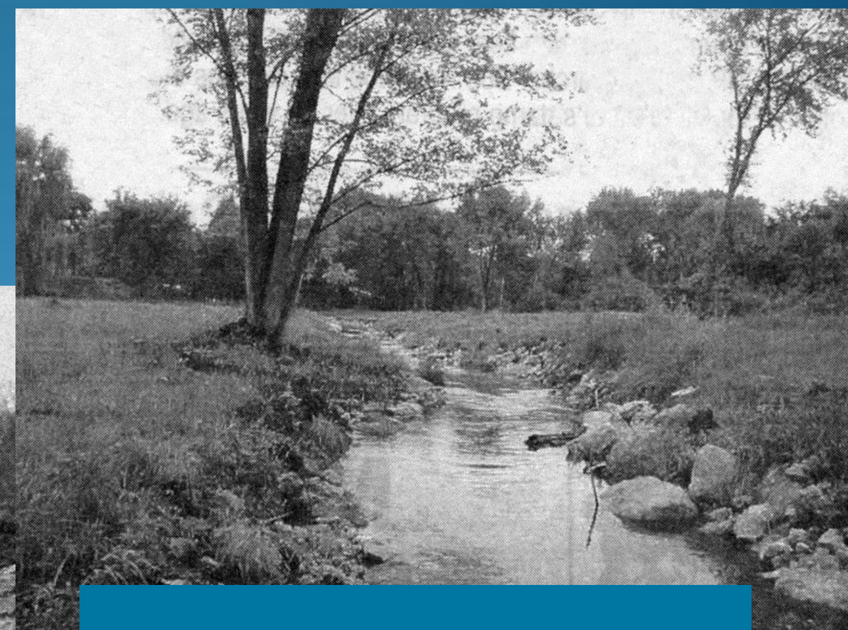
Project X

Project X

Results:

Not restoration.

Stream bed still silty, so no trout spawn, but more trout exist in the reach because they immigrate from downstream.



Rockery domination

Hinders lateral connectivity.

Bad effects on other wildlife?
Cost/benefit vs. other methods?

Project Y - A typical grazing-devastated situation in Wisconsin's Driftless Area before start of the work.

The region's pre-1930s agriculture had eroded upland soil, forming layers as much as several feet thick over the natural floodplain soil.

A patch of excellent concealment habitat for trout before Project Y. Project proponents considered this as something to be eliminated.

One objective of Project Y was to remove the floodplain's overburden of eroded upland soil and return it to ridgetop farms, thus restoring the natural floodplain, as had been done in a nearby project.

Political obstacles prevented that plan. The stream banks could only be sloped.

In the process, woody material was removed from the channel and banks. It could have been used again to create cover for trout.

But the wood was burned as work proceeded to simplify and stabilize the channel. “Lunker” coverts for trout were incorporated in the riprap wall.

Intuitive fear of bank erosion.

Craving for stability.

Trying to create a few “ideal” habitat forms.

↓

Inflexible prosthesis.

↓

Prevents natural, regenerative healing.

The finished Project Y – a simplified waterway, with natural processes blocked by “stabilization.”

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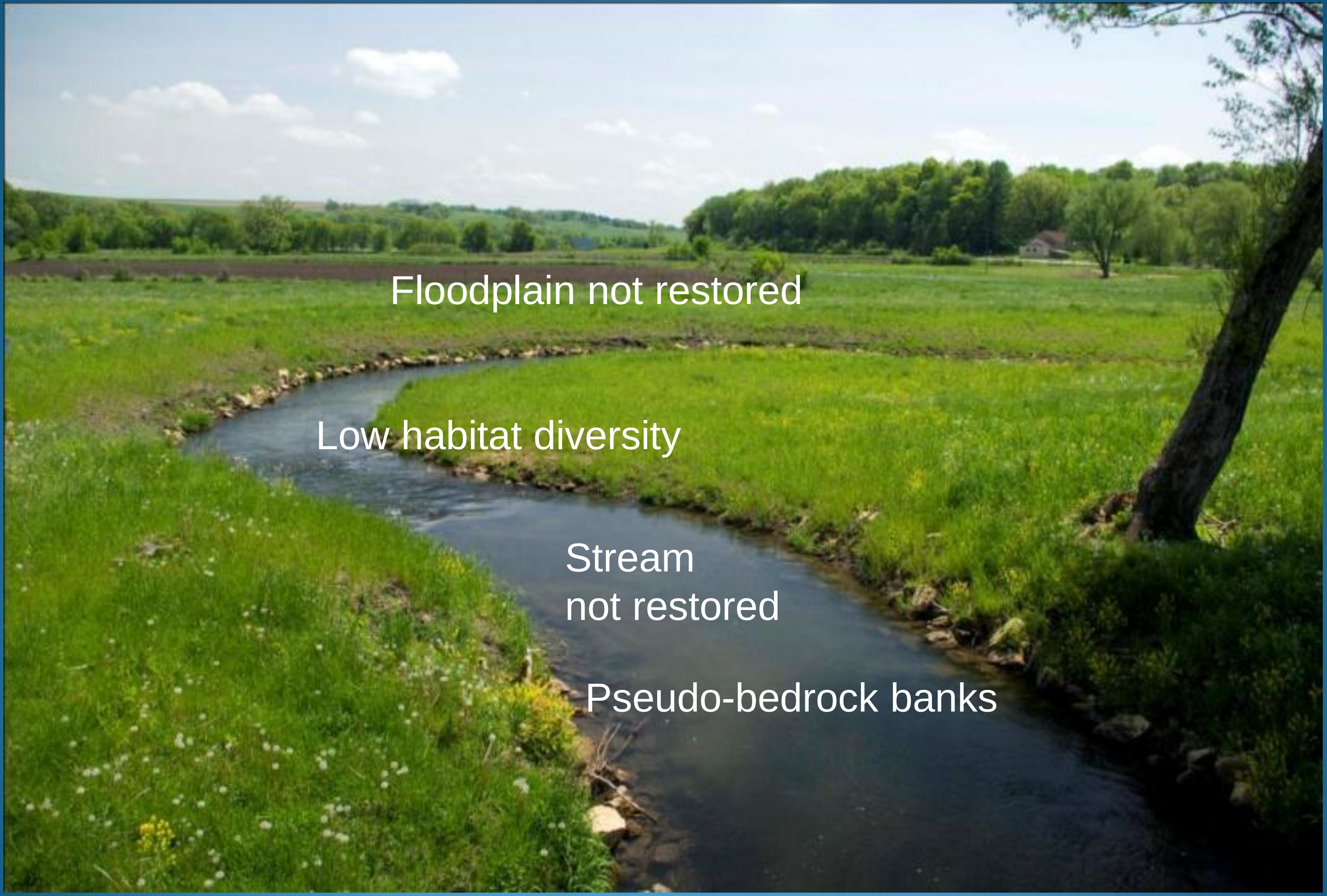

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Aldo Leopold had said it long ago:

1933 – “Very intensive game--or fish--management lowers the unit value of the trophy by artificializing it.”

Solution: “natural channel design?”

Solution: "natural channel ~~design~~?"

The term is well meant but illusory, misleading.
It's also hubris and an oxymoron - like "clean coal"

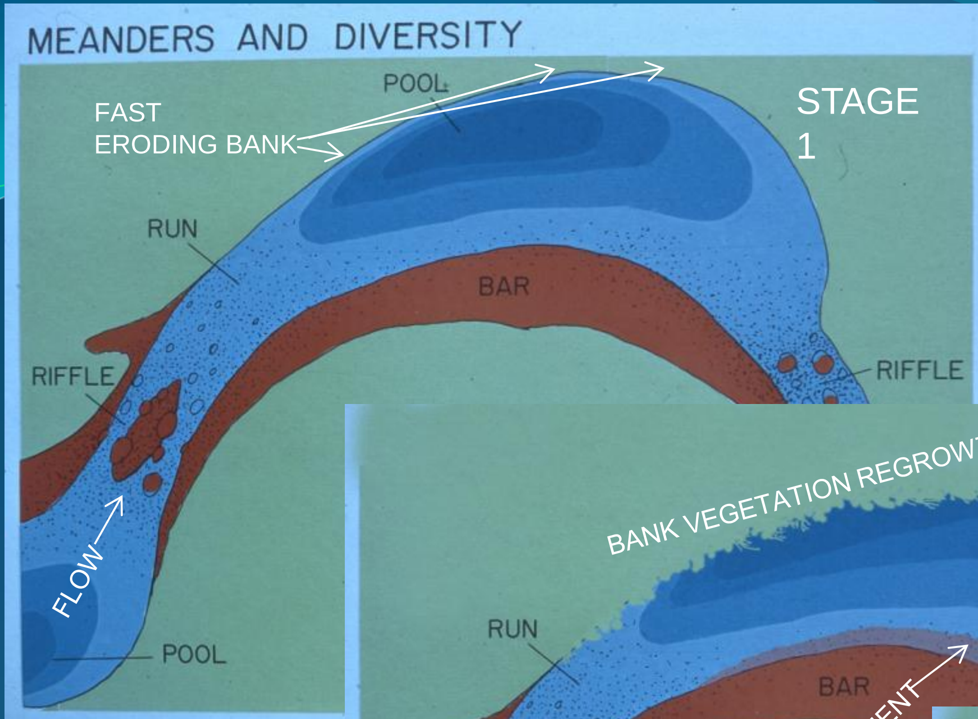
If we design it, it can't be natural.

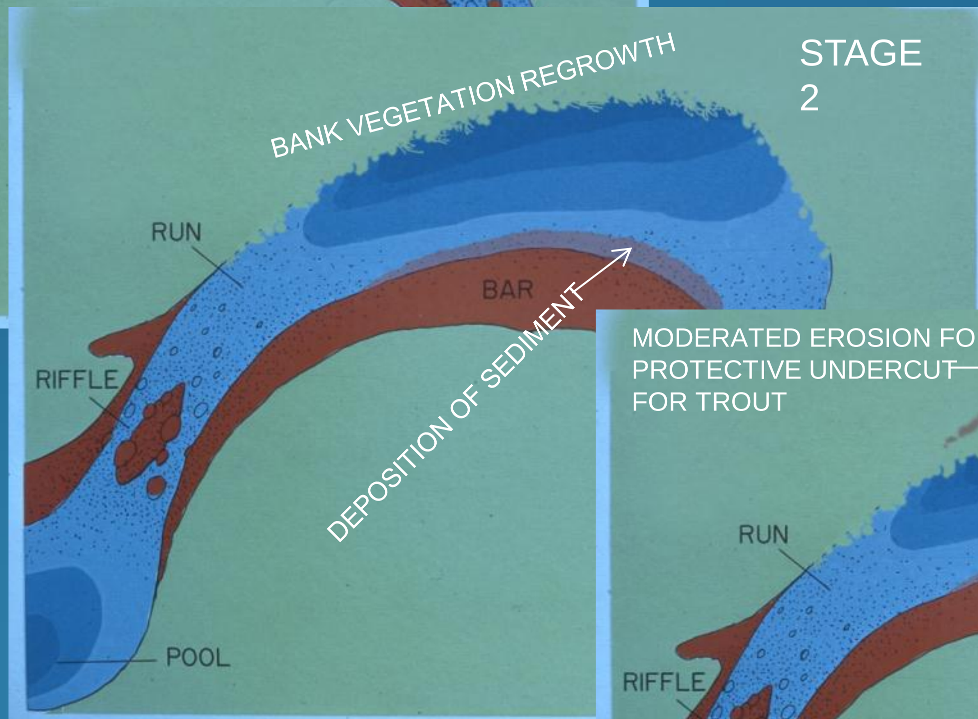
Where we have to do artificial work, the best we can do is
natural channel simulation!
True, if perceptively done

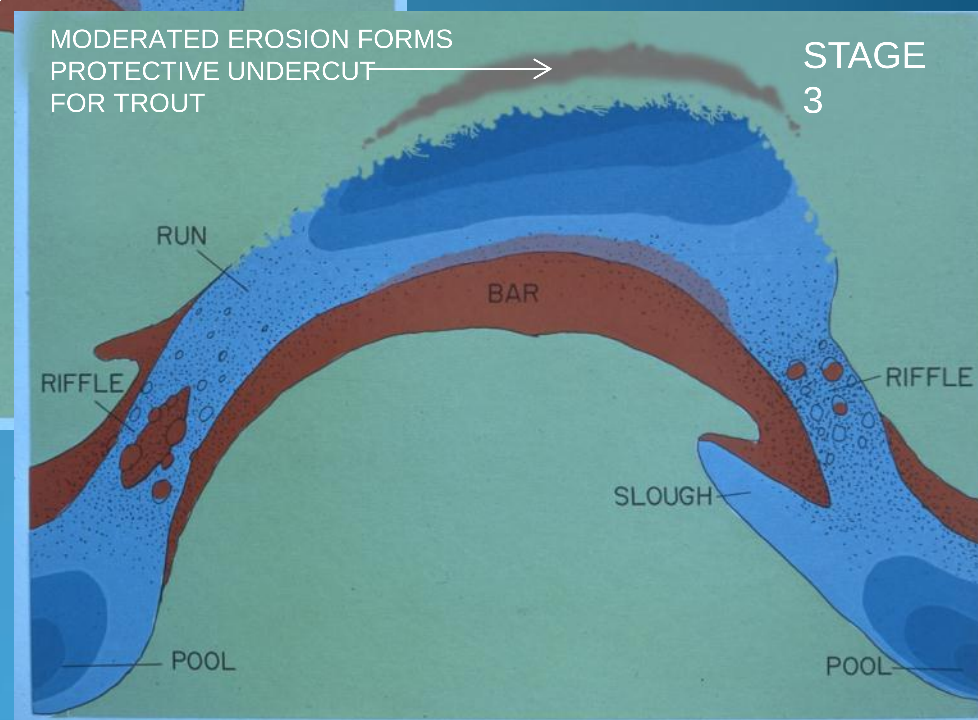
The ecological integrity of river ecosystems depends on their natural dynamic character.

“The natural flow regime: a paradigm for river conservation & restoration” Poff, at al. (1997)

Vegetation-moderated lateral channel migration generates habitat.

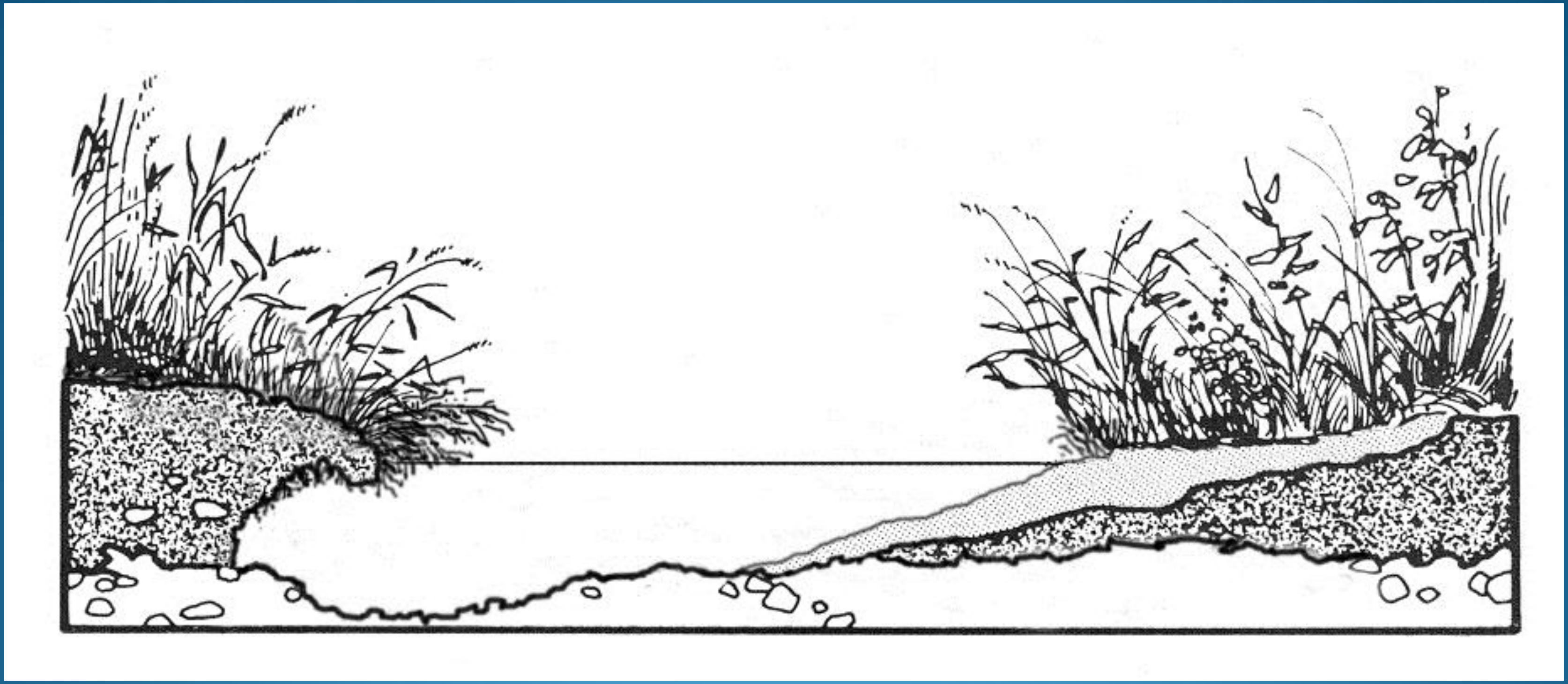






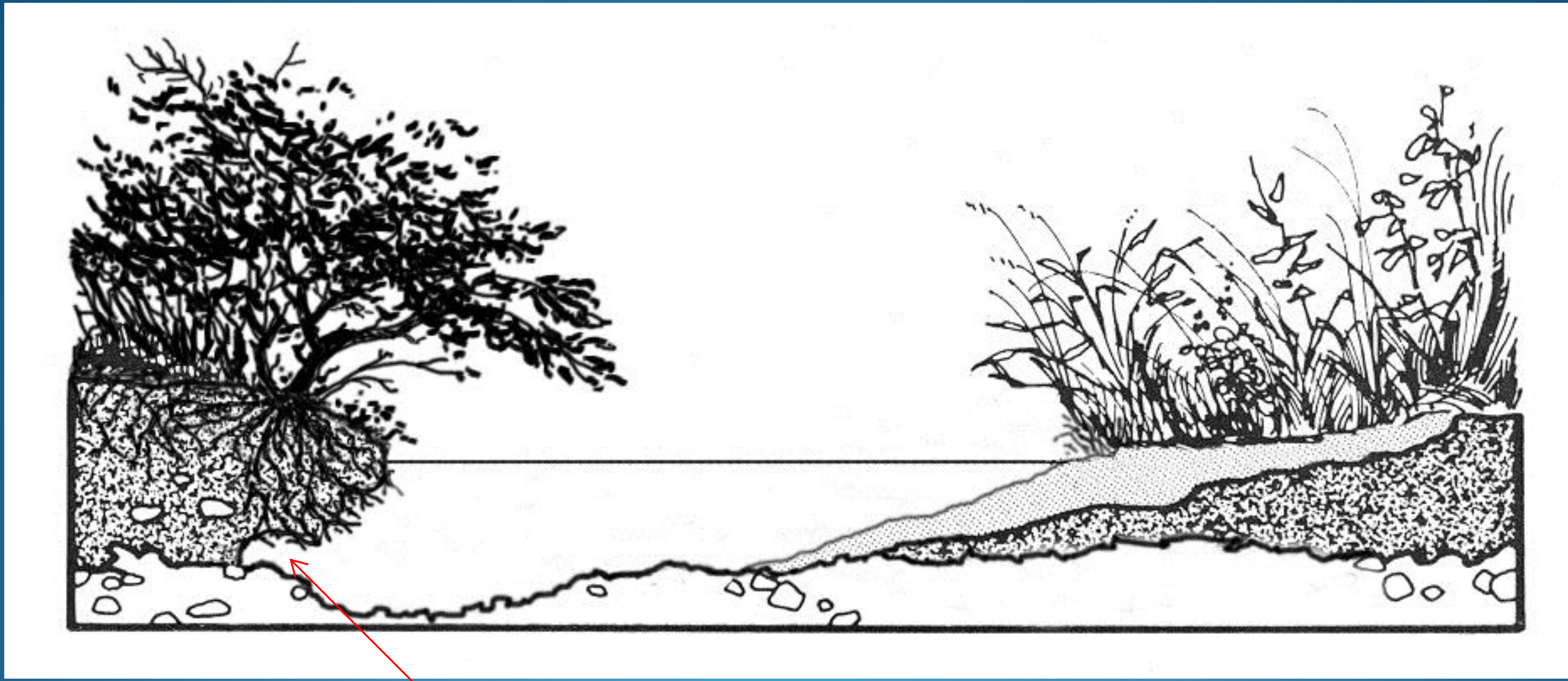
Modified from a diagram of stream meanders and diversity developed by John L. "Slim" Funk, Missouri Department of Conservation.

Natural undercutting of a meander's current-bearing bank – and deposition of sediment on the point bar – in a meadow creek



A tough turf of grasses and other low vegetation permits only slow lateral migration of the channel.

A situation where woody vegetation reinforces the bank.



Stuffing “toe-rock” here is common practice but blocks the best hiding cover for trout.

Shifting habitat mosaic

A river landscape in far-east Siberia, courtesy of Geomorphologist Uwe Koenzen, Hilden, Germany

A dynamic river landscape generating diverse habitats for many forms of life.

Not all land- and streamscapes undergo such extensive (or perhaps rapid) change as shown here. But natural amounts of change are the natural condition to which wild organisms are adapted.

A successful project – Black Earth Creek, Wisconsin

By the early 1950s, livestock grazing had devastated channel shape and sediment transport in this spring creek.

About 2-3 years after fencing and structural work, including paired deflectors made of rock, single-log bank-coverts, and other bank revetments.

Regrowth of riparian vegetation made most of the difference – as seen in the following slides:

Black Earth Creek after restoration

About 30 years after fencing

About 10 years after fencing

The view at left shows great narrowing of the channel by stream-edge plants. This concentrated the current, which swept a thick layer of silt off of streambed gravel, enabling trout to spawn.

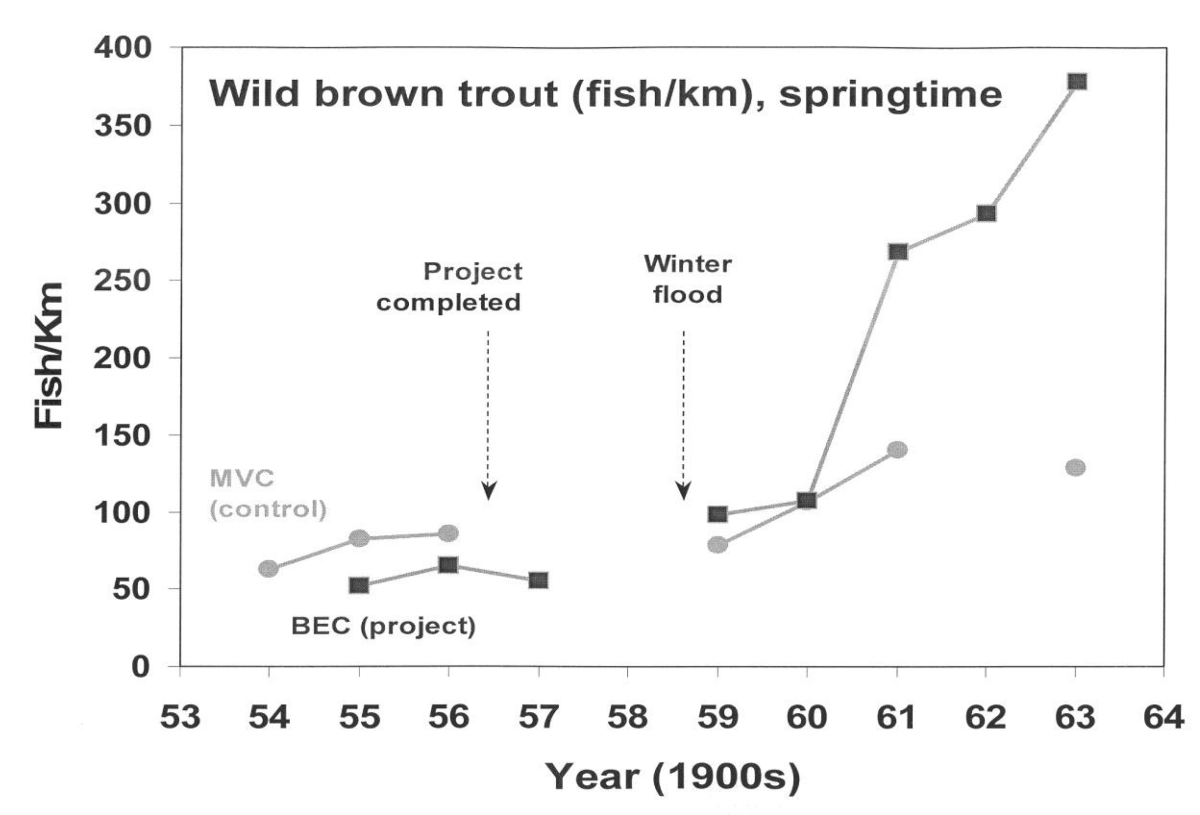
Mount Vernon Creek,

the untreated comparison-

stream, 18 miles south of

Black Earth Creek

Black Earth vs. Mount Vernon Creek



Black Earth Creek's trout population increased tremendously, whereas, the population in Mount Vernon Creek rose but slightly. Fast increase probably began before 1959, but a severe snowmelt flood (debilitating cold water) undoubtedly reduced the population.

Photo by Robert L. Hunt

When later fenced, habitat and trout population of the Mount Vernon Creek control stream underwent similar improvement. These are the larger brown trout (anesthetized) from an electrofishing catch of over 100 trout in a 300-foot stream section. The measuring board is probably 25 inches (63.5 cm) long.

A grazed section of Thompson Spring Creek near Bozeman, Montana.

Adjacent section of Thompson Spring Creek 2 years after cattle removal.

Prelude to a successful revegetation project in Montana

Spring Coulee Creek in Teton County was grazed and underwent high "waste flows" (unused water discarded from an irrigation system) several to many times each summer.

Inexpensive, semi-natural treatment:

Bank sloping and temporary revetment with trees before fencing to enable streambank stabilization—and trout habitat generation—by riparian vegetation in Spring Coulee.

The restoration result in Spring Coulee, Montana

Healed banks and much better trout habitat 12 years after tree revetment and cattle exclusion, despite continued frequent flooding by discarded irrigation-system water. Some willows and other vegetation were planted. Stream reaches without willow planting also healed well.

Overhanging vegetation and moderately undercut of banks form shelter for trout. Fishing excellent.

Stream reaches without willow planting also healed well. Note fence in background.

In conclusion, we return to the 1956 image of the self-healing trout creek in Wisconsin (South Branch of Wedde Creek, Waushara County).

Here’s how it looked 57.5 years later, Feb. 23, 2013. A photo in growing season would show little but foliage. Apparently, the landowner has cleared woody vegetation from the middle ground. Most of the creek is so tree-canopied that trout habitat has deteriorated (see post-talk question and answer).

“The art of land doctoring is being practiced with vigor, but the science of land health is yet to be born.”

“Health is the capacity of the land for self-renewal. Conservation is our effort to understand and preserve this capacity.”

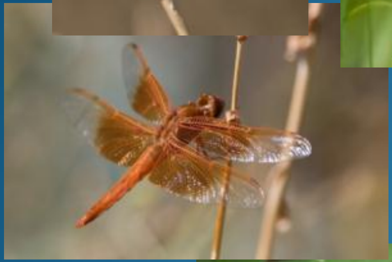
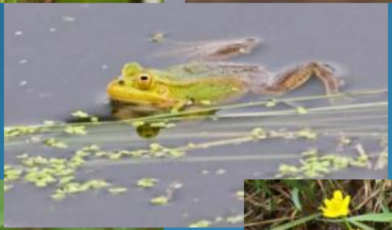
A Sand County Almanac, Aldo Leopold, (1949) We've been purposeful in striving for this.

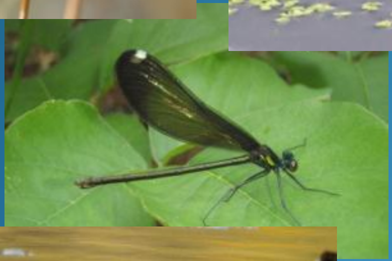
We can attain far more.









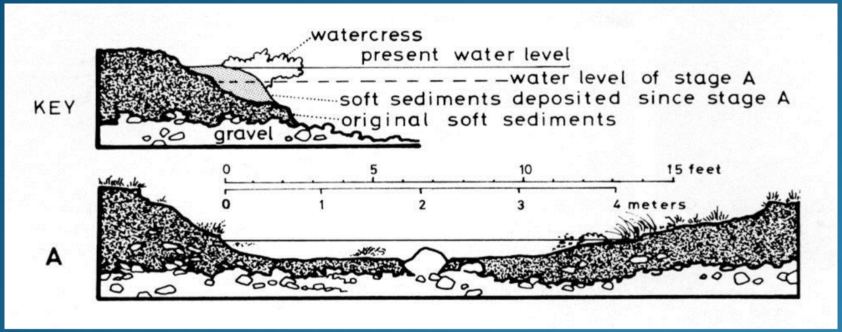



In the audience discussion after this presentation, Doug Shields asked how dense tree canopy over a creek—shown near the end of the talk—creates poor habitat for trout.

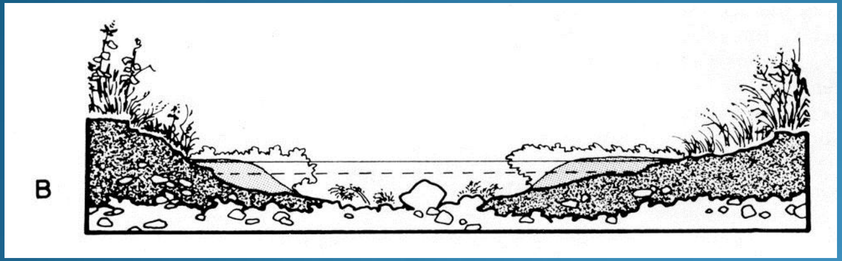
Answer: Excessive shade kills low, erosion-resisting plants that constrict the channel. Therefore, the channel becomes wider and shallower. Some of the habitat consequences for trout are less usable space, fewer deep pools, fewer bank-overhangs in which to hide from predators, and less spawning area—the latter because gravel beds become inundated by fine sediments.

The following diagrams illustrate this.

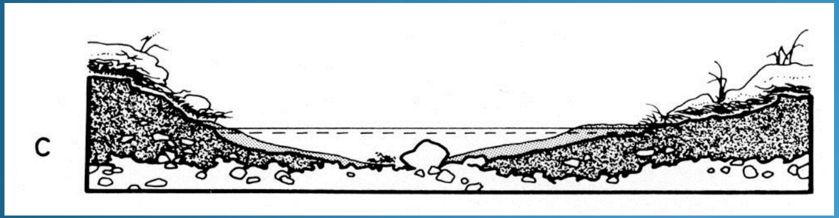
Stages in development of a lowland spring creek from overgrazed (A) to very trout-productive (DEF) to overforested (GH). From White & Brynildson, Wis. DNR Tech. Bull. 39 (1967).



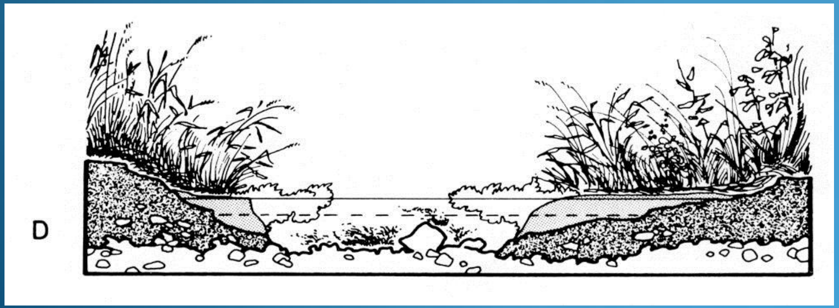
A - Midsummer conditions under heavy grazing by livestock: Bank vegetation and watercress grazed and trampled. Banks eroding, stream bed covered by shifting silt or sand. Trout have no shelter, no place to spawn, little food, and frequently unfavorable temperature.



B - Midsummer condition after 2-4 years of livestock exclusion: Bank vegetation forming turf. Stream edge watercress constricts channel, deepening and speeding current, thus scouring fine sediment away. Trout have shelter beneath water cress and beside rock. Newly exposed gravel is spawning habitat and harbors food.



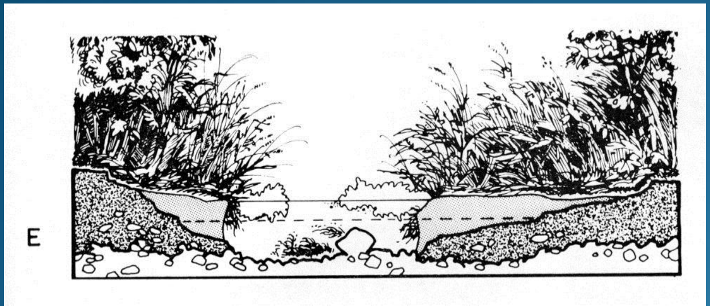
C – Late in the next winter: Watercress has withered and drifted away. The silt it held slumps into the channel, smothering trout eggs and sacfry. Broad surface of water exposed to cold. Trout shelter almost as poor as at stage A and won't redevelop until May or June.



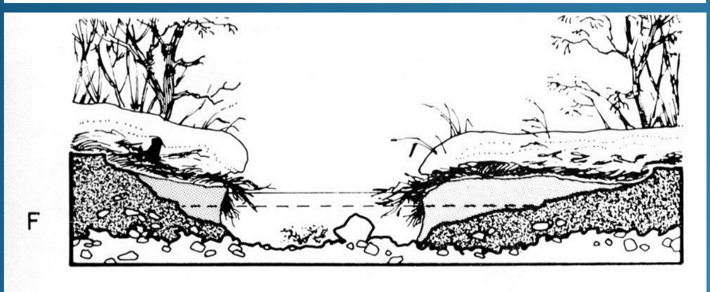
D – Midsummer condition in about the 3rd to 5th summer after grazing halted: Further scouring of sediment from stream bed. Silt bars at stream edges being tied down by roots of grass and sedge. Few feet of stream width exposed to sun. For trout, shelter, food and spawning gravels are ample.

(Sequence continued on next slide.)

Stages in lowland spring creek “succession,” continued.

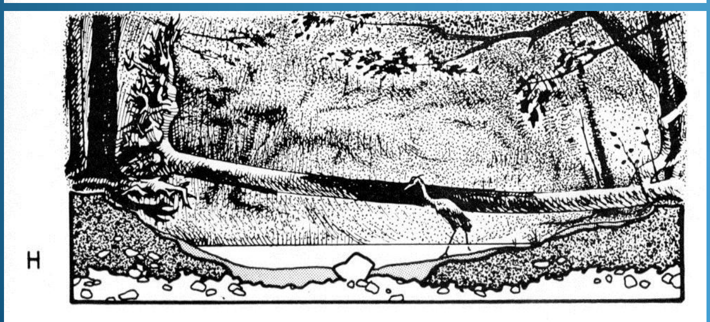


E – Midsummer a few years later: Silt banks further stabilized by turf. Channel narrowed by 40-50% since stage A. Shade has decreased the amount of watercress. Woody vegetation starting to dominate.



F – Late winter during stages D through E: Turf anchors the bank soils. Overhanging fringes of matter grass provide shelter for trout. Gravels stay clean enough to allow normal hatching of eggs and emergence of fry.

G – Midsummer 10 to 20 years later: Dense thicketing by brush, mainly speckled alder in central and northern counties, box elder in the south (saplings of poplar, ash or maple at left). Turf completely shaded out. Trout shelter abundant beneath banks and among roots and fallen branches. The innermost alders will soon tip into the channel, destroying the overhanging banks.



H – Many years later: Dense forest. Shade allows few plants on forest floor. Stream banks have eroded, the channel has spread, and silt or sand again covers the bed. Water depth is less than one foot. Until the forest is mature enough to shed many branches and logs into the channel, there will be little shelter for trout.

Vegetational composition of the stages varies regionally. Wildfire used to maintain streams at stages D through F in much of the Midwest before Euro-American settlement.