Breaking up with Lane
Rethinking stability and equilibrium in stream restoration

By: Mark Beardsley and Karin Boyd

Special thanks to: Jessica Doran
Scott Gillilan
Lots of French guys (1700s – 1800s)

Grove Karl Gilbert (a.k.a. Captain Bold) (1877)

Domenico Guglielmini (1697)

Emory Wilson Lane (1955)

Henry Joseph Mackin (1948)

William Morris Davis (1894)
Process domain

\[ Q_S D_S \propto Q_W S \]
Order
Equilibrium
Stability
Natural Equilibrium Paradigm

Natural Equilibrium

Order
Equilibrium
Stability
Natural Equilibrium Paradigm

Powerful heuristic
Understanding stability
Assessing function
Doing restoration

A convenient relationship
1. Thou shalt transport the streamflows and sediment of thy watershed.
2. Thou shalt maintain thy dimension, pattern, and profile.
3. Thou shalt not aggrade nor degrade.  

(per Rosgen 1996)
1. Thou shalt transport the streamflows and sediment of thy watershed.
2. Thou shalt maintain thy dimension, pattern, and profile.
3. Thou shalt not aggrade nor degrade.

Natural Equilibrium Paradigm

Pollock et al (2014)
1. Thou shalt transport the streamflows and sediment of thy watershed.
2. Thou shalt maintain thy dimension, pattern, and profile.
3. Thou shalt not aggrade nor degrade.

Natural Equilibrium Paradigm

Resistance
Balance
Resilience
Natural Equilibrium Paradigm

Assessment

Reference = stable equilibrium channel

"Higher" functions

Stability

Natural Equilibrium
Natural Equilibrium Paradigm

Reference = Natural stream

“Higher” functions

1. Hydrology
   - Transport of water from the watershed to the channel

2. Hydraulic
   - Transport of water in the channel, on the floodplain, and through sediments

3. Geomorphology
   - Transport of wood and sediment to create diverse bed forms and dynamic equilibrium

4. Physicochemical
   - Temperature and oxygen regulation, processing of organic matter and nutrients

5. Biology
   - Biodiversity and the life histories of aquatic and riparian life

Natural Equilibrium

Stability
Natural Equilibrium Paradigm

Pollock et al (2014)
Natural Equilibrium Paradigm

All channel design is based on the premise that “natural” channels tend toward equilibrium between channel form and sediment and hydrologic inputs (Leopold and Maddock 1953).

Natural Equilibrium

Natural Channel Design

The application of fluvial geomorphology to create stable channels that do not aggrade or degrade and that maximize stream functions given site constraints (Harman and Starr 2011)

1. Thou shalt transport the streamflows and sediment of thy watershed.
2. Thou shalt maintain thy dimension, pattern, and profile.
3. Thou shalt not aggrade nor degrade.
Natural Equilibrium Paradigm

**Goal =**

*stable equilibrium channel*

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**analytical method**

Continuity equations, roughness equations, hydraulic models, sediment functions...

**analog method**

Reference reach (presumed stable equilibrium)

\[ Q_{WS} \propto Q_S D_S \]
Natural Equilibrium Paradigm

How it usually goes...

1. Thou shalt transport the streamflows and sediment of thy watershed.
2. Thou shalt maintain thy dimension, pattern, and profile.
3. Thou shalt not aggrade nor degrade.
Natural Equilibrium Paradigm

Standards for ecologically successful river restoration
(Palmer et al 2005)

1. Guiding image of dynamic state
2. Ecosystems are improved
3. Resilience is increased
4. No lasting harm
5. Ecological assessment

↑ NCD Goal = stable equilibrium channel

Ecological Goal = dynamic natural system →
Standards for ecologically successful river restoration (Palmer et al 2005)

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Ecological Goal = dynamic natural system
Natural Equilibrium Paradigm

Static channel form and equilibrium are not universal criteria for stability

Stream functions are not just the product of stable equilibrium

Restoration is not just creating stable equilibrium channels
Natural Equilibrium Paradigm

To be continued...