S4C Research Agenda 2022–2030

Editors:

Pavel Cudlin

Joanna Zawiejska

Tamara Mitrofanenko

Katalin Mazsa

Mariana Melnykovych

6 Forests, their management and governance

William S. Keeton

Forest ecosystems in the Carpathians will continue to change into the future as compounded stresses from climate disruption, alteration of disturbance regimes, invasive species, land use pressures, and other factors increase. With changes in ecosystem dynamics will come shifts in the mix of ecosystem goods and services those forests provide (Kruhlov et al. 2018, Thom et al. 2019). Foresters, scientists, and policy makers alike are challenged to integrate knowledge from multiple disciplines in addressing questions

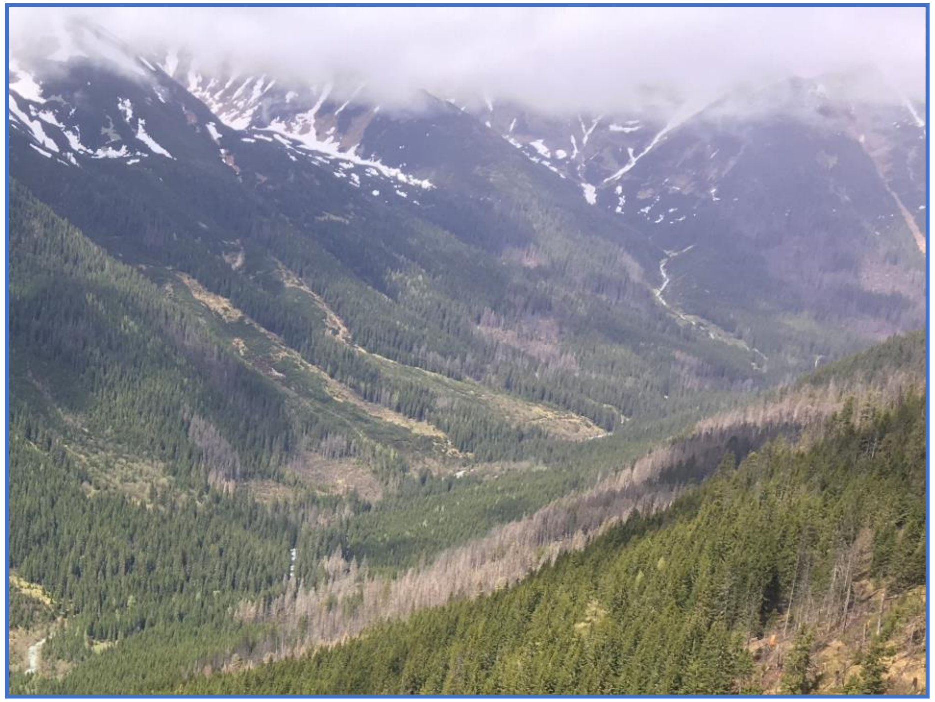
Beech forest with *Lunaria rediviva* in Western Carpathians

Natural forest in Western Carpathians

of climate change. Our research agenda will address the multiple ecological, social, and economic dimensions of global change as it pertains to the forest sector.

Forests in the Carpathians, as in the rest of the world, are increasingly valued as Natural Climate Solutions (NCS) (Griscom et al. 2017). Yet alterations of natural disturbance regimes, such as increases in the frequency and severity of bark beetle outbreaks and wind events, may limit NCS solutions through reduced carbon storage capacity in European forests (Seidl et al. 2014). Thus, forest managers face major challenges as they seek adaptive forest management approaches. Research on all aspects of forest resilience – from flood control and hydrologic regulation, to forest road design, to silviculture for functional trait diversity – will be particularly relevant to the Carpathian region.

Also of concern is conservation of rare and under-represented forested communities and seral stages, including intact floodplain and riverine systems, as well as primary and old-growth forests (Sabatini et al. 2018). Research is needed to identify both protection priorities (Sabatini et al. 2020) as well as vulnerabilities in the face of climate change, invasive species, and illegal timber harvesting, the latter posing threats to forest ecosystems even more generally (Korn et al. 2013). Research investigating the role that natural



Recommended topics

- Climate change effects, vulnerabilities, risks, and adaptation responses
- Invasive species effects on forest ecosystems
- Natural disturbance dynamics, including alteration of disturbance regimes and implications for habitat and ecosystem services
- Reforestation and restoration
- Ecological silviculture, including but not limited to close-to-nature forestry
- Forest biodiversity, including rare, threatened, and endangered species
- Forest carbon dynamics, carbon forestry, and implications for climate mitigation
- Protected areas and natural climate solutions
- Sustainable forest-based recreation
- Forest hydrology and relationships to flood regimes and risks
- Riparian ecology; forest-stream interactions; flood-plain forests
- Improving the region's forest road networks, design, and engineering
- Plant functional trait diversity and ecosystem resilience
- Primary, old-growth, and under-representated seral stages and communities
- Illegal timber harvesting and enforcement of country-specific forest laws

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WILEY

REVIEW ARTICLE

Ecohydrological disturbances associated with roads: Current knowledge, research needs, and management concerns with reference to the tropics

Beverley C. Wemple[1] | Trevor Browning[2] | Alan D. Ziegler[3] | Jorge Celi[4] | Kwok Pan (Sun) Chun[5] | Fernando Jaramillo[6] | Nei K. Leite[7] | Sorain J. Ramchunder[3] | Junjiro N. Negishi[8] | Ximena Palomeque[9] | Derek Sawyer[2]

Overly high logging road density
+ channelization:

→ delivers sediment
→ Delivers water
→ Increases peak flows
→ Changes hydrograph
→ Increases flooding flowing small to medium sized precipitation events

Bukit Tarek, Malaysia

Gully Channelization – California, USA

Slope failure due to logging roads and landings, Sierra Nevada Mountains, California, USA

Forest road design, layout, density management, and decommissioning

Channeled logging road, Romania

- Deeply cut logging road
- Steep gradient
- No water bars or diversions
- Road bed is channelizing, delivering sediment and water directly to streams below

Fagaras Mountains, Romania

- Hillside has been pulled into river bed to provide access for logging trucks and to small hydroelectric dam


Bull-dozed logging road on
officially mapped hiking
tral, Fagaras Range


Bladded road, no gradient
standards, used as a drag
line

Good forest road layout, design, and management are an imperative

From: Colorado Forest Road Field Handbook

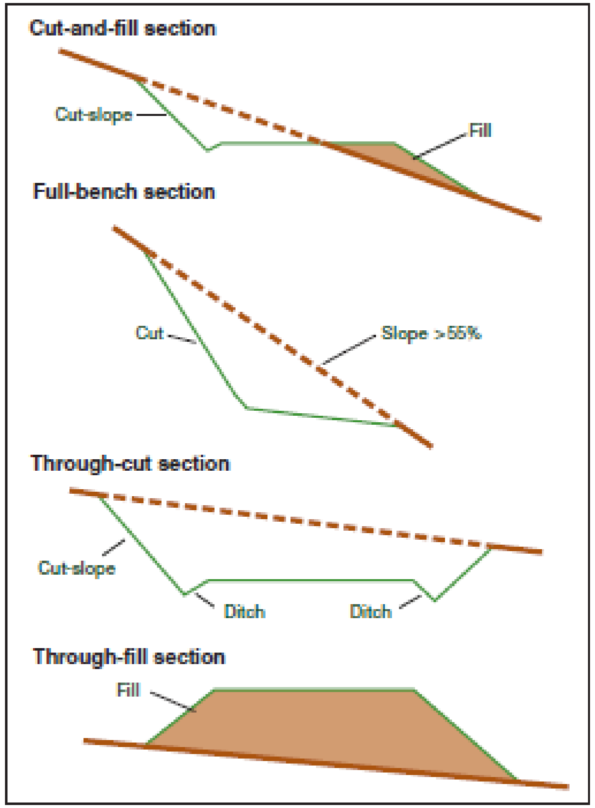


Figure 1-1. Types of road sections.
Source: Brian Kramer

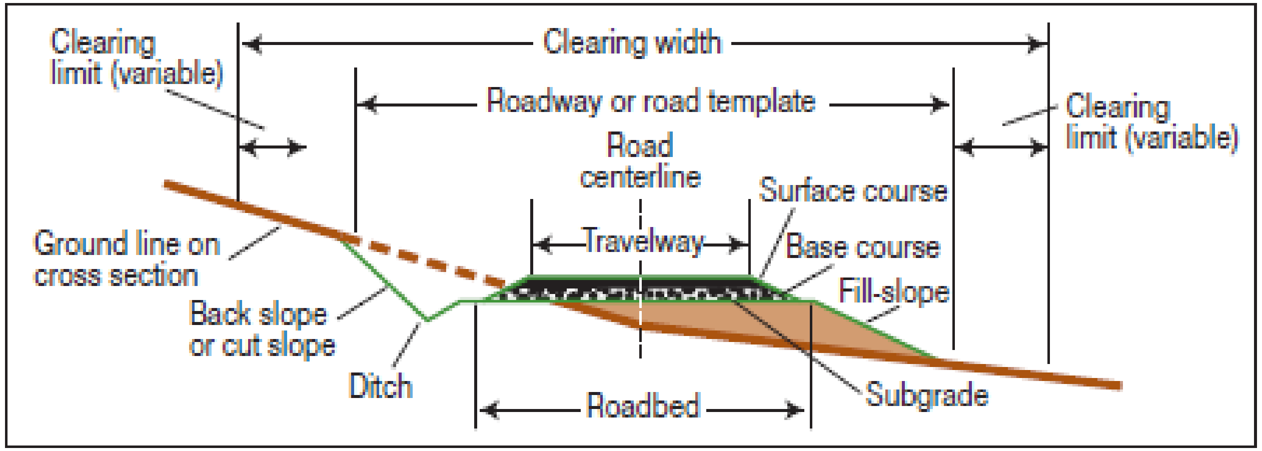


Figure 1-2. Road element nomenclature. *Source: Brian Kramer*

Culvert Design: Fish Passage

Remember that proper culvert design includes more than sizing for the 25-year peak flow.

The design also should evaluate such stream features as:

- gradient,
- elevation in relation to the road grade,
- width (active or un-vegetated width),
- depth to bedrock,
- road alignment and grade,
- potential for sediment and debris movement during high flows, and
- potential for sediment stored behind an old culvert to move downstream with the new installation.

Figure 4-6. Culvert example 3. *Photo: R.M. Edwards*

Following are factors to consider in order to protect fish passage:

- Don't force fish to jump in order to enter or pass through a culvert.
- Keep the culvert opening free of debris.
- Minimize culvert length.
- If possible, locate culverts on a straight part of the stream.
- Set culverts below stream grade so gravel can naturally accumulate in the culvert.
- Consider using natural or hand-placed gravel to facilitate passage of terrestrial species and benefit macroinvertebrates and other species important to the aquatic ecosystem.

Figure 4-7. Culvert example 4.

Alternative Stream Crossings

Figure 4-14. Example of low-tech solution for a temporary crossing using logs and lumber. *Photo: Kelly Rogers*

Figure 4-15. Example of a multiple culvert crossing with decorative retaining walls. *Photo: R.M. Edwards*

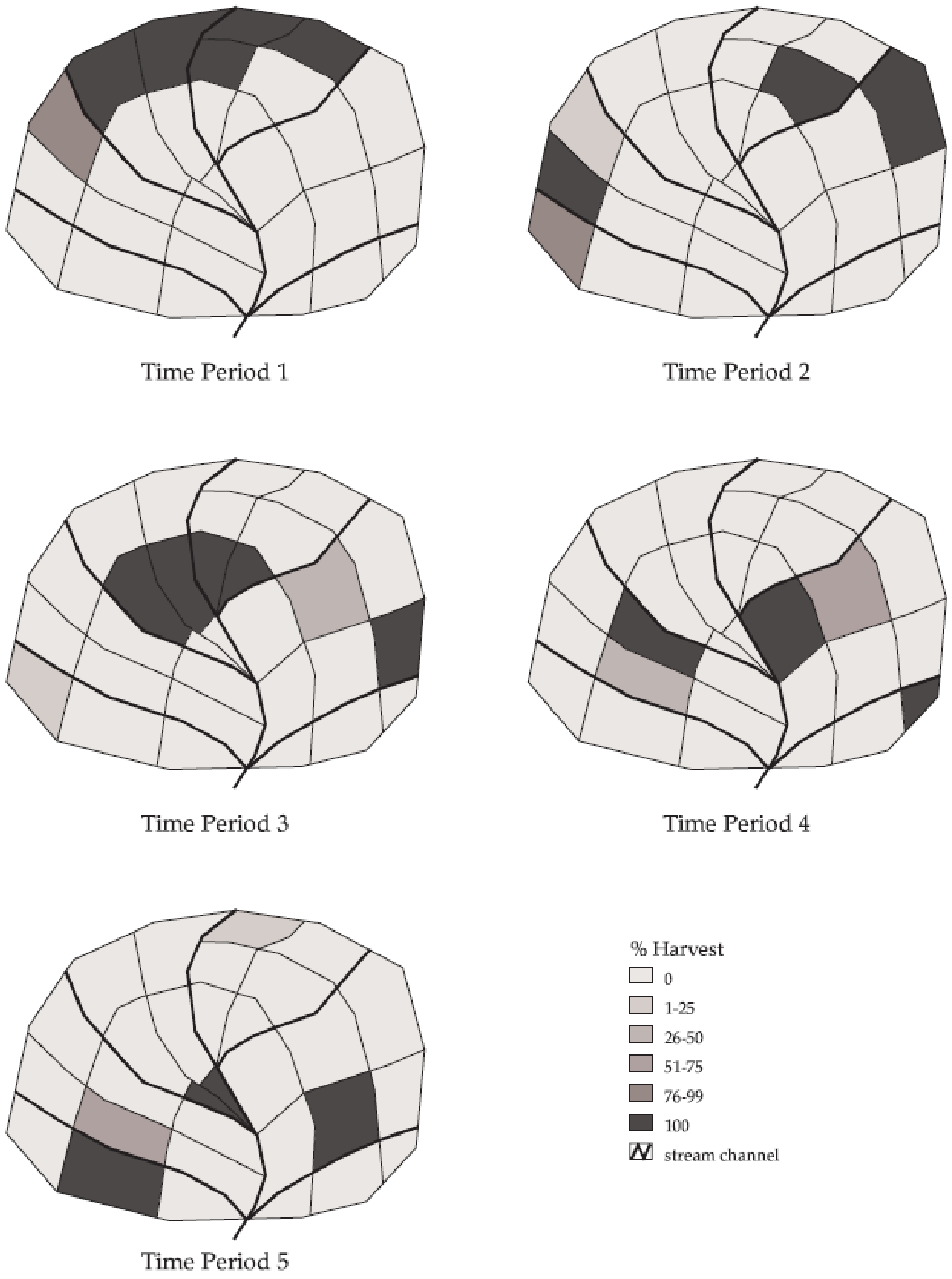
Figure 4-16. Example of a modular bridge with running planks. *Photo: Big R Bridge*

Figure 4-17. Example of a railroad car bridge with concrete abutments.

Cumulative Effects Analysis to limit road and harvesting impacts on watersheds

From: Hof and Bevers (1999). Optimal timber harvest scheduling and road density management for sediment control

Fig. 2. Harvest solution minimizing sediment in stream section 7, the watershed outlet.



Cumulative Effects Analysis

Table 1-3. Examples of cumulative effects (modified from NRC 1986 and Spaling 1995)

Type	Main characteristics	Example
1. Time crowding	Frequent and repetitive effects on an environmental system	Forest harvesting rate exceeds regrowth
2. Time lags	Delayed effects	Exposure to carcinogens
3. Space crowding	High spatial density of effects on an environmental system	Pollution discharges into streams from nonpoint sources
4. Cross-boundary	Effects occur away from the source	Acidic precipitation
5. Fragmentation	Change in landscape pattern	Fragmentation of historic district
6. Compounding effects	Effects arising from multiple sources or pathways	Synergism among pesticides
7. Indirect effects	Secondary effects	Commercial development following highway construction
8. Triggers and thresholds	Fundamental changes in system behavior or structure	Global climate change

Cumulative Effects Analysis

Table 1-4. Types of cumulative effects		
	Additive Process	**Interactive Process**
Single Action	**Type 1** — Repeated "additive" effects from a single proposed project. Example: Construction of a new road through a national park, resulting in continual draining of road salt onto nearby vegetation.	**Type 2** — Stressors from a single source that interact with receiving biota to have an "interactive" (nonlinear) net effect. Example: Organic compounds, including PCBs, that biomagnify up food chains and exert disproportionate toxicity on raptors and large mammals.
Multiple Actions	**Type 3** — Effects arising from multiple sources (projects, point sources, or general effects associated with development) that affect environmental resources additively. Example: Agricultural irrigation, domestic consumption, and industrial cooling activities that all contribute to drawing down a groundwater aquifer.	**Type 4** — Effects arising from multiple sources that affect environmental resources in an interactive (i.e., countervailing or synergistic) fashion. Example: Discharges of nutrients and heated water to a river that combine to cause an algal bloom and subsequent loss of dissolved oxygen that is greater than the additive effects of each pollutant.

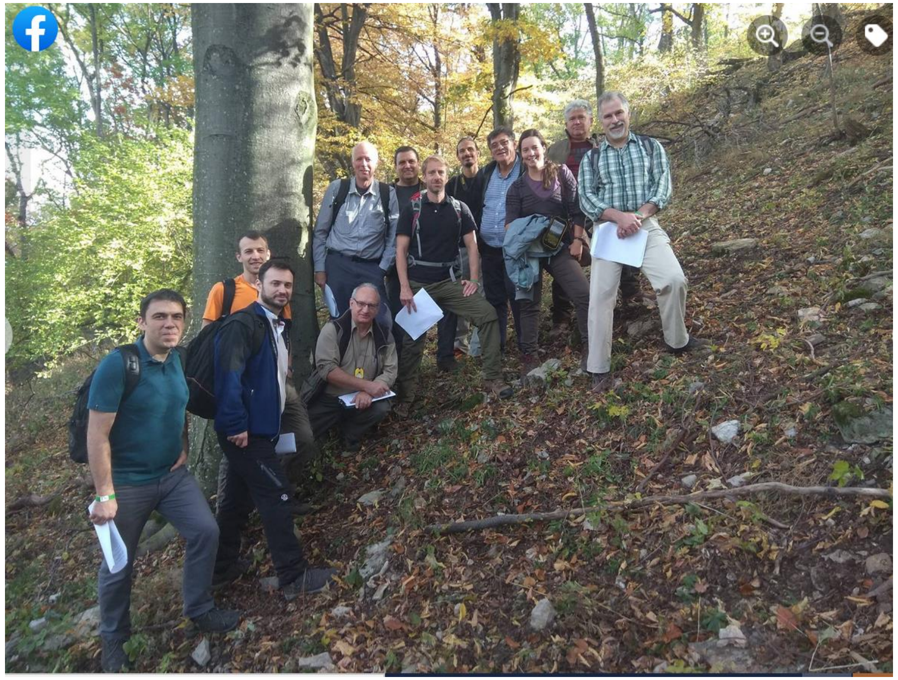
Road Decommissioning:

Three options:

1. Gate the road
2. Gate + Replant/Revegetate
3. Gate + Recontour + Revegetate

The Value of Scientific Exchange

S4C Forum Carpaticum,
Eger, Hungary 2018



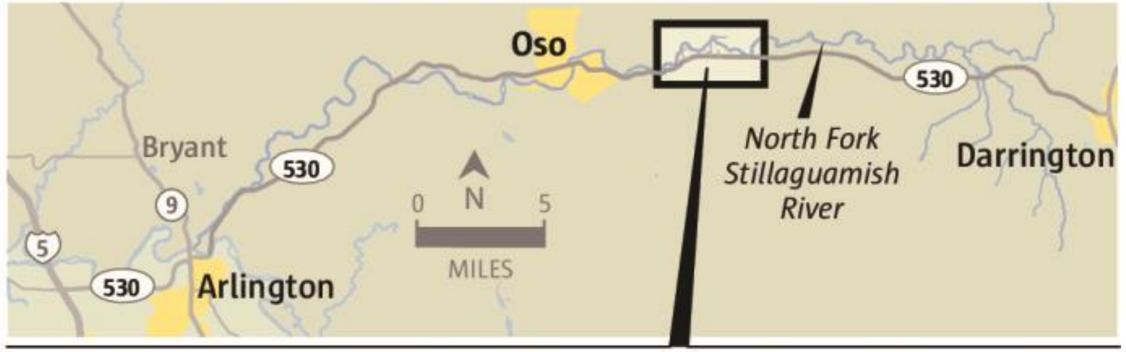
Workshop on Science,
Communication, Vermont USA 2022

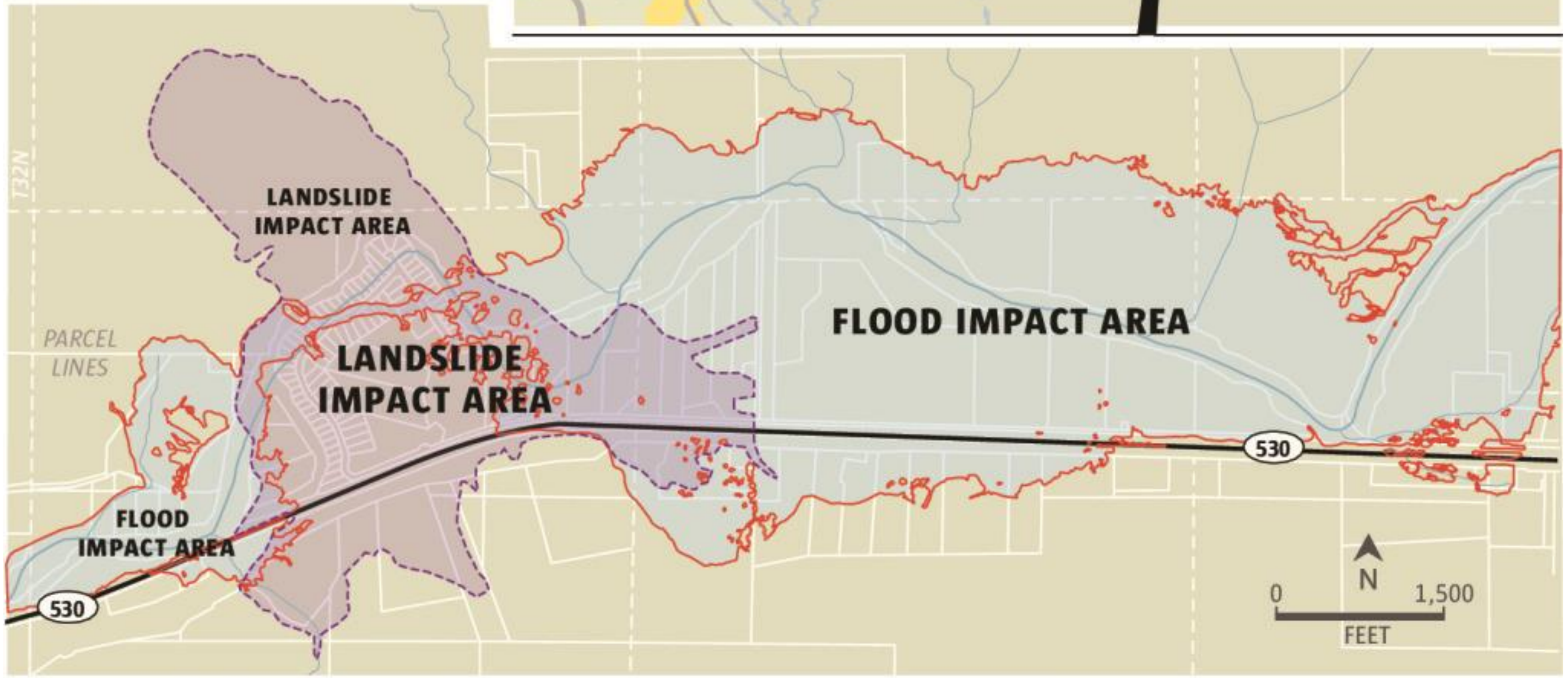
Workshop on Science,
Communication, Vermont USA 2022

Oso, Washington, 2014

Oso slide-area building ban

Three months after last year's deadly slide near Oso, Snohomish County imposed temporary building bans in the slide zone and an adjacent flood impact area, as officials prepared required updates to land-use laws and researched flood impacts.





Sources: Esri, IPC, Snohomish County

MARK NOWLIN / THE SEATTLE TIMES