Document 5

Compilation of IRST Road-Stream Connectivity Reviews to Date

For 8 November 2024 IRST meeting

IRST Road-Stream Connectivity Study Review - Beechie et al. 2005

Publication citation

Monitoring treatments to reduce sediment and hydrologic effects from roads

Objectives/Questions/Hypotheses

Focus on two types of monitoring: effectiveness (reducing sediment generation and/or delivery) and validation (cause-effect connections between sediment and hydrologic effects and stream WQ, habitat, and biota).

Dates and Duration

N/A – not a research or monitoring project. When and how long to sample are discussed as part of project design. For example, measuring sediment generation from large storms as well as chronically are important if trying to quantify sediment inputs from roads.

Location / Key Environmental Characteristics

N/A – not a specific research or monitoring project. More conceptual.

Connectivity Measure(s)

"measuring the amount of hydrologically connected road (is) the most informative parameter to measure." p. 52. Also, Table 5, p. 51.

Sampling Design

(Was sampling stratified, e.g. by ownership type or other?)

Provides literature review of techniques, approaches, and parameters used to measure channel, habitat, and biological responses to sediment. Review is annotated to point out benefits and drawbacks of different approaches. For biota and other instream measurements, authors state:

> "A variety of water-quality and biological parameters can be measured to detect the effects of changes in sediment supply or hydrology on the aquatic ecosystem. These include water temperature, primary production, macroinvertebrates, and vertebrates (e.g., fishes). However, each of these parameters is another step removed from road rehabilitation actions, and attributing changes in these parameters to road improvement actions is exceedingly difficult." p. 58.

Other Methods Information

(Were a baseline and trend measured? What explanatory variables / driving factors were tested?)

Nothing tested directly, but many variables described based on literature.

Results

(What factors were found to be important, e.g., slope, geology, etc.?)

N/A

Key Takeaways for IRST Research Proposal

Contains a thorough, thoughtful, and practical look at effectiveness and validation monitoring of road sediment reduction treatments and potential changes in conditions of receiving streams. Emphasizes time lags between road treatments and stream conditions, and other useful aspects of monitoring that could affect cost, duration, and expectations for monitoring projects.

> "There is no single monitoring protocol that is applicable to all settings or management scenarios, so each monitoring effort requires thoughtful planning to realize useful results. Design of both effectiveness and validation monitoring programs should begin with clear hypotheses of treatment outcomes (Table 2). These hypotheses guide the monitoring effort throughout, indicating parameters to be measured, sample-site selection, and frequency and duration of sampling. In general, parameter selection first considers which measures most strongly respond to the expected treatment outcome, and final selection considers such factors as cost and repeatability of measurements. Sample-site selection is guided first by the overall study design, then by the availability of treatment and reference sites. Sampling frequency and duration is determined based on the estimated lag time between treatment and response, anticipated duration of the effect, and sample size required to detect treatment effects." p. 59

IRST Road-Stream Connectivity Study Review - Black et al. 2012

Publication citation

The Geomorphic Road Analysis and Inventory Package (GRAIP) Volume 1: Data Collection Method

Objectives/Questions/Hypotheses

This is the first of 2 volumes describing the GRAIP method for estimating watershed-wide road sediment inputs to streams, and especially for identifying hotspots. This is the road inventory step of the process, and includes methods for measurement and recording to facilitate data analysis using GIS (Volume 2; see Cissel et al. 2012).

> *"The fundamental considerations in the design of a road inventory and analysis procedure for assessing watershed related effects of roads should focus on the questions; 1) Where are runoff and sediment generated or intercepted by roads, and 2) Where do the water and sediment go?" p. 4.*

Dates and Duration

N/A. Inventory is a snapshot in time.

Location / Key Environmental Characteristics

"Predictions of road sediment production are made for each road segment utilizing the information on road attributes, condition, length and slope. These predictions are made based on either locally collected sediment plot data for typical road segments (Luce and Black 1999, Luce and Black 2001) or values from comparable regions available in the literature (Megahan and Kidd 1972, Megahan 1974, Reid and Dunne 1984, Swift 1984, Bilby et al. 1989, Ziegler et al. 2001). An outline of a simple method for setting up local road erosion plots is available (Luce and Black 1999)." P. 5.

If no local road erosion measurements are made, the GRAIP method can provide a rough estimate of sediment volumes delivered to streams based on the available literature, and can reveal relative contributions from specific road segments or features across a watershed.

Connectivity Measure(s)

No specific metrics provided per se, but the inventory is intended to capture lengths of all flow paths between roads and streams, so when rolled up, connectivity can be estimated.

Sampling Design

(Was sampling stratified, e.g. by ownership type or other?)

There are two general scales at which to apply the GRAIP method. The principal method is to inventory all of the roads in a watershed, with the goals of determining where problems are located, so that they can be fixed, and quantifying the sediment risks and mass wasting risks that are associated with the road network in that watershed (e.g. Nelson et al. 2010, Fly et al. 2010). The secondary way is to apply GRAIP on a small scale as a project monitoring tool (e.g. Cissel et al. 2011, Black et al. 2009). A road or set of roads is inventoried before and after a road treatment (such as decommissioning or water-bar installation) in order to determine the effectiveness of that treatment. In this second method, untreated control roads *that have similar properties to the treatment roads are also inventoried so that the effectiveness of the treatments can be gauged by reinventorying all of the roads after a large storm event.*

Other Methods Information

(Were a baseline and trend measured? What explanatory variables / driving factors were tested?)

Both can be examined by inventorying roads before and after treatments.

Results

(What factors were found to be important, e.g., slope, geology, etc.?)

No results per se, as this is a data gathering inventory of roads.

Key Takeaways for IRST Research Proposal

Like Dube's SEDMODL (WARSEM), GRAIP is an empirically-based road sediment delivery estimation tool. Note that in this 2012 writeup, the GIS tools were changing so fast that some were considered obsolete, so current GRAIP versions may look different – but this is probably most pronounced on the analysis end (Cissel et al. 2012).

IRST Road-Stream Connectivity Study Review - Cissel et al. 2012

Publication citation

The Geomorphic Road Analysis and Inventory Package (GRAIP) Volume 2: Office Procedures.

Objectives/Questions/Hypotheses

This is the second of 2 volumes describing the GRAIP method for estimating watershed-wide road sediment inputs to streams, and especially for identifying hotspots. This is the analysis step of the process, and is heavy on ArcGIS procedures, drop down menus, etc. to allow novice users to do the analysis. The procedure also generates a hydro layer and a landslide risk layer.

Dates and Duration

N/A. Analysis provides assessment of road sediment inputs based on time of inventory inputs.

Location / Key Environmental Characteristics

N/A

Connectivity Measure(s)

No specific metrics provided per se, but the inventory is intended to capture lengths of all flow paths between roads and streams, so when rolled up, connectivity can be estimated.

Sampling Design

(Was sampling stratified, e.g. by ownership type or other?)

See volume 1 (black et al. 2012).

Other Methods Information

(Were a baseline and trend measured? What explanatory variables / driving factors were tested?)

Both can be examined by inventorying roads before and after treatments.

Results

(What factors were found to be important, e.g., slope, geology, etc.?)

Outputs can show overall quantity of road sediment delivered to streams, and also what segments/features are the dominant sources. Features common to all similar analyses of road erosion are included (e.g., slope, vegetation, material, traffic).

Key Takeaways for IRST Research Proposal

Like Dube's SEDMODL (WARSEM), GRAIP is an empirically-based road sediment delivery estimation tool. Note that in this 2012 writeup, the GIS tools were changing so fast that some were considered obsolete, so there are probably more current versions of these 2 volumes.

IRST Road-Stream Connectivity Study Review – Faubion 2020

Publication citation

SEDIMENT PRODUCTION AND DELIVERY FROM TIMBER HARVEST ROADS IN HUMBOLDT COUNTY, CALIFORNIA.

Objectives/Questions/Hypotheses

1. Measure erosion rates on different road categories (active and relatively inactive) across multiple water years.
2. Determine segment-scale controls on erosion and road-stream connectivity
3. Develop storm-based and annual sediment production estimates for road segments, and compare to WEPP estimates.
4. Estimate road sediment loads delivered to streams in study area.

Dates and Duration

2014-2019.

Location / Key Environmental Characteristics

Northern California coastal streams. Lithology was noted. Inventory measured typical segment-level parameters like road slope, width, surfacing material, vegetation. No direct measures of traffic levels.

Connectivity Measure(s)

Road-stream connectivity categorically assigned to each road segment: 1- no erosion features to 4 – erosion feature connecting road and watercourse.

Sampling Design

(Was sampling stratified, e.g. by ownership type or other?)

Stratified by active vs. inactive. The goal was to evaluate the effectiveness of landowners best management practices for stormproofing roads to minimize sediment delivery to streams at all times of the year, including large storms and floods. Used a before-after control-impact design. Local rain gauge used to measure storm erosivity; regional weather station used for annual precip. Data. Road segment field surveys were repeated each summer 2014-2018, before and after new road construction and timber harvesting/hauling. Used silt fences to capture sediment from road segments, subsequently weighed (vs. the tubs that Luce and Black and Sugden and Woods (2007) used).

Other Methods Information

(Were a baseline and trend measured? What explanatory variables / driving factors were tested?)

Both can be examined by inventorying roads before and after treatments.

Results

(What factors were found to be important, e.g. slope, geology, etc?)

- Very site-specific outcomes: Between 2014 and 2019, 1-2% of active road length, and 4-9% inactive road length were connected to streams. Road segments with no erosion or delivery have

<16% bare soil, slopes <5%, and 150 m^2 of area. Roads will have rills or sediment plumes > 10m in length if segments have >16% bare soil, >8% slope, and more than 83m^2 of area.

- WEPP (Water Erosion Prediction Project) underestimated annual sediment loads by 95%.
- Annual model over-predicted sediment production by 28%
- Storm-based model under predicted sediment production by 37%

Key Takeaways for IRST Research Proposal

This was a relatively small-scale effectiveness monitoring project (study basins were 1.3 and 1.5 km^2). It included on-site quantification of sediment production. Results generally supported hypothesis that road BMPs were effective at minimizing sediment inputs, when compared to unimproved (but relatively inactive) roads. Both generated and delivered sediment to study basin streams. Could provide cost info for projects, and closer scrutiny might help tighten connection between questions and results.

IRST Road-Stream Connectivity Study Review – Surfleet et al 2011

Publication citation

Surfleet, C.G.; Skaugset, A.E.; Meadows, M.W. 2011. Road runoff and sediment sampling for determining road sediment yield at the watershed scale. Canadian Journal of Forest Research. 41(10): 1970–1980. https://doi.org/10.1139/x11-104

Objectives/Questions/Hypotheses

We used road runoff – sediment loss relationships in conjunction with road runoff measurements to estimate watershed-scale sediment losses. We also applied a hydrologic model and two road erosion models to also estimate watershed-scale sediment losses. We then applied our Oak Creek approach at the South Fork of the Albion River, California, a watershed with a road network used for commercial forest management, a road network representing a high level of heavy truck and equipment use. We additionally tested if grab suspended samples alone could provide a reasonable prediction of the magnitude or relative amount of road erosion from road segments.

Dates and Duration

Oak Creek- 2001-2007 had all road drainage structures (114 culverts and road ditches) instrumented to calculate discharge from a rating curve. 2006-2007: used a turbidity threshold sampling approach to measure suspended sediment turbidity, and road runoff at 17 road segments. Monitored 1-2 months during winter. Peak flows and storm runoff volumes determined for 2006 and 2007 water years.

Location / Key Environmental Characteristics

Oak Creek, Oregon, with additional research at the South Fork of the Albion River, California. Oak Creek is part of the McDonald/Dunn Forest 4.5 km NW of Corvallis, Oregon. Soils are basalt formation, silty clay loam and silty loam. S. Fork of Albion River is in western Mendocino County, CA approx.. 200 km N of San Francisco. The highly sheared rocks of the Coastal Belt are composed of structurally deformed, massive, hard greywacke sandstone and shale interbedded with small amounts of limestone and pebble conglomerate. Soils in the Coastal Belt are of the Inceptisol soil order with primarily silt loam and clay loam textures (Rittiman and Thorson 1993).

Connectivity Measure(s)

Not directly described, but culverts and road ditches were sampled.

Sampling Design

(Was sampling stratified, e.g. by ownership type or other?)

Oak Creek- whole watershed approach, all culverts and ditches sampled. Not a private land site.

Other Methods Information

(Were a baseline and trend measured? What explanatory variables / driving factors were tested?)

Watershed scale model = simulated the road runoff to Oak Creek with the Distributed Hydrology Soil Vegetation Model (DHSVM) (DHSVM 2009) for the 2006 and 2007 water years.
Road Erosion model use: Extrapolated field samples with 2 road erosion models to extrapolate to a watershed scale, SEDMODL2 and WARSEM were used.

Results

(What factors were found to be important, e.g. slope, geology, etc?)

Study compared the use of models when field measurements were incorporated into them. Field measurements led to much lower estimates of sediment yields in tons/year. "When modeled by SEDMODL2 and WARSEM, estimates of total annual road sediment production for Oak Creek were 40%and 51% higher, respectively, without adjustment from field measurements than with adjustments. At the South Fork of the Albion River, the sediment yields estimated by SED-MODL2 and WARSEM without adjustment from field measurements were 480% and 610% higher, respectively, than with adjustments."

Key Takeaways for IRST Research Proposal

Incorporating field measurements into modeled erosion rates likely increased accuracy for those years. Models should be considered long-term averages because factors like precipitation will influence results at a water year scale.   "the measurement of road runoff may be the more important variable to measure for determining road sediment production."

IRST Road-Stream Connectivity Study Review – Takken et al. 2007

Publication citation

Takken, I.; Croke, J.; Lane, P. 2007. A methodology to assess the delivery of road runoff in forestry environments. Hydrological Processes. 22(2): 254–264. https://doi.org/10.1002/hyp.6581

Objectives/Questions/Hypotheses

The specific objective of this paper is to assemble a methodology to assess the road-to-stream connectivity and evaluate its use for three different forested catchments with contrasting road densities. Using this method- ology, the spatial pattern of the road network and delivery paths is used to predict both the distribution and volume of diffuse overland flow connecting to streams.

Dates and Duration

Single point in time assessment. I didn't see a year.

Location / Key Environmental Characteristics

Australia- Albert River, Sandy Creek and Tyers Catchments in New South Wales and Victoria.
By Catchment- road density, road class, roads by slope position, typical immutable metrics of soil, relief, slope, rainfall.

Connectivity Measure(s)

Road characteristics that are potential connection points to the stream systems: Mitre drains, culverts, cross banks, push-outs. Abundance of each differ across catchments. To quantify the connectivity of the drains, we used the Vbt5 model of Hairsine et al. (2002). This model was developed to predict the volume or probability of road-derived runoff reaching the stream by diffuse overland flow from a drain outlet.

Sampling Design

(Was sampling stratified, e.g. by ownership type or other?)

'-72-90% of major gravel roads surveyed, less for minor or natural surface roads. Categorized by slope class, catchment, etc.

Other Methods Information

(Were a baseline and trend measured? What explanatory variables / driving factors were tested?)

This was a modeling study and not about examining trends through time. Roads were classified by density, total length, road class, slope position. Drains were by type: stream crossing, culverts, mitres, push outs, cross banks. Catchments described by area, type of forestry, geology, soil type, relief range, slope range, rainfall, density.

Results

(What factors were found to be important, e.g. slope, geology, etc?)

- Our analysis highlights important differences in drain characteristics, related to catchment
- topography, drainage density, slope position of the roads and type of drainage
- structure used.

The magnitude of predicted runoff production and delivery is controlled by interactions between topography, rainfall and road placement and design.

Key Takeaways for IRST Research Proposal

- Although road density is clearly important, primarily through the obvious impact upon the number of direct stream crossings, factors such as contributing area to a road drain, landscape position and hence distance to streams are also significant fac-tors.
- We developed a practical methodology to assess road to stream connectivity, which allows taking into account factors such as catchment topography, the slope position of the roads, the drain spacing along the road network and drainage density.

IRST Road-Stream Connectivity Study Review – Turton 2009

Publication citation

Turton, D.J.; Smolen, M.D.; Stebler, E. 2009. Effectiveness of BMPS in Reducing Sediment From Unpaved Roads in the Stillwater Creek, Oklahoma Watershed1. JAWRA Journal of the American Water Resources Association. 45(6): 1343–1351. https://doi.org/10.1111/j.1752-1688.2009.00367.x

Objectives/Questions/Hypotheses

The objectives of this study were to measure sediment yields from typical low-volume unpaved road segments in north-central Oklahoma and determine the reduction in sediment yields following the installation of Best Management Practices (BMPs). Note this was not a forestry management centric paper.

Dates and Duration

1 year before BMPs and 1 year after BMPs

Location / Key Environmental Characteristics

Four rural unpaved road segments in the Stillwater Creek Watershed were instrumented in a paired watershed design to measure sediment yields to streams before and after the installation of Best Management Practices (BMPs). (Oklahoma). The watershed is located approximately 70 km north of Oklahoma City and 96 km west of Tulsa. The road sites were not chosen randomly, but in consultation with the Payne County, Oklahoma Commissioners,

Connectivity Measure(s)

Did not measure connectivity, but rather sediment yields, suspended sediment yields, Interval suspended sediment loads.

Sampling Design

(Was sampling stratified, e.g. by ownership type or other?)

Sites not randomly selected. The study was designed as a paired watershed study, where one road segment of each pair remained under existing conditions and maintenance (1C and 2C) to serve as a control, and the neighboring segment was treated with road BMPs (1B and 2B). Sediment yield, rainfall, and discharge data were collected for 1 year before BMPs were installed and 1 year after the BMPs were installed. The watershed of each segment included approximately half of the road surface (from the crown to the bar ditch), the bar ditch and the associated cutslope (Figure 1). The upslope divides were defined by the hillcrest of the road.

Other Methods Information

(Were a baseline and trend measured? What explanatory variables / driving factors were tested?)

1 year prior and 1 year after BMPs installed. Phys characteristics of roads (length, slope metrics, road area, drainage, soil texture), local precipitation measures, annual sediment yields.

Results

(What factors were found to be important, e.g. slope, geology, etc?)

Sediment yields were significantly reduced on both segments by the installation of BMPs, approximately 80% on one segment pair and 20% on the other.   Rainfall important.

Key Takeaways for IRST Research Proposal

limited replication here, but some findings related to repeated storm events and sediment yield and incision of road. Sediment yields from unpaved roads can be reduced as much as 80% by installing appropriate BMPs, even on a limited bud-get. Particularly effective were providing a stable sur-face with geotextile fabric and gravel, a proper crown for drainage of the roadway, and stable channels t oremove water without eroding the road bed or the cutslopes.

IRST Road-Stream Connectivity Study Review – Wang et al. 2023

Publication citation

Wang, A.; Zhao, Q.; Yu, Z.; Yu, J.; Liu, Y.; Wang, P.; Zhang, G.; Zhou, J.; Ding, S. 2023. Factors and thresholds determining sediment delivery pathways between forest road and stream in mountainous watershed. CATENA. 224: 106976. https://doi.org/10.1016/j.catena.2023.106976

Objectives/Questions/Hypotheses

This study aims (1) to quantify the morphological characteristics of different delivery pathways, (2) to clarify the downstream effects of different delivery pathways on soil texture and vegetation characteristics, (3) to determine the primary factors driving the formation and development of different delivery pathways, and (4) to elucidate the threshold for the formation and development of delivery pathways of road-eroded sediment. Selected forest roads were unpaved with a total length of 2.55 km, a total of 25 drainage outlets (all are naturally formed), and three road-stream crossings.

Dates and Duration

Single point in time field survey was carried out in July and August of 2021 to measure morphological characteristics.

Location / Key Environmental Characteristics

Xiangchagou watershed in the Dabie Mountains of China as a small case study (6.4 km2)

Connectivity Measure(s)

Examined delivery via 3 pathways: Gullied, partially gullied, or diffuse.

Sampling Design

(Was sampling stratified, e.g., by ownership type or other?)

No- a single small watershed as a case study.

Other Methods Information

(Were a baseline and trend measured? What explanatory variables / driving factors were tested?)

Rainfall, area, area and slope gradient of the upslope catchment, the slope gradient, length, and area of the road segment, and the slope gradient of the delivery pathways and their lateral adjacent zones which are reference areas at least 2 m away from a delivery pathway. Also forest canopy density, plant spp diversity, soil texture, bulk density, surface roughness. Also examined gully formation and development.

Results

(What factors were found to be important, e.g. slope, geology, etc?)

We found that soil D50, bulk density, shrub-grass cover, and plant species diversity varied significantly among the three delivery pathways, but that there was little variation within pathways as we moved from road to stream. Slope gradient (upslope catchment, road segment, and lower hillslope) and effective contributing area were found to drive gully formation. Soil median particle size, surface roughness, and shrub-grass cover of lower hillslope were found to drive the development of gullies from existing non completely gullied pathways. Furthermore, this study produced several power law relationships which appear to define critical topo- graphic thresholds for the occurrence and development of gully erosion, i.e., Ds = 0.35Eca 0.13 and Ds = 0.41Eca 0.17, respectively. However, these need further verification, and future work should seek to build on our progress by holistically synergizing topography, soil, vegetation, and land use characteristics

Key Takeaways for IRST Research Proposal

Perhaps some non-standard factors like surface roughness or vegetation were considered here.

IRST Road-Stream Connectivity Study Review – Wemple et al. 2017

Publication citation

Wemple, B.C.; Clark, G.E.; Ross, D.S.; Rizzo, D.M. 2017. Identifying the spatial pattern and importance of hydro-geomorphic drainage impairments on unpaved roads in the northeastern USA. Earth Surface Processes and Landforms. 42(11): 1652–1665. https://doi.org/10.1002/esp.4113

Objectives/Questions/Hypotheses

We aimed to (1) identify the type and extent of these drainage impairments using a landscape-level survey, (2) assess factors that explain the occurrence of these impairments, (3) evaluate the effectiveness of BMPs in mitigating against these impairments, and (4) provide a first-order estimate of the relative importance of these drainage impairments on water quality degradation at the watershed scale

Dates and Duration

Single point in time field sampling in 2011. GIS inventory first.

Location / Key Environmental Characteristics

Winooski River watershed, a 2753 km 2 basin draining to Lake Champlain (Vermont, USA)

Connectivity Measure(s)

Estimated via GIS with this method: Using ArcGIS, we estimated the mean length of roads draining to culverts, commonly expressed as culvert spacing, as the quotient of road length and culvert number (Figure 4). We identified stream crossing culverts by conducting an INTERSECT analysis of the roads and streams layers, and used these intersection points to attribute culverts as such in the culverts layer, with all remaining culverts coded as cross drains. Based upon field observations, we made the simplifying assumption that road segments on both sides of a topographic depression occupied by a stream drained to a stream crossing. This allows the road network length directly connected to stream crossings to be derived as the product of two times the average culvert spacing and the number of stream crossing culverts. For the remaining culverts, we estimated the number of cross drains within 50 m of a stream using the NEAR function, and assumed, based upon field observations, that runoff discharged at these stream-proximal points would reach receiving waters. Response variables included: Erosional frequency, depositional frequency, volume eroded.

Sampling Design

(Was sampling stratified, e.g., by ownership type or other?)

Not related to land ownership types.

Other Methods Information

(Were a baseline and trend measured? What explanatory variables / driving factors were tested?)

Single point in time. Road design factors (ditches, culverts, etc), culvert condition, topographic factors,

Results

(What factors were found to be important, e.g. slope, geology, etc?)

Road gradient and slope position. "The frequency of erosional features was related to the steepness, or grade, of the road and to the absence of best management practices recommended for unpaved roads located in these rural settings."

Key Takeaways for IRST Research Proposal

Similar to other studies, slope position and gradient important, BMPs are very effective.

IRST Road-Stream Connectivity Study Review – Yu et al. 2024

Publication citation

Yu, J.; Zhao, Q.; Yu, Z.; Liu, Y.; Ding, S. 2024. A Review of the Sediment Production and Transport Processes of Forest Road Erosion. Forests. 15(3): 454. https://doi.org/10.3390/f15030454

Objectives/Questions/Hypotheses

A review paper without specific questions or hypotheses. "his review systematically summarizes the sediment transport processes associated with road erosion at varying scales, explores its ecological and hydro-logical consequences, and evaluates the mitigation measures employed. "

Dates and Duration

n/a. Does not describe search criteria but appears to be global without a time restriction, focused on forest roads.

Location / Key Environmental Characteristics

Global review of research on forest roads. Considers road type, soil type, notes effects after wildfire.

Connectivity Measure(s)

n/a- a review of road sediment studies, but discusses the sediment transport ratio (erosion from road that enters the watershed outlet.

Sampling Design

(Was sampling stratified, e.g., by ownership type or other?)

n/a- a review of road sediment studies

Other Methods Information

(Were a baseline and trend measured? What explanatory variables / driving factors were tested?)

n/a- a review of road sediment studies

Results

(What factors were found to be important, e.g. slope, geology, etc?)

rainfall, pathways (diffuse, partially gullied, gullied, with gullied having the greatest transport), sediment size.

Key Takeaways for IRST Research Proposal

Unique aspect considers emerging technologies for improved methods- UAVs, fingerprinting, terrestrial laser scanning.

IRST Road-Stream Connectivity Study Review – Zhao et al. 2022a

Publication citation

Zhao, Q.; Jing, Y.; Wang, A.; Yu, Z.; Liu, Y.; Yu, J.; Liu, G.; Ding, S. 2022a. Response of Sediment Connectivity to Altered Convergence Processes Induced by Forest Roads in Mountainous Watershed. Remote Sensing. 14(15): 3603. https://doi.org/10.3390/rs14153603

Objectives/Questions/Hypotheses

Using the Xiangchagou catchment in the Dabie Mountain area of China as a case study, this research was conducted (1) to clarify the road-induced changes in the confluence direction and transmission pathways of sediment by conceptualizing the drainage networks of the catchment, (2) to comparatively analyze the response of the confluence process and sediment connectivity to roads based on scenario simulation, and (3) to determine the primary factors that contribute to sediment connectivity in a mountainous watershed.

Dates and Duration

Remotely derived data, single point in time.

Location / Key Environmental Characteristics

Xiangchagou catchment (114◦1′1′′–114◦3′30′′E, 31◦46′5′′–31◦48′5′′N) is located in the Jigongshan National Nature Reserve in Henan Province of China. Forest roads with a total length of 11.26 km and a road density of 1.76 km/km2 in this catchment were constructed for forest production, harvesting, and management. The total stream length in this catchment is 7.15 km, with a stream density of 1.12 km/km2. Due to the low design standards and lack of maintenance, the unpaved forest roads have been severely eroded due to heavy rainfall, causing the formation of numerous rills on the road surfaces.

Connectivity Measure(s)

Different groups of indicators of susceptibility to roads were calculated to quantify the impact of roads on the confluence process and connectivity of sediment, including flow length (FL), flow accumulation (FA), upslope contributing area (UCA), topographic index (TI), and accessibility (Shimbel index, SHI) which were used to characterize the confluence processes, the elevation (DEM), slope gradient (SG), relative-smoothness index (RS), and terrain relief (TR) that were used to characterize the terrain features in the watershed, as well as distance to stream (Stream_DS), distance to road (Road_DS), stream density (Stream_D), and road density (Road_D) that were used to characterize the spatial structure characteristics of road and stream networks in the watershed.

Other variables included: Flow length, flow accumulation, upslope contributing area, topographic index, accessibility, terrain relief, characteristics of road and stream networks. '

Index of Connectivity was used to describe sediment connectivity in the study area.

Sampling Design

(Was sampling stratified, e.g., by ownership type or other?)

Small scale case study that included the entire very small watershed.

Other Methods Information

(Were a baseline and trend measured? What explanatory variables / driving factors were tested?)

Remotely derived data included: topography, stream network, road network, and vegetation datasets. The confluence process indicators, sediment connectivity, road and stream network characteristics, and topographic characteristics were calculated based on the DEM, stream networks, and road networks datasets.

Results

(What factors were found to be important, e.g. slope, geology, etc?)

Distance from stream or road, terrain relief. Under the influence of the road, changes in the flow length of the confluence path were the most important factor affecting the IC.

Key Takeaways for IRST Research Proposal

Another example of a small scale study of sediment, roads, and modeled pathways to connectivity.

IRST Road-Stream Connectivity Study Review – – Zhao et al. 2022b

Publication citation

Zhao, Q.; Wang, A.; Jing, Y.; Zhang, G.; Yu, Z.; Yu, J.; Liu, Y.; Ding, S. 2022b. Optimizing Management Practices to Reduce Sediment Connectivity between Forest Roads and Streams in a Mountainous Watershed. Remote Sensing. 14(19): 4897. https://doi.org/10.3390/rs14194897

Objectives/Questions/Hypotheses

The objectives of this study were to (1) clarify spatial relationships between forest roads and streams, (2) analyze how forest roads affect the confluence of water and sediment to change the spatial distribution of sediment connectivity, (3) reveal how different BMPs (sediment basins and riparian buffers) affect the spatial response of sediment connectivity, and (4) determine the specific locations and optimal quantity/width of BMPs to be implemented.

Dates and Duration

GIS data from 2018. Did not appear to be field measurements at all.

Location / Key Environmental Characteristics

The Xiangchagou watershed in the Dabie Mountain area of China

Connectivity Measure(s)

We used the index of connectivity (IC), which was proposed by Borselli et al. [37] to describe the dynamics of sediment transport processes at the watershed scale, specifically the potential of sediment to be transported from source (forest roads) to sink (streams). IC was calculated from the DEM-provided terrain data, in addition to weighting factors, and roads and streams data from ArcGIS 10.2,

Sampling Design

(Was sampling stratified, e.g., by ownership type or other?)

No- the entire small watershed was analyzed.

Other Methods Information

(Were a baseline and trend measured? What explanatory variables / driving factors were tested?)

No- this was a single point in time, not a time series. Distance between road and streams, topographical metrics.

Results

(What factors were found to be important, e.g. slope, geology, etc?)

IC, and thus, sediment connectivity was generally higher near the streams and forest roads, especially in the upper hillslopes of forest roads.

Key Takeaways for IRST Research Proposal

Another small-scale point in time case study. This one did not incorporate precipitation.   Optimum mitigation measures are context-specific, and they depend on sediment retention and connectivity, making it difficult to provide suggestion across different watersheds