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White Paper on Landslides, Public Safety, and the Alaska Forest Resources & Practices Act (FRPA) for Discussion at the July 2008 Board of Forestry meeting

June 18, 2008

Background. The Mitkof Highway Homeowners Association (MHHA) requested that the FRPA be amended to address public safety hazards associated with slope failures. MHHA specifically requested the following addition to the FRPA:

> *"Activities that increase susceptibility to slope failures (such as logging) should be prohibited or restricted if slope failures pose a danger to life or property. Critical facilities, homes, and other buildings for human occupancy should not be located in areas susceptible to major slope failure.*

The FRPA currently requires that adverse impacts of mass wasting be prevented or minimized, but its authority is limited to impacts on water quality and fish habitat. Forest practices acts in some states add public safety to the considerations for addressing mass wasting.

The MHHA concerns were initially based on proposed forest operations on Mitkof Island above the Mitkof Highway. Similar situations may exist in some other areas, but are limited to areas with a combination of commercial timber, steep topography, unstable soils, land ownership where logging may occur, and human occupancy. The occurrence of high-risk sites may increase as residential areas expand near past and current logging sites. Mass wasting risks associated with activities other than commercial timber harvesting are outside the authority of FRPA (e.g., utility lines, non-timber road construction, or other land clearing activities).

Current FRPA standards and best management practices (BMPs) regarding mass wasting. The Forest Resources & Practices Act and regulations include the following standards and BMPs.

- On state, municipal, and private land, significant adverse effects of mass wasting on water quality and fish habitat shall be prevented or minimized (AS41.17.060(b)(5)).
- Include information on known unstable or slide-prone slopes, and site-specific erosion prevention measures in Detailed Plans of Operation (11AAC95.220(a)(9))
- A Change of Operations notification needs to be submitted for changes to proposed operations on unstable slopes (11AAC95.230(a)(1))
- In Region I, slope stability standards apply along anadromous waters and their tributaries. In these areas, operators must
    - Avoid constructing a road that will undercut the toe of a slope that has a high risk of slope failure;
    - Leave low-value timber where prudent along the riparian areas of tributaries to anadromous streams;
    - Use full or partial suspension yarding;
    - Fall timber away from streams in V-notches; and

drainage, precipitation, and potential impacts. (Tongass Forest Plan, Jan. 2008, p. 4-65)

- Oregon State forest practices regulations include:
  - A screening process for identifying areas with high landslide hazards and exposed populations (OAR 629-623-0100) and categories for degrees of landslide potential and potential risk to public safety (OAR 629-623-0200 and -0300)
  - Guidelines for operations in different risk categories. In the areas with the highest slide potential and greatest public safety risk,
    - harvesting is not allowed unless "a geotechnical report demonstrates to the State Forester that any landslides that might occur will not be directly related to forest practices because of very deep soil or other site-specific conditions.
    - Operators must leave trees adjacent to high landslide hazard locations to reduce the likelihood of trees retained in these locations blowing down.
    - New road construction is prohibited. Road reconstruction is allowed if it will reduce landslide hazard. (OAR 629-623-0400)
  - Less restrictive requirements in areas with intermediate risks (OAR 629-623-0500 and -0550)
  - Along debris torrent-prone streams, a requirement to fell and yard in ways to minimize slash and other debris accumulation where there is substantial or intermediate public safety risk, remove slash from channels, and leave large standing trees along depositional reaches. (OAR 629-623-0600)
  - A requirement that operators submit a written plan for all timber harvesting or road construction in areas with intermediate or substantial public safety risk. (OAR-629-623-0700)

- Washington State has a State Environmental Policy Act (SEPA). SEPA gives state agencies the ability to condition or deny a proposal due to identified likely significant adverse impacts.
  - In areas with potentially unstable slopes or landforms, determination of whether a state environmental impact statement (SEIS) is required is based in part on "the likelihood of delivery of sediment or debris to any public resources, or in a manner that would threaten public safety" (WAC 222-10-030), and on whether the proposed harvest is consistent with an approved watershed analysis (WAC 222-16-050)
  - Specific mitigation measures must be designed to avoid accelerating rates and magnitudes of mass wasting that could threaten public safety. (WAC 222-10-030).
  - Definitions of potentially unstable slopes or landforms are provided. (WAC 222-16-050)
  - Guidelines for evaluating potentially unstable slopes and landforms are included. (2004 Board Manual).

Recommendations for Board discussion. The Division of Forestry recommends that the Board of Forestry convene a science and technical committee group to review the current mass wasting standards, and if appropriate, draft language for presentation to the Board of Forestry. The committee should consider the following items:

- Including public safety in the factors to consider for preventing or minimizing adverse impacts of mass wasting. This would require a statutory change.
- Defining the following terms and providing guidance for determining where these conditions exist:
    - "unstable or slide-prone slope",
    - "slope that has a high risk of slope failure"
    - "fill material prone to mass wasting".

  This would require a regulatory change.
- Providing guidance for determining where a public safety risk exists, e.g., combination of unstable slopes and human occupancy/use in potential slide path. This would require a regulatory change.
- Developing additional BMP(s) for harvesting and yarding methods in unstable or slide-prone areas. This would be a regulatory change.

DOF does not recommend adding language on location of structures to FRPA – FRPA applies only to commercial forestry operations.

A Science & Technical Committee would need to include representatives with expertise in the following areas and representatives of the state resource agencies responsible for implementing FRPA.

- Hydrology
- Geology
- Soil science
- Forest management
- Logging engineering
- Fish biology
- DNR Division of Forestry
- DEC Division of Water
- ADF&G Habitat Division

Recommendations from the Science & Technical Committee would be forwarded to the Board and, if appropriate, to an Implementation Group with representatives from state resource agencies, forest landowners, local governments, homeowners, and other affected interests.

White Paper on Landslides, Public Safety, and the Alaska Forest Resources & Practices Act (FRPA)

Updated January , 201

In response to a request from the Board of Forestry, this document summarizes the history of the forest landslide and public safety issue in Alaska, the results of the geographic scoping process, existing FRPA standards regarding mass wasting, and approaches used in other west coast states, British Columbia, and the Tongass National Forest.

I. Background

In October, 2007, the Mitkof Highway Homeowners Association (MHHA) requested that the FRPA be amended to address public safety hazards associated with slope failures. MHHA specifically requested the following addition to the FRPA:

> *"Activities that increase susceptibility to slope failures (such as logging) should be prohibited or restricted if slope failures pose a danger to life or property. Critical facilities, homes, and other buildings for human occupancy should not be located in areas susceptible to major slope failure.*

The FRPA currently requires that adverse impacts of mass wasting be prevented or minimized, but its authority is limited to impacts on water quality and fish habitat. Forest practices acts in some states have added public safety to the considerations for addressing mass wasting.

II. Scoping model and results

The MHHA concerns were initially based on proposed forest operations on Mitkof Island above the Mitkof Highway. The Board of Forestry asked for an assessment of the geographical extent of this issue.

The Landslide Science & Technical Committee developed a model and scoping maps to identify areas where risks may occur based on topography, forest cover, land management, and proximity to public roads and areas with residential or commercial buildings.

- The scoping maps are tools for assessing the general scope of landslide hazards and public safety risks associated with commercial timber harvesting subject to FRPA[1]. They do not replace the need for site-specific analysis and design of timber sales and access roads.
- The scoping model is a first approximation based on available data of the geographic extent of potential landslide hazards in areas open to commercial timber harvest operations subject to FRPA where there is public use, in the portion of coastal Alaska from Cordova south.

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[1] Mass wasting risks associated with activities other than commercial timber harvesting (e.g., utility lines, non-timber road construction, or other land clearing activities) are outside the authority of FRPA and are not addressed by the scoping model.

- Fall timber away from streams in V-notches; and
- Avoid sidecasting soil. (11 AAC 95.280)

- Avoid locating forest roads on slopes >67%, on unstable slopes, or in slide-prone areas. If avoidance is not feasible, site-specific measures must be approved by DOF and must
  - Balance cuts and fills, but not use fill that is unstable, fine-textured, or prone to mass wasting;
  - Minimize cuts in fine-textured soils;
  - Not bury log chunks, organic debris, or slash in the load-bearing portion of a road fill; and
  - Not excavate or blast during saturated soil conditions if mass wasting is likely to result and degrade water quality. (11AAC95.290(a), (b))
- Use end-hauling and full-bench construction if mass wasting is likely to occur and cause degradation of water quality. (11AAC95.290(d))
- Fell trees away from surface waters and standing waters, if not feasible remove tree and debris from surface waters (11AAC95.290(e), 11 AAC 95.355)
- Stabilize the slide path and exposed soils where mass wasting is caused by forest operations. (11AAC95.330)
- For a landing on a slope >67%, an unstable slope, or in a slide-prone area, keep fill material free of stumps and excessive slash, and compact fill to prevent mass wasting. A helicopter drop zone is considered a landing. (11AAC95.345(b)(4) and (d))
- Where feasible avoid crossing deep gullies where fine textured soils such as clay or ash soils exist (11 AAC 95.285(a)(9)
- Maintain bank integrity and prevent felled timber from entering surface waters (11 AAC 95.350).
- Design operation so yarding can be done in compliance with FRPA (11 AAC 95.340)
- Yarding up, down or across a V-notch channel must be accomplished in a manner that does not create significant erosion (11 AAC 95.360)
- Where downhill yarding is used, need to lift leading end and minimize downhill movement of slash and soils (11 AAC 95.360(c))
- Landowner shall reforest harvested land to the fullest extent practicable (11 AAC 95.375)
- "Mass wasting" is defined as the slow to rapid downslope movement of significant masses of earth material of varying water content, primarily under the force of gravity (11 AAC 95.900(44))

C. "Gaps" in FRPA standards for landslides

Statutory

- FRPA does not include public safety in the factors to consider for preventing or minimizing adverse impacts of mass wasting. This would require a statutory change.

Regulatory

Note: The following gaps exist currently and apply to prevention of impacts to fish habitat and water quality, as well as public safety.

- FRPA does not define the following terms nor does it provide guidance for determining where these conditions exist. Definitions would require a regulatory change.
  - "unstable or slide-prone slope",
  - "slope that has a high risk of slope failure"
  - "fill material prone to mass wasting".
- FRPA does not have BMPs for specific harvesting and yarding methods in unstable or slide-prone areas. This would be a regulatory change.
- FRPA does not have BMPs for helicopter operations or partial harvesting other than those noted above.

IV. Overview of other west coast forest practices standards regarding mass wasting

A. Tongass National Forest

Tongass National Forest standards and guidelines require

- the same standards as FRPA for slopes >67% (see 11 AAC 95.290(a) above;
- evaluation of potential mass wasting effects
- case-by-case review and approval of harvesting on slopes ≥72% based on an on-site analysis of slope and Class IV channel stability and potential impacts of accelerated erosion on fish habitat, other water uses, and other resources. The analysis should assess steepness, channel dissection, parent material, soil drainage, precipitation, and potential impacts. (Tongass Forest Plan, Jan. 2008, p. 4-65)

B. State of Oregon

Oregon forest practices regulations include:

- A screening process for identifying areas with high landslide hazards and exposed populations (OAR 629-623-0100) and categories for degrees of landslide potential and potential risk to public safety (OAR 629-623-0200 and -0300)
- Guidelines for operations in different risk categories. In the areas with the highest slide potential and greatest public safety risk,
  - harvesting is not allowed unless "a geotechnical report demonstrates to the State Forester that any landslides that might occur will not be directly related to forest practices because of very deep soil or other site-specific conditions.
  - Operators must leave trees adjacent to high landslide hazard locations to reduce the likelihood of trees retained in these locations blowing down.
  - New road construction is prohibited. Road reconstruction is allowed if it will reduce landslide hazard. (OAR 629-623-0400)

C. State of Washington

Washington has a State Environmental Policy Act (SEPA). SEPA gives state agencies the ability to condition or deny a proposal due to identified likely significant adverse impacts.

- In areas with potentially unstable slopes or landforms, determination of whether a state environmental impact statement (SEIS) is required is based in part on "the likelihood of delivery of sediment or debris to any public resources, or in a manner that would threaten public safety" (WAC 222-10-030), and on whether the proposed harvest is consistent with an approved watershed analysis (WAC 222-16-050)
- Specific mitigation measures must be designed to avoid accelerating rates and magnitudes of mass wasting that could threaten public safety. (WAC 222-10-030).
- Definitions of potentially unstable slopes or landforms are provided. (WAC 222-16-050)
- Guidelines for evaluating potentially unstable slopes and landforms are included. (2004 Board Manual).

D. State of California

In California, a Timber Harvest Plan (THP) must be approved by the Dept. of Forestry and Fire Protection prior to harvest of live trees.

- A THP must include identify unstable areas and avoid or mitigate hazards in such areas.
- THPs must include estimated erosion hazard ratings by areas down to 20 acres, and down to 10 acres for areas with high/extreme hazard ratings.
- A Road Management Plan submitted as part of a THP must identify issues regarding public safety that could be affected by road management activities.
- The state review team for a THP includes an engineering geologist who reviews the plan with respect to slope stability, and inspects sites if necessary. One purpose of site inspections is to look for public safety hazards. The geologist can recommend additional measures to reduce hazards to public safety.

The California Forest Practices Act (2009) doesn't directly address public safety, but actions under the FPA must be consistent with the California Environmental Quality Act, which does include public safety.

THPs are subject to interagency review and public hearings. THPs may not be approved until 35 days after filing unless the Director finds there will be no significant environmental damage or threat to public safety with a shorter approval period. The Board of Forestry will grant a hearing on an appeal of a THP from the Dept. of Fish & Game or State Water Resources Control Board if there are substantial issues with respect to the environment or public safety involving threats to the lives, health, or property of state residents.

Use of heavy equipment for tractor operations is

- Prohibited on
    - slopes >65%
    - slopes >50% with a high or extreme erosion hazard rating

    - slopes >50% w/o flattening before reaching a watercourse or lake
- Limited to existing tractor roads that don't require reconstruction or THP-approved new tractor roads on slopes 50-65% with moderate erosion hazard rating
- Exceptions may be proposed in a THP with site-specific justification.

Mechanical timber harvesting (not including cable or helicopter yarding) shall not be conducted during a winter period (Nov. 15-April 1 in most areas) unless a winter period operating plan is incorporated in the THP and is followed, unless a Registered Professional Forester specifies the following winter operation measures in the THP:

- Tractor operations will be conducted only during dry, rainless periods where soils are not saturated,
- Erosion control structures are installed on all constructed skid trails and tractor roads prior to the end of the day if the U.S. Weather Service forecast is a "chance" (30% or more) of rain before the next day, and prior to weekend or other shutdown periods, and
- Site specific mitigation measures for erosion are established in riparian areas and unstable areas during THP preparation and review.

Decommissioned roads are inspected following the first bank-full storm event to ensure treatments are functioning to restore hillslope stability.

Sensitive watersheds may be identified for additional planning and protection measures. Designation as a sensitive watershed is based in part on risks to public safety.

E. Province of British Columbia

British Columbia's Forest and Range Practices Act covers tenuring (general licensing) for forest operations and permitting for individual harvest areas. Under the forest planning and practices regulations, a person carrying out a "primary forest activity" must ensure that the activity does not cause a landslide that adversely affects

- Soils
- visual quality
- timber
- forage
- water
- fish
- wildlife
- biodiversity
- recreation
- resource features
- cultural heritage resources

Primary forest activities are timber harvesting, silvicultural treatments, and road construction, maintenance, and deactivation.

The Minister of Forests and Range also has the power to intervene on any activity that is likely to have a catastrophic impact on public safety. The minister can stop the activity and require a remedy or mitigation.

Minutes
FRPA Phase 2 Landslide Science & Technical Committee (S&TC)
Meeting #3 – November 23, 2010
Web meeting – Juneau, Ketchikan, Thorne Bay

S&TC Attendees:

Ketchikan: Bert Burkhart, Dennis Landwehr, and Pat Palkovic
Juneau: Marty Freeman, Kevin Hanley, Adelaide (Di) Johnson, and Kyle Moselle
Thorne Bay: Jim Baichtal and Greg Staunton
There were no visitors.

Minutes. The minutes from the November 1were adopted incorporating minor changes.

Bibliography. Moselle reviewed literature relevant to landslide effects on fish habitat. The following papers are already included in the Landslide S&TC bibliography:

- Gomi, T., R.C. Sidle, and D.N. Swanston. 2004. Hydrogeomorphic linkages of sediment transport in headwater streams, Maybeso Experimental Forest, southeast Alaska. Hydrological Processes. 18: 667-683.

- Gomi, T., R.C. Sidle, M.D. Bryant, and R.D. Woodsmith. 2001. The characteristics of woody debris and sediment distribution in headwater streams, southeastern Alaska. Canadian Journal of Forest Research. 31: 1386-1399.

- Gomi, T., R.C. Sidle, R.D. Woodsmith, and M.D. Bryant. 2003. Characteristics of channel steps and reach morphology in headwater streams, southeast Alaska. Geomorphology. 51: 225-242.

- Johnson, A.C., D.N. Swanston, and K.E. McGee. 2000. Landslide initiation, runout, and deposition within clearcuts and old-growth forests of Alaska. Journal of the American Water Resources Association. 36: 17-30.

- Cederholm, C.J., and L.M. Reid. 1987. Impact of forest management on coho salmon (*Oncorhynchus kisutch*) populations of the Clearwater River, Washington: A project summary. In: Streamside Management: Forestry and Fishery Interactions. Proceedings of a symposium held at University of Washington, 12-14 February 1986, Seattle. E.O. Salo and T.W. Cundy, Editors. Institute of Forest Resources, Seattle, Washington, Contribution No. 57. Pages 373-398.

In addition, Moselle recommended including the following papers:

- For Miscellaneous Section: Bash, J. C. Berman, and S. Bolton. 2001. Effects of turbidity and suspended solids on salmonids. Univ. of Washington Center for Streamside Studies. Washington State Dept. of Transportation Technical Report WA-RD 526.1. 74 pp.

"Frequently dissected slopes"

At the last meeting, there was a discussion of whether we need a more specific definition of "frequently dissected slopes." Johnson reviewed the literature and talked with Doug Swanston on this issue. She said the "frequently" begs for a number definition, and suggested that it would be better to just say, "dissected slopes." In the literature, the references are often to both frequency and magnitude of dissections. For example, a deep gully with many feeder hollows may have a history of slides and chronic failures. Where there are many shallow incisions, lower magnitude slides often occur. We just need to note gullies and potential contributing areas from hollow and dissections. There is no good way to specify something like an area with "eight dissections per ½-mile is unstable."

Landwehr generally agreed. He noted that the guide by Chatwin et al., 1994[1] refers to "dissected" or "highly-dissected" slopes but doesn't provide any quantitative measure.

Johnson said that the indicator is incised slopes, whether or not flowing water is present. Burkhart observed that 80% of Southeast Alaska slopes would fit that category. Johnson agreed that it could be a huge area. She also noted that Swanston said that the 50% gradient suggested in the indicators should be lowered to 45% in protection of public safety is the goal. Moselle said that such a change could be the difference between a 90% and 95% confidence level, and didn't see the need to change it to a 45% gradient.

Baichtal asked how "frequently" is currently defined by the USFS. Landwehr said that the Alaska Region landform guide uses 10 dissections/mile, or an interfluve distance <500'. However, that standard was developed as a hydrologic indicator for mapping, not necessarily for assessing landslide potential. Landwehr suggested a distance of ≤200-250' or tree height between dissections for a definition of "frequently" for identifying unstable terrain. He added that the Chatwin, et al. 1994 guide has photographs of highly dissected slopes – we could use that as a reference.

Johnson said that Taain Creek on Mitkof Island has failed repeatedly due to multiple hollows, but the slope isn't highly dissected.

Hanley referred back to the suggestion that if you can't split-yard away from a dissection, it's an indicator of a highly dissected area. He prefers "highly dissected" to "frequently dissected."

Burkhart asked whether it is primarily roads or yarding that cause failures on dissected slopes. Landwehr answered that it can be either one, especially where there are deep till soils on a slope gradient >50%. On unstable terrain with helicopter yarding, the problem areas would be on steeper

[1] Chatwin, S. C., D. E. Howes, J. W. Schwab, and D. N. Swanston. 1994. A guide for management of landslide-prone terrain in the Pacific Northwest. 2nd ed. British Columbia Ministry of Forests and U.S. Forest Service. 218 pp.

Forest Resources & Practices Act
Landslide Science & Technical Committee (S&TC)
Minutes -- Meeting #2 - April 1, 2009 Juneau

Attendees: Greg Staunton, Pat Palkovic, Jim Baichtal, Kevin Hanley, Kyle Moselle, Dennis Landwehr, Adelaide (Di) Johnson, Marty Freeman. Ralph Swedell was absent.

Agenda. No changes

February 10 Minutes. Minor changes were made to consensus point C1, as follows.

C1. The scoping model and associated maps are tools for assessing the general scope of landslide hazards and public safety risks associated with forest operations. They do not replace the need for site-specific analysis and design of timber sales and access roads.

[Note – edits were also made to Consensus Point C2 during subsequent discussions. See amended version on page 5.]

Public and Board input. Freeman handed out an excerpt from the draft minutes of the March 18-19 Board of Forestry meeting covering the briefing on the S&TC work to date, and Board discussion. In general, the Board was pleased with the progress made on scoping. The Board also clarified that the intent is to address issues of public safety risks to people rather than to infrastructure such as utility lines or roads.

Freeman also handed out a copy of a March 23, 2009 letter from Ed Wood of the Mitkof Highway Homeowners Association and attachments. The attachments include

- an affidavit from Robert Peterson about the location of Taain Creek,
- the 2006 Detailed Plan of Operations (DPO) for a timber harvest on Mental Health Trust land above the Mitkof Highway,
- a transmittal memo from the Division of Forestry to the Habitat Division accompanying the DPO
- a memo from the Department of Environmental Conservation to the Division of Forestry with comments on the DPO
- a letter from the California Board for Geologists and Geophysicists issuing a citation and fine to Craig Erdman
- Douglas Swanston's critique of the slope stability assessment by Craig Erdman
- Excerpts from the US Geological Survey Geologic Map of Southeastern Alaska Dept of Natural Resources
- Photos and a Geographic Information System (GIS) analysis of the 2004 Boulder Point landslide
- A map of land ownership and proposed timber harvest units along the Mitkof Highway.

Palkovic said that the statement attributed to her in footnote 21 of the letter is misleading. She clarified that landowners and operators have to comply with all relevant laws, and with forest practices requirements in the agency review comments on the FRPA Detailed Plan of

Johnson described Johnson et al. (2000)[1] data compiled from a random sample of 45 landslides which include a mix of slides in old-growth, second-growth, and clearcuts. All the slides were associated with storm events. Initiation angles ranged from 44-96%, with a mean of 63%. More than half of the slides started on slopes ≤62%. She emphasized that the S&TC shouldn't just look at slopes greater than 62% for determination of landslide hazard areas. She recommended looking at gradients of 45% and up – that would include ≥95% of slides.

Four of the 45 slides (9%) traveled more than a half-mile. They ranged from 0.02 to 1.01 miles long. Johnson said that runout length is dictated by slope and junction angles of channels the slide travels into more than distance alone. She brought a copy of a 1990 paper by Lee Benda and Terrance Cundy[2]. Their model uses a 6% gradient for deposition slopes. Johnson et al., (2000) found that deposition slopes ranged from 4% to 33%, with a mean of 17%. Landslides in old-growth typically deposit on steeper slopes – they back up behind standing trees, downed trees and debris. Runout length of debris flows depends on whether a slide enters a creek, especially a 3rd order or larger channel – in these conditions, slides travel farther.

Landwehr noted that there are differences between the slides in his report and Johnson's. His study included slides associated with recent harvests and road construction – not all were from storm events. Johnson's study included a mix of cover types, but all were during a storm event. Some slides were included in both analyses. Slides in recent harvest areas are smaller on average than those in second-growth or old-growth. For the harvest area slides, 90% initiated on slopes >52%. Storm-event slides are typically bigger. Slides from road construction are generally smaller and are not a public safety hazard because they occur at a known point in time (during construction). Johnson noted that slides that start in old-growth areas may have longer runouts if they travel downslope into a clearcut, as the deposition slope of a landslide in a clearcut is generally lower..

These two analyses did not separate slides that were channelized vs. non-channel flow. All of the channel flow slides are in HC (high-gradient contained) channels, usually in TLMP Class 3 or some Class 4 channels. Class 4 channels won't increase flow much. Class 3 streams are larger – ≤5 feet wide and incised 15 feet or more. [3]

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[1] Johnson, A.C., Swanston, D., and McGee, K., Landslide initiation, runout and deposition within clearcuts and old-growth forests of Alaska, Journal of the American Water Association, 36(1): 17-30.

[2] Benda, L.E., and T. W. Cundy. 1990. Predicting deposition of debris flows in mountain channels. Canadian Geotechnical Journal. Volume 27, Number 4. pp 409-417.

[3] Class III and IV streams are defined in TLMP as follows.

Class III: Perennial and intermittent streams with no fish populations but which have sufficient flow, or transport sufficient sediment and debris, to have an immediate influence on downstream water quality or fish habitat capability. For streams less than 30% gradient, special care is needed to determine if resident fish are present. A stream segment is designated Class III if the following conditions are met **for the majority of its length:** Bankfull stream width greater than 1.5 meters (5 feet) **and** channel incision (or entrenchment) greater than 5 meters (15 feet). Streams that do not meet both the width and incision criteria may be classified as Class III streams based on a professional interpretation of stream characteristics for the stream segment being assessed. The following characteristics **could** indicate a Class III stream:

a. Steep side-slopes containing mobile fine sediments, sand deposits, or deep soils that can provide an abundant source area for sedimentation.

b. Very steep gradient channels (greater than 35 percent slope).

Douglas N. Swanston, Ph.D., CPG

Dr. Swanston has more than 46 years experience in applications of engineering geology to land use planning and analysis and mitigation of the effects of geologic processes on urban and rural land use, a major portion of it gained in western Canada and coastal and interior Alaska. For 35 years (1962-1997), Dr. Swanston led a United States Forest Service engineering geology and slope stability research program. This program established goals, set priorities, and guided research on the influence of road construction, facilities development, and federal management practices on mass erosion and sediment transport in the Pacific Northwest and Alaska. From 1983 to 1988, Dr. Swanston served as a member of the Committee on Ground Failure Hazards Mitigation, National Academy of Sciences, National Research Council. This committee developed criteria and recommendations for identification, control, and correction of ground failure hazards (landslides and subsidence) in urban areas of the United States. From 1998 to 2002, Dr. Swanston was a partner in BRD Consultants, L.L.C. providing civil and geological engineering services and stability hazard analysis to central and southeast Alaska and the North Pacific Coast. He retired in 2003. Dr. Swanston has published more than 80 scientific articles in books and professional geology and engineering journals.