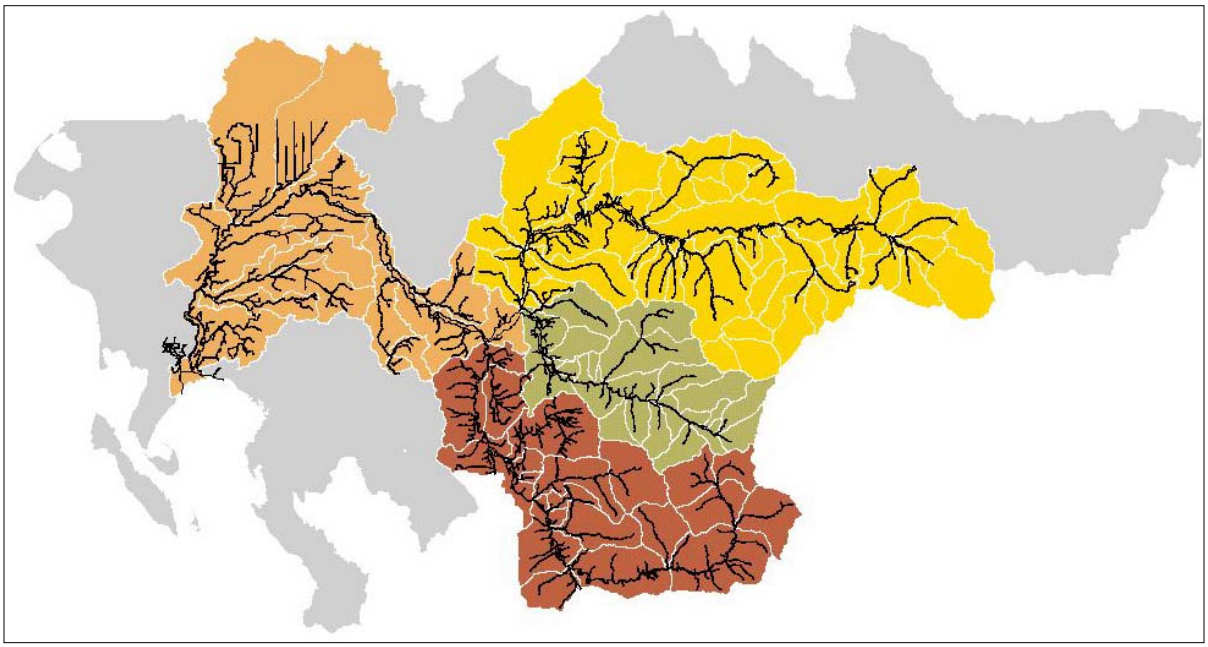
Nooksack River Watershed
Riparian Function Assessment



Treva Coe

Natural Resources Department

Nooksack Indian Tribe

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INTRODUCTION

Riparian zones exert a strong influence on the structure and function of stream ecosystems (Naiman et al. 1998). Riparian vegetation provides bank stability, moderates stream temperatures, and delivers organic matter to the stream in the form of insects, leaves, dissolved nutrients, and woody debris. Large woody debris (LWD) in turn can function to form and deepen pools, store sediment and organic matter, increase habitat complexity and channel roughness, provide cover for stream biota, and moderate flow into floodplain habitats and the hyporheic zone (Bilby and Bisson 1998).

Assessments of riparian vegetation can be used to evaluate the extent to which riparian zones are functioning. For instance, the size, type and density of vegetation in the riparian zone are indicators of its near-term LWD recruitment potential, or ability to provide LWD to the adjacent stream, while vegetation type and height are an important control on stream shading. Given that the assessment of current watershed condition is critical to development of restoration priorities (NNR et al. 2001), riparian function assessment in the Nooksack River watershed fulfills a significant data need.

In May 2000, Nooksack Natural Resources and Lummi Natural Resources contracted with Duck Creek Associates to conduct a riparian function assessment for salmonid-bearing[1] and contiguous[2] streams in the Nooksack River watershed (Figure 1). Using 1:12,000 scale aerial photos obtained from the U.S. Forest Service (federal ownership; 1991 photo year) and Washington Department of Natural

[1] Salmonid-bearing streams are those depicted as encompassing the known and presumed distribution of salmonids in the Nooksack River watershed, as identified by basin experts in 1999 (WCD 2000).
[2] Stream segments meeting the following three criteria were also included in the assessment: (1) contiguous to mapped salmonid-bearing streams; (2) identified as Type 4 in Washington Department of Natural Resources' GIS hydrography layer; and (3) less than 20% map gradient in the SSHIAP database (NWIFC 2000).

Resources (all other ownerships, 1995 photo year)[3], riparian condition was classified in 100-foot-wide units beyond apparent channel migration zones along both right and left banks of relevant stream segments. Photo-classification was ground-truthed in numerous locations. Riparian function assessment was based on Watershed Analysis methods (WFPB 1997) with some modification for non-forested lands. For each riparian condition unit, percentage canopy shading, vegetation type, vegetation size class, and vegetation density were classified (17,923 total acres; Table 1). Near-term LWD recruitment potential was derived from combinations of vegetation type, size class and density (Table 2). Riparian condition was also classified in apparent channel migration zones (7,371 total acres). Methods are described in detail in *Methodology for Conducting the Year 2000 Riparian Assessment for the Nooksack Basin* (Appendix A).

Table 1. Relevant attributes from the Nooksack River Basin Riparian Function Assessment GIS database.

Attribute	Definition	Values
Shade_Code	Percentage canopy cover	1 (0-20%), 2 (20-40%), 3 (40-70%), 4 (70-90%), 5 (>90%)
Near_Potent	Near-term LWD recruitment potential	H (High), M (Moderate), L (Low)
Type	Vegetation type	C (Conifer), H (Hardwood), M (Mixed), P (Pasture), R (Regenerating Conifer), S (Shrub), U (Urban), W (Water)
Size	Vegetation size class	L (Large; >20"dbh†), M (Medium; 12"-20"dbh), S (Small; 3"-12"dbh), X (not applicable)
Density	Vegetation density	D (Dense; less than 1/3 ground exposed), S (Sparse; more than 1/3 ground exposed)

†Diameter-at-breast-height (4 feet).

[3] 1998 DNR Digital Orthophotos were also used, primarily as a base layer for GIS mapping, but also to incorporate more recent changes in riparian condition. Discrepancies between the two photo sets, however, occurred infrequently (Gerald Middel, Duck Creek Associates, personal communication).

Table 2. Derivation of LWD recruitment potential from riparian condition.

Recruitment Potential	Riparian Condition Code†
Low	CSD, CSS, HLS, HMS, HSD, HSS, MSD, MSS, PXX, RXX, SXX, UXX
Moderate	CLS, CMS, HLD, HMD, MLS, MMS
High	CLD CMD MLD MMD

† First letter in code refers to vegetation type, second letter to vegetation size class, and third letter to vegetation density. See Table 1 for letter assignments.

The objectives of this report are to: (1) summarize LWD recruitment potential and stream shading for the Nooksack River basin by land use (as indicated by zoning) and geographic area; and (2) evaluate results and develop general recommendations for riparian restoration and protection. Basin- and subbasin-scale patterns are presented in the narrative Results section; the reader is directed to the figures and to Appendix B tables for results at the smaller scales of specific mainstem reaches and tributary watersheds.

METHODS

Methods for creation of the riparian function data layers (*nooksack_rcu* and *nooksack_cmz* shape files), including classification of attributes in Table 1, are presented in Appendix A. All subsequent GIS data manipulation and analyses were conducted in ESRI's ArcView 3.2 software. In order to facilitate comparison with other GIS data layers, Nooksack_RCU and Nooksack_CMZ shape files were reprojected to UTM Zone 10N (NAD 1927) with the -5000000 False Northing commonly used in Whatcom County. Polygons were partitioned into four subbasins: (1) North Fork Nooksack and associated tributaries, upstream of the confluence with the South Fork; (2) Middle Fork Nooksack and associated tributaries; (3) South Fork Nooksack and associated tributaries; and (4) Mainstem Nooksack and associated tributaries, downstream of South Fork confluence. Within

each subbasin, polygons were further partitioned into mainstem[4] and tributary reaches.

Mainstem river segments were subdivided into geomorphic segments based on SSHIAP[5] gradient and confinement class and WRIA 1 stream catalog description (Phinney and Williams 1975), with the exception of the Mainstem Nooksack, for which we used reaches designated in the Whatcom County Flood Hazard Management Plan (Whatcom County DPW 1999). Reaches are summarized in Table 3. Where riparian condition units crossed reach breaks, polygons were split. Tributary riparian condition units (RCU's) were assigned to WRIA 1 drainage basins[6] using the *assign data by spatial location* function. Subbasins within the same Nooksack River tributary drainage were grouped (i.e. Lower Deadhorse, Upper Deadhorse). Where RCU's crossed basin divides, manual assignments were made based on USGS 7.5' quads and the WRIA 1 stream catalog (Phinney and Williams 1975).

Whatcom County zoning data (WCZONECP shape file; Behee 1998) were used to evaluate relationships between land use and riparian condition. Similar zoning designations (*wczone* attribute) were aggregated into the following zoning classes: urban, agriculture, rural, rural forest, commercial forest, federal forest, and federal park lands (Table 4). Adjacent polygons in the WCZONECP shape file with

[4] Throughout this report, *Mainstem Nooksack* refers to the Nooksack River channel below the South Fork confluence, while *mainstem* refers to channels of the Mainstem, as well as North, Middle, and South Forks.
[5] Salmon and Steelhead Habitat Inventory and Assessment Program, a cooperative effort between the western Washington Treaty Indian Tribes and the Washington Department of Fish and Wildlife that characterizes freshwater habitat conditions and maps the distribution of salmon and steelhead stocks in Washington state.
[6] Drainage basins were delineated as part of the WRIA 1 Watershed Management Project. Basins, referred to in the text hereafter as watersheds, may contain more than one tributary to the Nooksack River or its forks. For instance, *Lower Middle Fork Nooksack, Middle Fork Diversion,* and *Upper Middle Fork Nooksack* are all composite watersheds containing several smaller tributaries to the Middle Fork Nooksack. Similarly, the following are composite watersheds: *Nooksack Deming to Everson* in the Mainstem Nooksack subbasin; *Lower North Fork Nooksack , Slide Mountain, Middle North Fork Nooksack,* and *Upper North Fork Nooksack* in the North Fork Nooksack subbasin; and *Lower South Fork Nooksack, South Acme Area, Dye, Upper South Fork Nooksack – East* and *West, Heart Lake Area,* and *Elbow Lake* in the South Fork Nooksack subbasin.

identical zoning class were merged (*dissolve features based on zoning class*). Zoning class was assigned to riparian condition units using the *intersect two themes* function (zoning as input, relevant riparian condition shape file as overlay). Since WCZONECP covered only Whatcom County, portions of the South Fork sub-basin occurring in Skagit County were partitioned into commercial forest or federal forest based on the Department of Natural Resources Mt. Baker map and a GIS layer of the Mount-Baker Snoqualmie National Forest boundary (mbsnf_bndry.shp, WCD 2000).

Table 3. Delineation of mainstem river reaches in the Nooksack River watershed.

Sub-Basin	Reach	Description
Mainstem	1	Bellingham Bay to just below Interstate 5
	2	Interstate 5 to Guide Meridian
	3	Guide Meridian to Everson Ave.
	4	Everson Ave. to confluence with South Fork Nooksack
North Fork	1	South Fork confluence to Middle Fork confluence
	2	Middle Fork confluence to Maple Creek
	3	Maple Creek to Glacier Creek
	4	Glacier Creek to Nooksack Falls
	5	Nooksack Falls to White Salmon Creek
	6	White Salmon Creek to uppermost reaches
Middle Fork	1	North Fork confluence to Mosquito Lake Road bridge
	2	Mosquito Lake Road bridge to Diversion Dam
	3	Diversion Dam to Clearwater Creek
	4	Clearwater Creek to Rankin Creek
	5	Rankin Creek to uppermost reaches
South Fork	1	North Fork confluence to Highway 9 at Acme
	2	Highway 9 at Acme to Saxon Rd. bridge
	3	Saxon Rd. bridge to Cavanaugh Creek
	4	Cavanaugh Creek to Larsen's bridge
	5	Larsen's bridge to RM 24.7 bridge
	6	RM 24.7 bridge to ~RM 30.5
	7	~RM 30.5 to uppermost reaches

Table 4. Zoning class as interpreted from zoning designation.

Zoning Class	Zoning Designation (Wczone)	Description
Urban	AO	Airport Operations
	City	Current City Limits
	GC	General Commercial
	GI	Gateway Industrial
	GM	General Manufacturing
	HII	Heavy Impact Industrial
	LII	Light Impact Industrial
	NC	Neighborhood Commercial
	RC	Resort Commercial
	TC	Tourist Commercial
	UR3	Urban Residential 3 units/acre
	UR4	Urban Residential 4 units/acre
	URM12	Urban Residential Medium Density 12
	URM18	Urban Residential Medium Density 18
	URM6	Urban Residential Medium Density 6
	URMX	Urban Residential Mixed Use
Agriculture	AG	Agriculture
Rural	R10A	Rural 1 unit/10 acres
	R2A	Rural 1 unit/2acres
	R5A	Rural 1 unit/5 acres
	ROS	Recreation Open Space
	RR1	Rural Residential 1 units/acre
	RR2	Rural Residential 2 units/acre
	RR3	Rural Residential 3 units/acre
	RRI	Rural Residential Island
	STC	
Rural Forest	RF	Rural Forest
Commercial Forest	CF	Commercial Forest
Federal Forest	NATFOREST	National Forest - Federal
	RECAREA	National Recreation Area - Federal
Federal Park	NATPARK	National Forest - Park
	WILDERNESS	Wilderness Area - Federal

Since lower-elevation streams require greater canopy cover (stream shading) to maintain temperatures below 16°C, percentage canopy cover (*shade_code*) was intersected with 30-m DEMs (Digital Elevation Models) reclassified into zones with elevation-specific target shade values (WFPB 1997; Table 5). Target shade values are likely conservative for glacially influenced parts of the Nooksack River watershed, since they were developed for non-glacial streams. Stream shading hazard was defined as the degree to which percentage canopy cover was below target shade (High: >40% below target, Moderate: 10-40% below target, Low: within 10% of target, Above target: >10% above target). Since target shade values were developed for streams with low flow width less than 100 feet, only tributaries and Forks mainstems were evaluated for stream shading hazard.[7] However, it should be recognized that stream shading might also be important for the Mainstem Nooksack, where temperatures exceeding 18°C have been documented (Lummi Natural Resources, unpublished data).

Table 5. Riparian target shade (canopy closure) values by elevation zone[8].

Minimum shade category (%)	Elevation Zone (feet)
<10	>3600
10	3280-3600
20	2960-3280
30	2400-2960
40	1960-2400
50	1640-1960
60	1160-1640
70	680-1160
80	320-680
90	<320

[7] Potential shade levels can be more accurately calculated for streams using stream width, mature vegetation height, and solar angle. A comprehensive set of low-flow width data, especially for the Mainstem Nooksack and other mainstem reaches, should be developed to model effects of stream shading on stream temperature.
[8] Derived from Table D-7 of Watershed Analysis Manual (WFPB 1997), *Riparian target shade (canopy closure) values for non-glacial streams in western Washington (Class AA Standard)*. Values are those considered necessary to maintain stream temperatures below 16°C and apply to stream reaches with low flow width less than 100 feet.

Polygon areas were calculated in ArcView, and attribute tables were exported to MS Access and MS Excel for synthesis and analysis. Areas (in acres) of LWD recruitment potential and either percentage canopy cover (Mainstem Nooksack) or stream shading hazard (all other streams) were summarized by subbasin, zoning class, and mainstem reach or WRIA 1 drainage.

RESULTS

Geographic Distribution

Riparian condition was classified in 17,923 acres of riparian areas in the Nooksack River basin. Most of this area (81%) occurred in tributary reaches (i.e. along tributaries to the North, Middle and South Forks and the Mainstem Nooksack River). Distribution of riparian areas among subbasins was 34%, 28%, 9%, and 29% for Mainstem Nooksack, North Fork, Middle Fork, and South Fork, respectively. Commercial forestry was the most common zoning class in riparian areas (36% of total), followed by agriculture (22%), rural (15%), federal forest (15%), rural forest (7%), urban (3%), and federal park (2%). Agricultural and rural zoning classes dominated the Mainstem subbasin, while the North, Middle and South Fork subbasins were dominated by commercial forest, followed by federal forest zoning class for the North and Middle Forks and agricultural zoning class for the South Fork (Table 6).

Table 6. Relative proportion (%) of zoning classes in riparian areas by subbasin.

Zoning Class	Subbasin			
	Mainstem	**North Fork**	**Middle Fork**	**South Fork**
Urban	8	1	0	0
Agriculture	55	0	0	12
Rural	26	13	9	5
Rural Forest	4	13	10	6
Commercial forest	7	31	58	67
Federal forest	0	38	19	9
Federal park	0	5	4	2
Total	100%	100%	100%	100%

Near-Term LWD Recruitment Potential[9]

Nooksack River Watershed

Near-term LWD recruitment potential (LWDRP; Fig. 2) varied by subbasin and, to a lesser extent, between mainstem and tributary reaches (Fig. 3). Overall, LWDRP in Nooksack River basin riparian areas is predominantly low (50%); areas characterized by moderate and high LWDRP comprised 19% and 31%, respectively, of the total study area. Although it contributes only 34% of the total riparian area, the Mainstem Nooksack subbasin contributed most (52%) of the riparian area in the Nooksack River watershed with low LWDRP. By contrast, most (76%) of the riparian area with high LWDRP occurred in the North Fork (40%) and South Fork (36%) subbasins, which together comprised 57% of the total riparian area.

[9] Refers to riparian areas within 100 feet of stream channels or, where they exist, channel migration zones.

Relative LWDRP (i.e. the distribution of LWDRP within a geographic area) within subbasins also varied geographically (Figs. 2, 3). The Mainstem Nooksack subbasin was characterized by the worst LWDRP, with 76% of the riparian area in low LWDRP. Proportions of low LWDRP within other subbasins were substantially less (32% North Fork, 34% Middle Fork, 41% South Fork). The Middle Fork and North Fork subbasins had the greatest LWDRP, as evidenced by proportions of riparian area with high LWDRP (47%, 44%, respectively). Distribution of LWDRP between mainstem and tributary reaches was generally proportional to area across all subbasins (e.g. 84% of areas with low LWDRP occurred along tributaries, which comprised 81% of the area), although moderate LWDRP riparian areas were generally underrepresented and high LWDRP riparian area generally overrepresented in tributary reaches. An extreme example of this pattern occurred in the Mainstem Nooksack subbasin, where riparian areas with high LWDRP were found only in tributary reaches.

LWDRP for riparian areas in agricultural, urban and rural zoning classes was predominantly low (85%, 77%, 60% of area, respectively; Fig. 4). Low LWDRP was also most common in Rural Forest and Commercial Forest riparian areas (41%, 37%), although proportions of high LWDRP differed, comprising 42% in Commercial Forest and 22% in Rural Forest zoning classes. By contrast, most of the riparian area in the Federal Forest (69%) and Federal Park (50%) zoning classes is characterized by high LWDRP.

Mainstem Nooksack Subbasin

No riparian areas with high LWDRP were found along the Mainstem Nooksack (Figs. 5, 6); most (60%) of the riparian area with moderate LWDRP occurred in reach 4, upstream of Everson. Relative LWDRP was lowest in reaches 1 through 3, where 76% to 88% of the riparian area has low LWDRP (Figs. 5, 6). Reach 4 was

characterized by mostly moderate LWDRP (53%).

Four tributary watersheds representing 51% of the overall riparian area in Mainstem Nooksack tributaries (Figs. 5, 7) comprised 53% of the riparian area with low LWDRP: Fishtrap, Tenmile, Bertrand and Silver. Most (82%) of Mainstem Nooksack tributary riparian areas with high LWDRP occurred in Nooksack Deming to Everson, Bertrand, Smith, Silver, and Anderson watersheds, which together comprised less than half (45%) of the overall riparian area. In terms of relative LWDRP within tributary watersheds, all but Nooksack Deming to Everson and Anderson were predominantly low in LWDRP. LWDRP was worst in Lummi Peninsula West, Scott, Fishtrap, Kamm, and Schneider watersheds, in which proportion of riparian area with low LWDRP ranged from 98 to 100% and there was no high LWDRP. LWDRP was greatest among Nooksack Deming to Everson, Anderson, Deer, and Smith watersheds; proportions ranged from 15 to 40% of area with high LWDRP and from 31 to 69% of area with low LWDRP.

North Fork Nooksack Subbasin

Most (55%) of the riparian area along the North Fork Nooksack (Figs. 8, 9) with low LWDRP occurred downstream of Maple Creek (reaches 1 and 2), while most with high LWDRP (70%) occurred further upstream, between Glacier and White Salmon Creeks (70%; reaches 4 and 5). Within reaches 1, 2, and 6, proportions of riparian area with low LWDRP were 56, 41, and 47%, respectively. Riparian areas between Glacier and White Salmon Creeks were characterized by predominantly high LWDRP (77% of reach 4, 83% of reach 5).

Five tributary watersheds comprised 55% of the riparian area with low LWDRP in North Fork Nooksack tributaries (Figs. 8, 10): Slide Mountain, Kendall, Maple, Racehorse, and Cornell, which together represented only 38% of overall riparian area. Glacier, Canyon, Slide Mountain, Wells, and Maple watersheds comprised

57% of North Fork tributary riparian areas with high LWDRP (and 49% of overall riparian area). In terms of relative LWDRP within tributary watersheds, the following watersheds were predominantly low: Kendall (73% low LWDRP), Hedrick (70%), Hamilton (65%), Boulder (63%), lower North Fork (62%), and Racehorse (57%). LWDRP in Glacier, White Salmon, middle North Fork, Wells, Deadhorse, Anderson, Canyon, and Swamp was predominantly high (76%, 69%, 66%, 65%, 65%, 57%, 56%, 52%, respectively).

Middle Fork Nooksack Subbasin

No clear longitudinal patterns occurred in the distribution of either high or low LWDRP along the Middle Fork Nooksack (Figs. 11, 12). For instance, most of the riparian area with low LWDRP was split between reaches 1 (30%) and 4 (40%), while high LWDRP was split between reaches 4 (35%) and 2 (25%). Relative LWDRP was lowest upstream of Rankin Creek (reach 5, 71% low LWDRP) and highest between the Mosquito Lake Road bridge and Clearwater Creek in the middle reaches (reach 2, 77% of riparian area with high LWDRP; reach 3, 56%).

Three tributary watersheds representing only 54% of the overall riparian area along Middle Fork tributaries (Figs. 11, 13) comprised 79% of the riparian area with low LWDRP: Lower Middle Fork, Canyon Lake and Middle Fork Diversion. Clearwater, Middle Fork diversion, and Canyon Lake watersheds comprised 61% of the riparian area with high LWDRP, and 53% overall, along Middle Fork tributaries. Relative LWDRP within tributary watersheds was lowest for Rankin Creek and Lower Middle Fork, where 100% and 62% of the riparian area had low LWDRP, respectively. The highest relative LWDRP occurred in Upper Middle Fork, Ridley and Galbraith watersheds, wherein all riparian area assessed had high LWDRP, and to a lesser extent in Green (88% high LWDRP), Warm (75%) and Clearwater Creek (69%) watersheds.

South Fork Nooksack Subbasin

No riparian areas with high LWDRP were found along the lower South Fork Mainstem Nooksack (Figs. 14, 15) below the Saxon Rd. bridge; indeed, these reaches (1 and 2) comprised 44% of the riparian area with low LWDRP. Most (71%) of the high LWDRP riparian area occurred in the uppermost reaches of the South Fork (upstream of RM 24.7 bridge), near the upper limit of anadromous use for most salmonid species. Relative LWDRP was lowest in reaches 1, 2 and 4 where LWDRP was predominantly low (52%, 62%, and 67%, respectively), and highest in reach 7 where LWDRP was predominantly (64%) high.

Five tributary watersheds comprised 65% of the riparian area with low LWDRP in South Fork Nooksack tributaries (Figs. 14, 16): Hutchinson (14%), Black Slough (14%), Lower South Fork Nooksack (13%), Upper South Fork Nooksack - East (13%), and South Acme Area (11%). Tributary watersheds contributing at least 10% of the riparian area with high LWDRP included Hutchinson (19%), Skookum (12%), Upper South Fork Nooksack – East (10%), and Lower South Fork Nooksack (10%). LWDRP was predominantly low within Saxon (69% low LWDRP), Upper South Fork Nooksack – West (65%), Black Slough (59%), Heart Lake Area (59%), and South Acme Area (54%) watersheds. High LWDRP predominated in Elbow Lake (75%), Wanlick (74%), Bell (63%), Howard (58%), Skookum (55%), and Deer, Roaring & Plumbago (51%) watersheds.

Stream Shading[10]

Nooksack River Watershed

As with LWD recruitment potential, the stream shading function of Nooksack River watershed riparian areas is also degraded. Stream shading hazard in riparian areas

[10] Refers to riparian areas within 100 feet of stream channels or, where they exist, channel migration zones. NOTE: In contrast to LWDRP, high rating for stream shading hazard denotes degraded function.

of the Nooksack River basin[11] is predominantly either high (37%) or moderate (29%); only 21% of the riparian area is above target shade levels (Figs. 17, 18). Most (63%) of the riparian area with high hazard for stream shading occurred in the Mainstem Nooksack subbasin, while most of the riparian area above target shade levels occurred in the North or South Fork subbasins (46% and 37%, respectively).

Relative stream shading hazard within subbasins was similarly distributed (Fig. 18). Mainstem Nooksack subbasin riparian areas were characterized by predominantly high hazard for stream shading (77%), with only 3% above target shade levels. Relative stream shading hazard varied little among the North, Middle and South Fork subbasins, ranging from 19 to 21% with high hazard for stream shading, 31 to 38% with moderate, 16 to 18% with low, and 26 to 33% above target.

Stream shading hazard for riparian areas in agricultural, urban and rural zoning classes was predominantly high (85%, 73%, 65% of area, respectively), with less than 1 to 4% above target (Fig. 19). By contrast, riparian areas in federal park zoning class were predominantly above target (70%); none had high hazard for stream shading. Stream shading hazard generally decreased from rural forest to commercial forest to federal forest zoning classes, with 80%, 52%, 35%, respectively, in high and moderate hazard and 20%, 48%, and 65% in low hazard or above target for stream shading. To some degree, these patterns were influenced by the distribution of zoning classes throughout the watershed (i.e. agricultural zoning class concentrated in lower elevations where target shade levels are higher).

Mainstem Nooksack Subbasin

Although stream shading hazard was not calculated for the Mainstem Nooksack, shading was predominantly low (0-20% stream shading over 98% of riparian area;

[11] As discussed in the Methods section, stream shading hazard was calculated for riparian areas both along the Forks and along *tributaries* to the Forks and Mainstem Nooksack, but not along the Mainstem Nooksack itself.

Fig. 20). Among tributaries to the Mainstem Nooksack (Figs. 20, 21), four tributary watersheds contained the majority of the riparian area with high hazard for stream shading: Tenmile (16%), Bertrand (14%), Silver (13%), and Fishtrap (12%). Nooksack Deming to Everson tributaries and Smith Creek watershed comprised most of the riparian area above target shade levels (59% and 36%, respectively). In terms of relative stream shading hazard within tributary watersheds, all but three watersheds were predominantly high, especially Scott (100% high hazard), Kamm (98%), Wiser Lake/Cougar Creek (96%), Lummi Peninsula (95%), Schneider (94%), Tenmile (93%), and Nooksack River Delta (88%). The three with riparian area above target shade levels were Nooksack Deming to Everson tributaries (39% above target shade levels), Smith (15%), and Anderson (2%); most of the remaining riparian area, however, was characterized by either high or moderate stream shading hazard (47%, 70%, and 96%, respectively).

North Fork Nooksack Subbasin

Along the North Fork Nooksack (Figs. 22, 23), most (89%) of the riparian area with high hazard for stream shading occurred downstream of Glacier Creek (reaches 1-3), while all of the riparian area above target shade levels occurred upstream of Nooksack Falls (reaches 5-6). Relative stream shading hazard within reaches was greatest downstream of Maple Creek (reaches 1-2), where all of the riparian area was characterized by high hazard for stream shading, followed by reaches 3 (84% high hazard, 12% moderate hazard), 4 (31% high, 59% moderate, 10% low), and 5 (54% moderate, 34% low, 12% above target). Most of the riparian area along reach 6 was above target for stream shading.

Three tributary watersheds comprised 62% of the riparian area with high hazard for stream shading in North Fork Nooksack tributaries (Figs. 22, 24): Kendall, Maple, and Slide Mountain. Most (53%) of the North Fork Nooksack tributary riparian area

above target shade levels occurred in Canyon, Glacier, Swamp, Wells, and Anderson watersheds. In terms of relative stream shading hazard within tributary watersheds, several were predominantly above target shade levels: Swamp and Upper North Fork (96%), White Salmon (90%), Anderson (71%), Bagley (68%), Middle North Fork (60%), Hedrick and Canyon (59%), and Wells (58%). While none were dominated by high hazard for stream shading, the following were predominantly high and moderate: Boulder (89%), Lower North Fork (89%), Coal (87%), Kendall (67%), Hamilton (66%), Maple (61%), Slide Mountain (58%), Bells (57%), and Racehorse (56%).

Middle Fork Nooksack Subbasin

All of the riparian area along the Middle Fork Nooksack (Figs. 25, 26) with high hazard for stream shading occurred downstream of the Diversion Dam (reaches 1-2), while all above target shade levels occurred upstream of Clearwater Creek (reaches 4-5). Following a similar longitudinal pattern, relative stream shading hazard was highest in reach 1 (100% high), followed by reaches 2 (55% high, 45% moderate), 3 (98% moderate), and 4 (61% moderate, 29% low). Within reach 5, stream shading hazard was distributed among moderate (28%), low (33%), and above target (39%) classes.

Two tributary watersheds comprised almost all (99.8%) of the riparian area with high hazard for stream shading in Middle Fork Nooksack tributaries (Figs. 25, 27): Lower Middle Fork (79.6%) and Canyon Lake (20.2%). Riparian areas above target shade levels were distributed among Middle Fork Diversion (29%), Clearwater (24%), Warm (19%), and Green (9%) watersheds. In terms of relative stream shading hazard within tributary watersheds, the following were predominantly above target shade levels: Galbraith, Warm, Green, and Upper Middle Fork (100% each); Rankin (82%); and Middle Fork Diversion (63%). Only one watershed, Lower Middle Fork,

was predominantly (51%) high hazard for stream shading, although several were predominantly high and moderate: Porter (100%), Canyon Lake (94%), Heislers (76%), and Sisters (64%).

South Fork Nooksack Subbasin

Most of the riparian area with high stream shading hazard along the South Fork Nooksack (Figs. 28, 29) occurred downstream from Larsen's bridge (36%, 21%, 12%, 16% in reaches 1-4, respectively), while all of the riparian area above target shade levels is above the RM 24.7 bridge (83% in reach 7), near the upper anadromous limit for most species. Relative stream shading hazard decreased upstream, from 100% high hazard in reach 1 to 2% in reach 7, 70% of which was in moderate hazard for stream shading.

Most of the riparian area with high hazard for stream shading was distributed among five watersheds tributary to the South Fork Nooksack (Figs. 28. 30): Hutchinson (28%), Black Slough (22%), South Acme Area (15%), Dye (10%), and Lower South Fork (9%). Most of the area above target shade levels occurred in Hutchinson (18%), Upper South Fork Nooksack East (10%), Cavanaugh (9%), Skookum (9%), South Acme Area (8%), and Black Slough (7%). Heart Lake, Elbow Lake, Wanlick, Skookum, Edfro, and Howard watersheds all had riparian areas with moderate hazard for stream shading or better (i.e. low hazard or above target), while only Saxon had no riparian area above target shade levels. In terms of relative stream shading hazard, Saxon was predominantly high (69%), Deer, Roaring & Plumbago and Lower South Fork predominantly moderate (58-59%), and Edfro, Bell, Cavanaugh, Elbow Lake, Howard, and Wanlick predominantly above target shade levels (51-65%).

Near-Term Channel Migration Zones

Although the large scale of this assessment prohibited delineation of channel migration zones (CMZs) over multiple photo years, readily identifiable CMZs were delineated nonetheless to isolate the effects of channel migration on LWD recruitment potential (i.e. the preceding analysis summarizes riparian condition outside the mapped CMZ). The use of only one photo year, however, limits the interpretation of the following results. Analysis of channel migration potential should consider valley confinement, sediment supply and transport, LWD, bank stability, and anthropogenic influences. CMZs delineated in this assessment, for example, do not represent historical channel migration zones, especially considering the numerous channel modifications and bank protection measures implemented over the past 150 years. Readers interested in historical channel migration in Nooksack River are referred to the Nooksack Historic Channel and Floodplain Conditions Report (B. Collins et al., in preparation).

Of the 6305 acres of CMZ associated with mainstem river segments (Fig. 31), most (53%) occurred in the Mainstem Nooksack, followed by the North Fork (31%), and the South and Middle Forks (each 8%). Near-term channel migration zones were identified in 3 of 4 Mainstem Nooksack reaches, all 6 North Fork reaches, 2 of 5 Middle Fork reaches, and 4 of 7 South Fork reaches. Almost half (47%) of CMZ area identified in the Mainstem Nooksack was associated with the Nooksack River delta, with another 45% in Reach 4 (upstream of Everson). Most of the CMZ area identified in the three Forks occurred in the downstream reaches, including 90% of North Fork CMZ downstream of Glacier Creek, 98% of Middle Fork CMZ downstream of Mosquito Lake Rd. bridge, and 84% of South Fork CMZ downstream of Saxon Road bridge. As expected given recent channel migration, near-term LWD recruitment potential in mainstem CMZ units was predominantly low (97% of total

area) and vegetation was dominated by shrubs and small and medium-sized (<20" dbh) hardwoods.

Of 1066 acres of CMZ associated with tributary stream segments (Fig. 32), most (54%) occurred in North Fork tributaries, followed by Mainstem Nooksack (25%), South Fork (12%), and Middle Fork (9%). CMZs were identified in 4 of 15 Mainstem Nooksack, 11 of 25 North Fork, 2 of 13 Middle Fork, and 7 of 16 South Fork tributary basins (Figure 1b). Small hardwoods (<12" dbh) hardwoods, shrubs, pasture, and open water dominated the CMZs of tributary basins.

CONCLUSIONS

LWD recruitment potential, as evidenced from the size, type, and density of vegetation immediately adjacent to the stream or channel migration zone, is predominantly low (50%), especially in the Mainstem Nooksack subbasin, 76% of which was characterized with low near-term LWD recruitment potential. High LWD recruitment potential was found in only 31% of the study area. Riparian areas with high LWD recruitment potential generally occur in the upper watershed; 44% and 47% of the riparian area in North Fork and Middle Fork subbasins, respectively, were characterized as having high LWD recruitment potential. LWD recruitment potential was associated with land use (as interpreted from zoning classification) in the following order, from greatest to least: federal forest, federal park, commercial forest, rural forest, rural, urban, and agriculture.

Results for stream shading hazard, or the degree to which current canopy coverage falls short of elevation-zone-specific target shade levels, also indicate degraded riparian function; there is high hazard for stream shading (shade levels >40% below target) in 37% of the riparian area in the Nooksack River watershed and moderate hazard (shade levels 10-40% below target) in 29% of the riparian area. Distribution of stream shading hazard is similar to that of LWD recruitment potential, with 77%

of Mainstem Nooksack subbasin having high hazard, compared to only 19-21% in each of the Forks subbasins. Canopy coverage above target shade levels was found in only 21% of the study area. As with LWD recruitment potential, stream shading relative to target shade levels decreased in order from federal park to federal forest, commercial forest, rural forest, rural, urban, and agricultural zoning classes.

RECOMMENDATIONS

Efforts to improve riparian function in the Nooksack River watershed should include: (1) protection of functional and recovering areas through acquisition and enforcement of existing land use rules; (2) improvement of riparian conditions in existing riparian contribution areas; and (3) restoration of recruitment processes for large woody debris. It is anticipated that this study will lead in the near future to specific recommendations for riparian restoration and protection, including both identification and prioritization of treatments in specific geographic areas, which will be incorporated into the watershed restoration strategy for the Nooksack River basin. For the interim, we present general recommendations for acquisition, restoration, and improved land management practices.

Acquisition

We recommend focusing protection efforts in mainstem reaches and tributary watersheds where riparian function is currently high (high LWD recruitment potential, above target shade levels; NNR et al. 2001), especially in reaches that currently provide habitat important to priority salmonid species and where current land use rules provide insufficient assurances of protection.

Restoration

The need for active riparian restoration will depend on localized stand characteristics, including the species distribution and density and the presence of

seed sources (Beach & Halpern 2001). To this end, the Nooksack River Basin Riparian Function Assessment GIS dataset (summarized herein) can prove useful – specifically, the vegetation type, vegetation size class, and vegetation density within individual riparian condition units. On-the-ground verification of these attributes, however, is highly recommended. Selection of species for planting should be informed by assessments of historic vegetation (e.g. DiDomenico 1982, B. Collins et al., in prep). Additionally, riparian restoration should focus in reaches important for highest priority species and on activities that restore a high degree of function, e.g. planting buffers of at least 100 feet, and greater in unconfined reaches. Sequencing with other actions, such as restoration of a channel to a more natural configuration prior to planting, may also be appropriate.

Active restoration, especially in agricultural, urban and rural areas, is warranted in areas with severely degraded riparian condition. Restoration in such areas should include removal or control of exotic species, planting of native species, maintenance, and some form of assurance of protection over time. Conifer re-establishment along mainstem reaches, especially the Mainstem Nooksack (below South Fork confluence), is a high priority, given that: (1) riparian areas along the Mainstem Nooksack are all degraded (no high LWD recruitment potential, high hazard for stream shading), (2) mainstem reaches are important connecting habitats for all species of anadromous salmonids in the basin; (3) large-volume LWD will provide the greatest habitat benefits in large rivers, and (4) conifers have the potential to eventually provide the largest-volume LWD. Since lateral channel migration (which causes bank undercutting) is a significant LWD recruitment process in unconstrained reaches (Murphy & Koski 1989), efforts should be focused in areas where the channel has been less impacted by hydromodifications (dikes and levees).

Forested land use areas tend to have both abundant seed sources and trees of some size and type already providing a degree of function. Such areas will require more

passive restoration, including limited silvicultural practices[12] such as thinning and underplanting, along with the passage of time and assurances of protection through either forest practice rules or acquisition.

Land Use Management

Functional LWD in mainstem reaches is most likely to be recruited from beyond, rather than within, the channel migration zones (CMZs) identified in this assessment, as indicated by the predominance in CMZs of shrubs and small to medium-sized hardwoods with low LWD recruitment potential. Any reach meander belt delineation, river corridor analysis, flood control analysis, or individual flood control project should explicitly consider the effect that restricted channel migration has on LWD recruitment rates (i.e. through bank undercutting). Moreover, critical areas variances and shorelines substantial development permits that allow encroachment into riparian areas reduces our ability to improve riparian conditions and the habitats formed and maintained by functional riparian zones. Continued permitting of structures within channel migration areas is also likely to result in future requests to limit channel migration, with resulting decreases in both the potential riparian contribution area and the recruitment rates of LWD.

Low LWD recruitment potential along mainstem reaches, especially the Mainstem Nooksack, suggests that in-channel LWD loading in the near-term is likely to be determined primarily from routing of LWD from upstream sources. Structures should be carefully evaluated for their capacity to disrupt the routing of LWD, such as culverts and bridges (especially those with in-channel pillars) that restrict channel width during LWD-transporting flows. In addition, stream-adjacent roads and railroads can reduce upstream LWD sources by restricting channel migration, thereby decreasing potential recruitment area. Removal of roads, railroads, and

[12] Silvicultural activities within portions of the riparian area may require Forest Practice applications.

other structures from the channel migration zone should be a long-term goal. Minimizing impacts to LWD recruitment and routing will help link areas in the upper basin that have high LWD recruitment potential with LWD-deficient reaches in the lower basin and estuary.

Finally, the need for improved riparian protection rules on agricultural lands is strongly warranted. Agriculture is the second largest zoning class but was characterized by both the lowest LWD recruitment potential and shade levels furthest below target shade levels. Further, streams and rivers in this zone are predominantly low-gradient and unconfined, which historically had high salmonid production potential.

Additional Data Needs

The recommendations outlined above can be refined with additional information; to that end, the following should be taken into account: (1) *Size of functional wood scales to stream size.* LWD recruitment potential ratings were applied to riparian areas regardless of stream size; however, the size of wood that both resides and functions in streams – forming pools, storing sediments – is dependent on stream size (i.e. larger streams have greater transport capacity (Bilby and Ward 1989) and need larger wood to function (Beechie et al. 2000). Analysis of the ability of the riparian zone to supply large woody debris of sufficient size to form pools is pending (T. Hyatt et al. in preparation). (2) *Effects of LWD vary by geomorphic channel type*. The influence of LWD on channel form and fluvial processes depends on channel gradient and confinement (Montgomery and Buffington 1998). Channel type inventories are needed to understand where LWD provides the greatest habitat benefits. (3) *LWD recruitment potential is not a measure of wood loadings instream.* LWD inventories should be compared with target wood loading standards to determine whether current wood levels are deficient. Further, hydromodifications and other

factors can diminish LWD recruitment rates regardless of the LWD recruitment potential of the adjacent vegetation. (4) *Comparison of current with potential stream shading is needed.* The extent to which vegetation provides shade to streams is a function of vegetation height and channel width. Riparian restoration will provide greater benefit in terms of water temperatures in smaller streams, where potential stream shading is 100%, than in larger streams. Current and potential stream shading (given site potential tree height) should be assessed. (5) *Analysis of the effects of stream shading on stream temperatures is needed.* Relationships among stream temperatures, stream shading, elevation and other variables should be examined.

ACKNOWLEDGEMENTS

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ADDITIONAL COPIES

Limited copies of this report can be obtained by contacting Treva Coe at:

Nooksack Indian Tribe
Natural Resources Department
P.O. 157 • 5016 Deming Rd.
Deming, WA 98244
(360) 592-5176 ext 3286
tcoe@nooksack-tribe.org

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Figure 1. Nooksack Riparian Function Assessment Study Area.

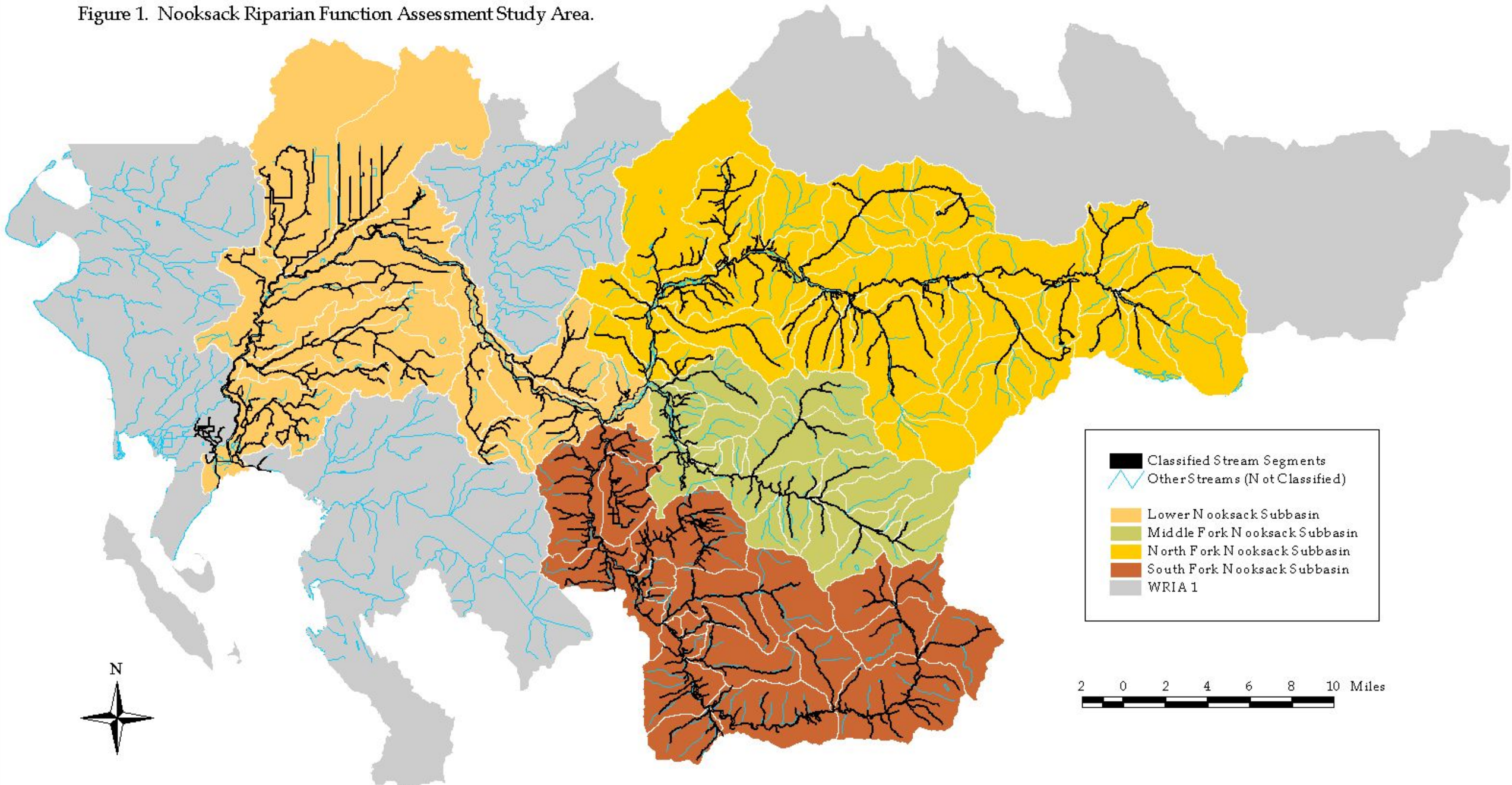


Figure 2. Near-term LWD Recruitment Potential in the Nooksack River watershed.

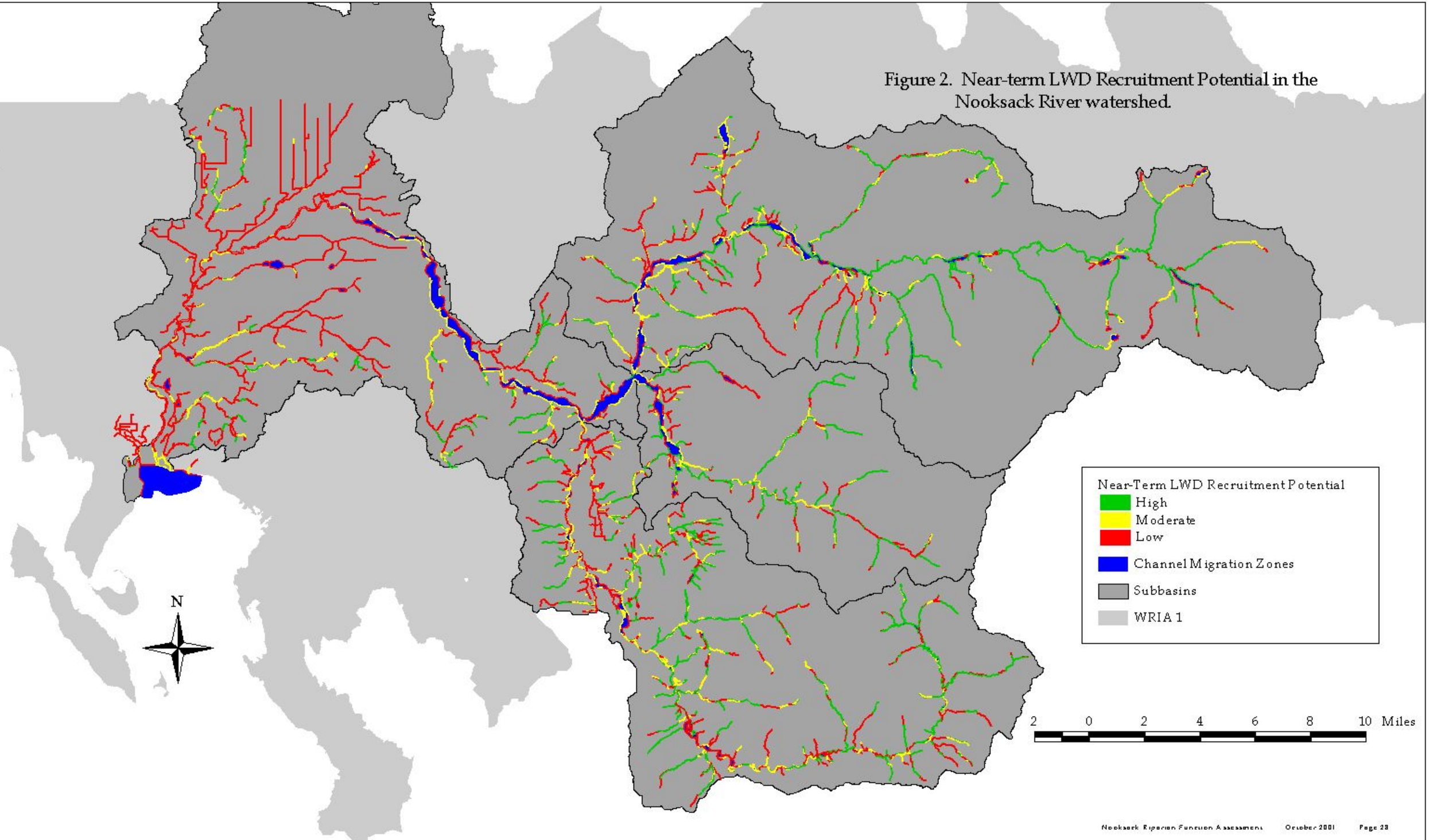


Figure 3. Near-term LWD recruitment potential in the Nooksack River watershed by subbasin.

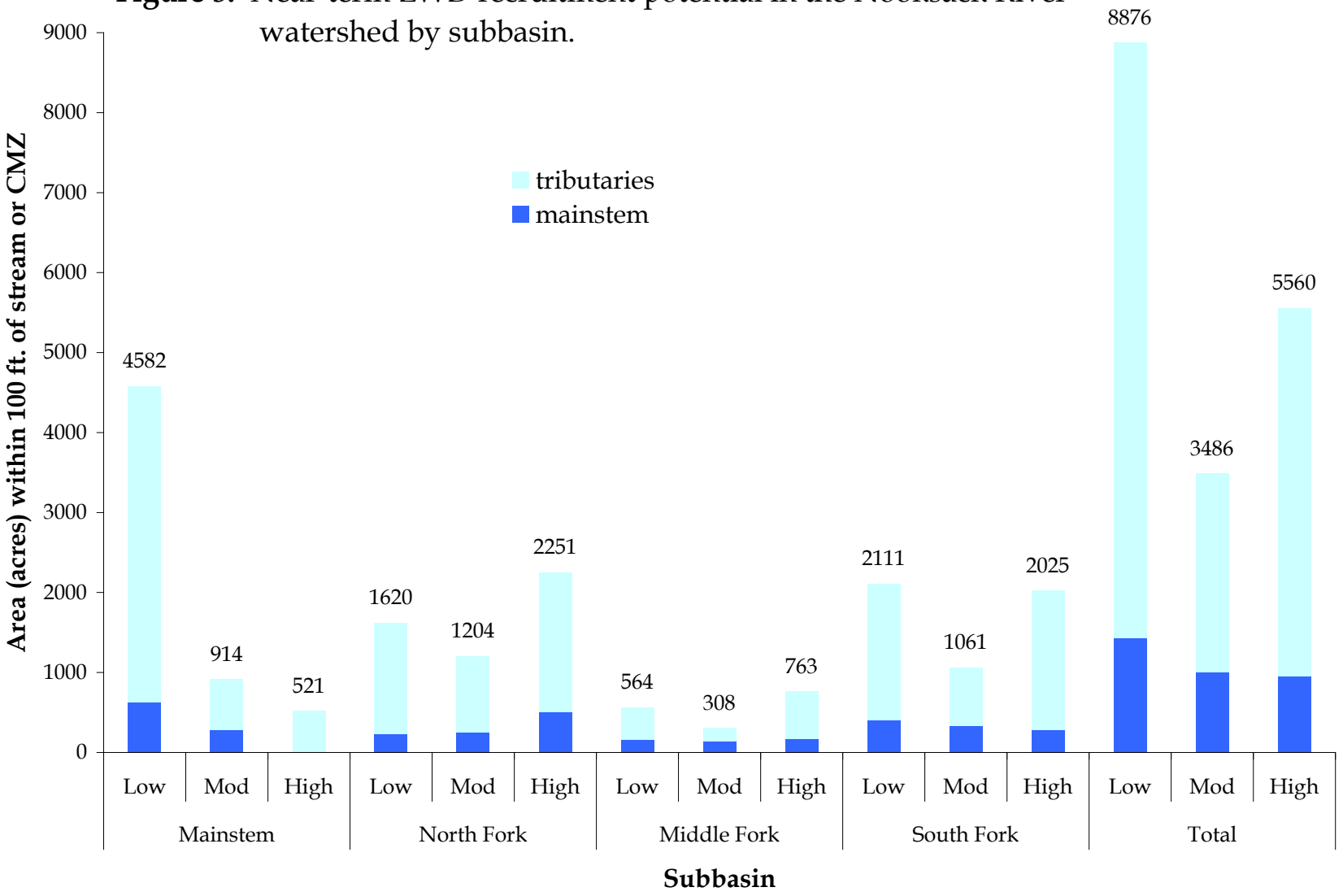


Figure 4. Distribution of near-term LWD recruitment potential in the Nooksack River watershed by zoning class.

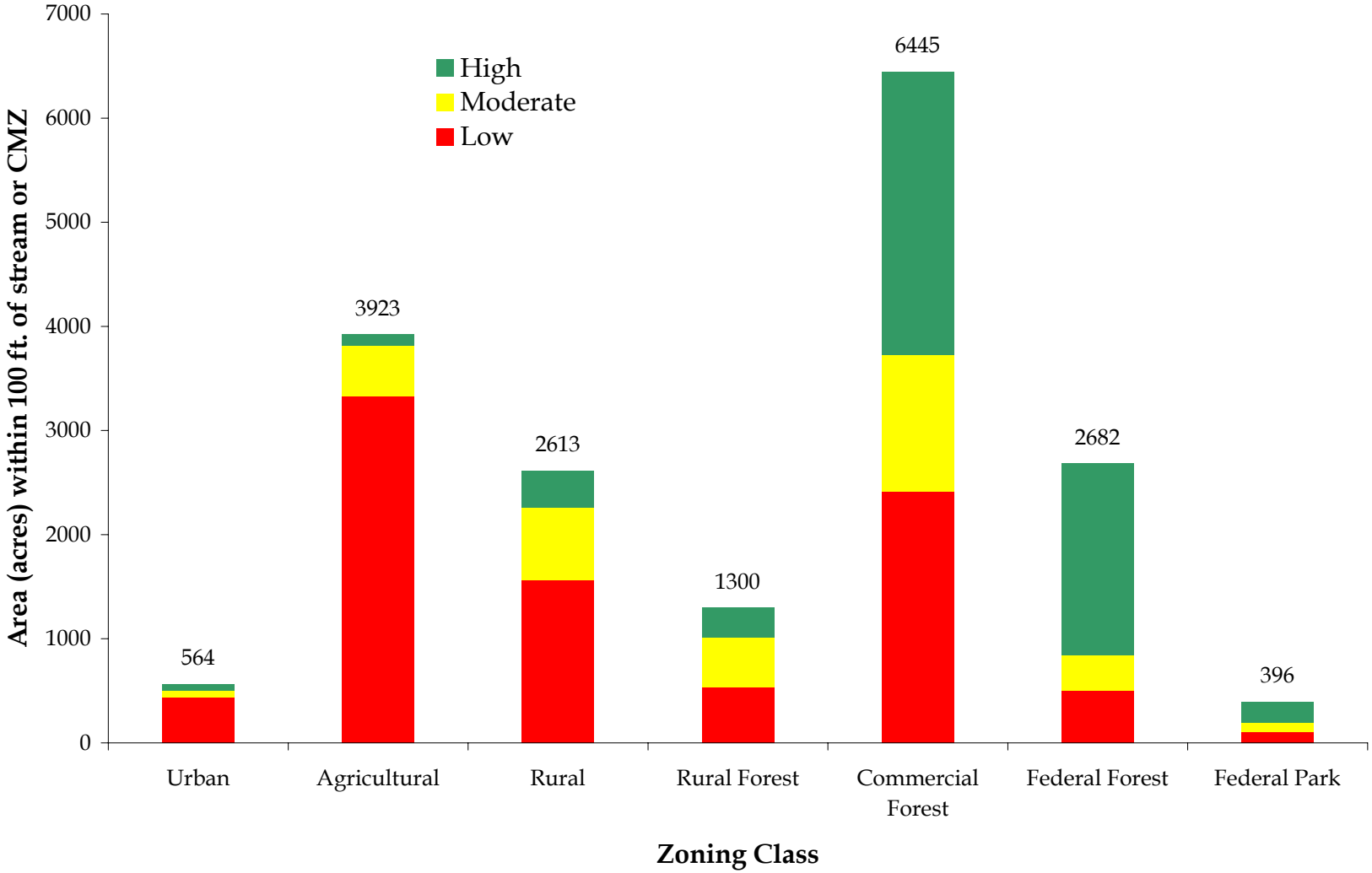


Figure 5. Near-term LWD Recruitment Potential in the Mainstem Nooksack River Subbasin.

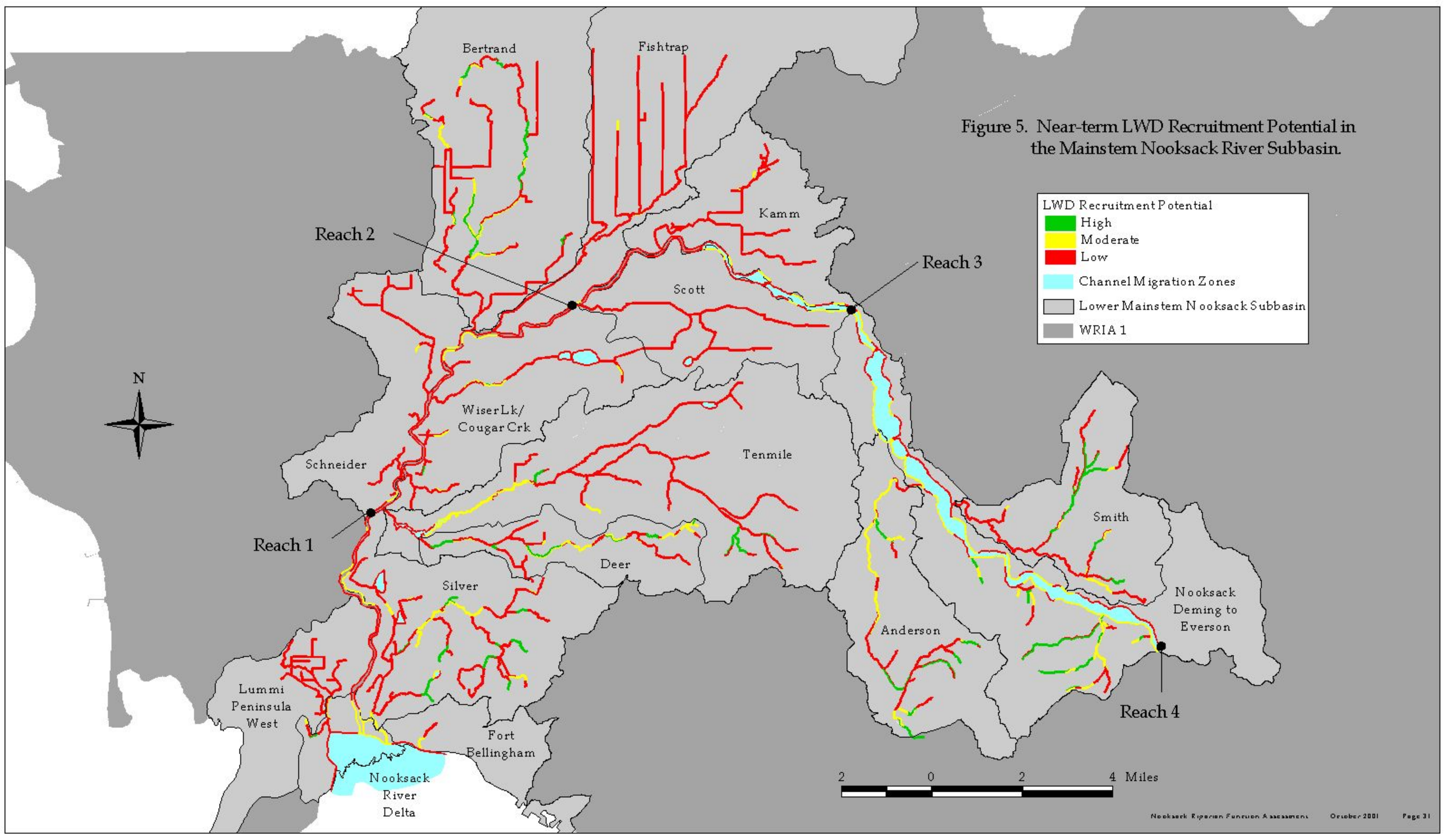


Figure 6. Near-term LWD recruitment potential and zoning class by reach: Mainstem Nooksack.

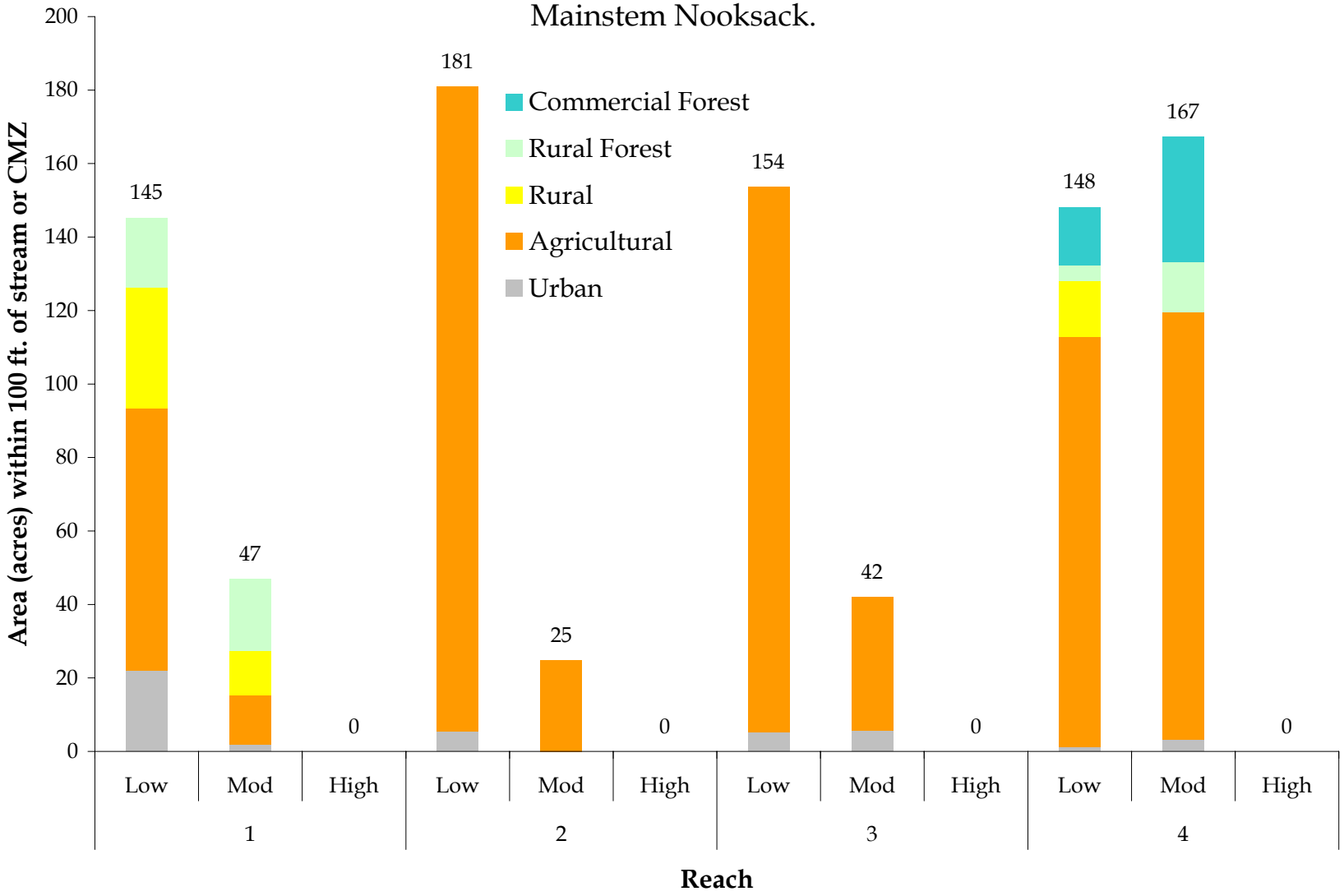


Figure 7a. Near-term LWD recruitment potential and zoning class by watershed: Mainstem Nooksack tributaries (lower subbasin).

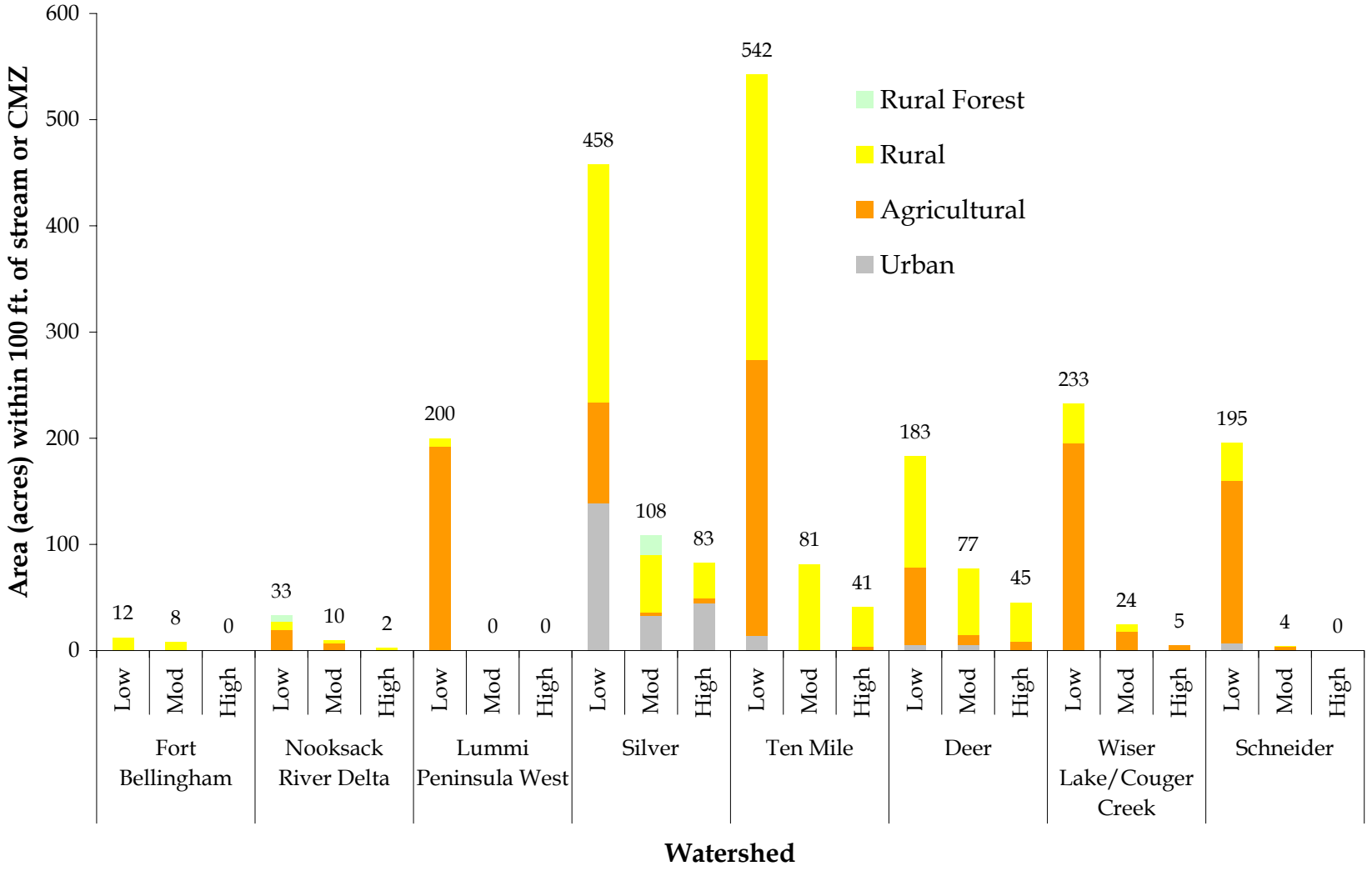


Figure 7b. Near-term LWD recruitment potential and zoning classs by watershed: Mainstem Nooksack tributaries (upper subbasin).

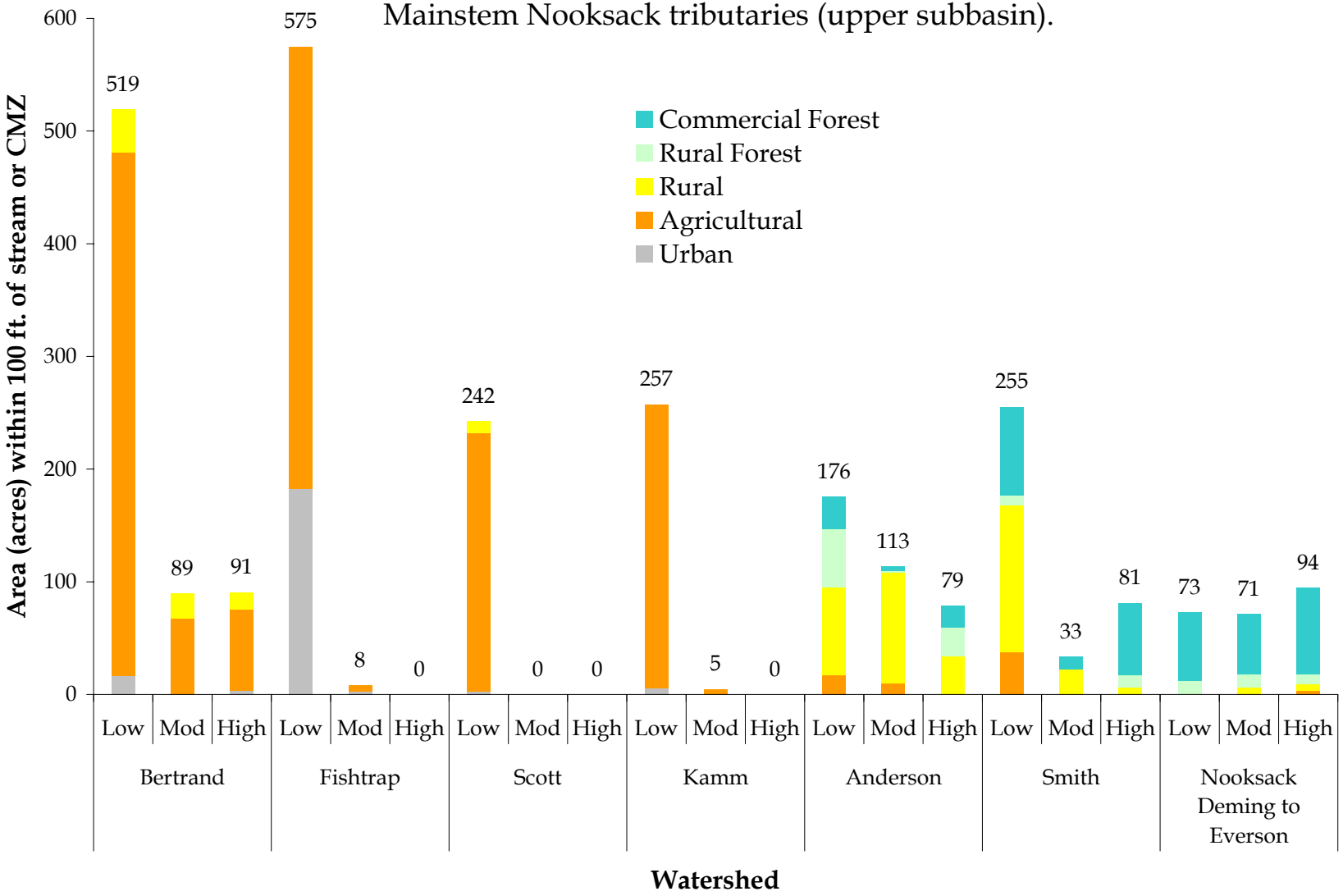


Figure 8. Near-term LWD Recruitment Potential in the North Fork Nooksack River Subbasin.

Reach 1
Reach 2
Reach 3
Reach 4
Reach 5
Reach 6
Maple
Kendall
Boulder
Canyon
Swamp
Upper North Fork Nooksack
Middle North Fork Nooksack
Slide Mountain
Coal
Anderson
Ruth
Bells
Deadhorse
Bagley
Hamilton
Racehorse
Kenny
White Salmon
Wells
Lower North Fork Nooksack
Cornell
Hedrick
Gallup
Glacier
N
LWD Recruitment Potential
High
Moderate
Low
Channel Migration Zones
North Fork Nooksack Subbasin
WRIA 1
1 0 1 2 3 4 5 Miles

Figure 9. Near-term LWD recruitment potential and zoning class by reach: North Fork Nooksack.

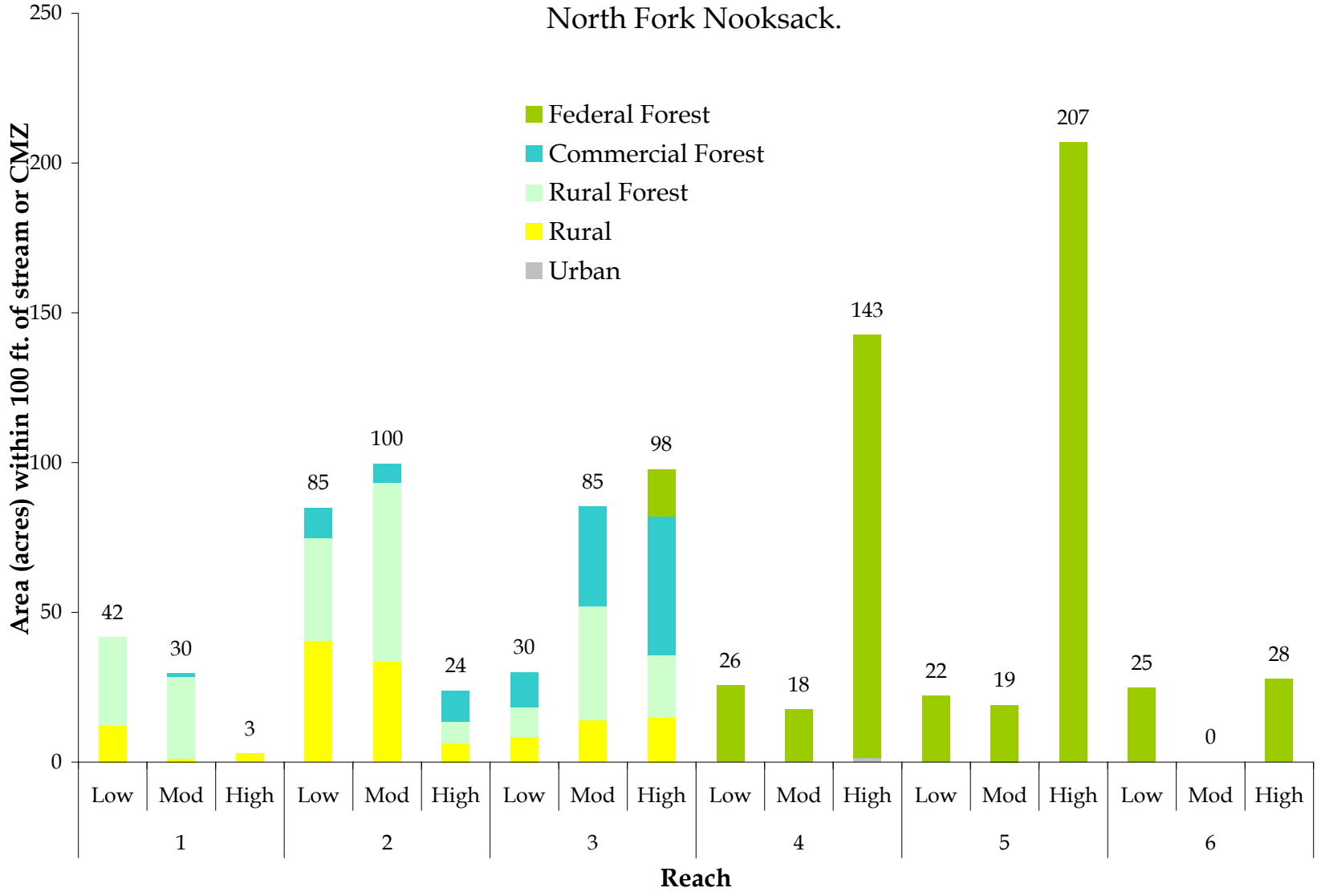


Figure 10a. Near-term LWD recruitment potential and zoning class by watershed: North Fork Nooksack tributaries (lower subbasin).

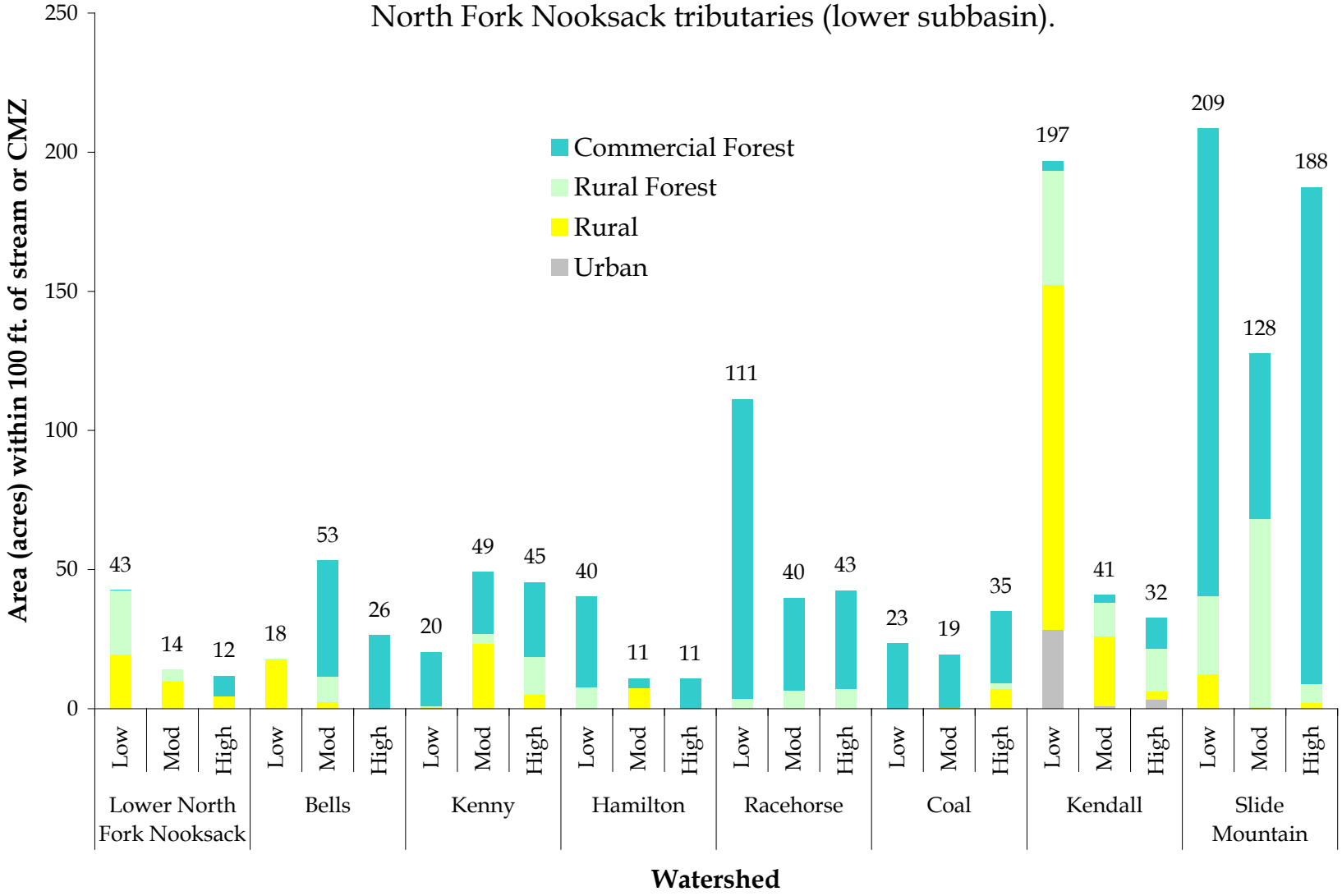


Figure 10b. Near-term LWD recruitment potential and zoning class by watershed: North Fork Nooksack tributaries (mid subbasin).

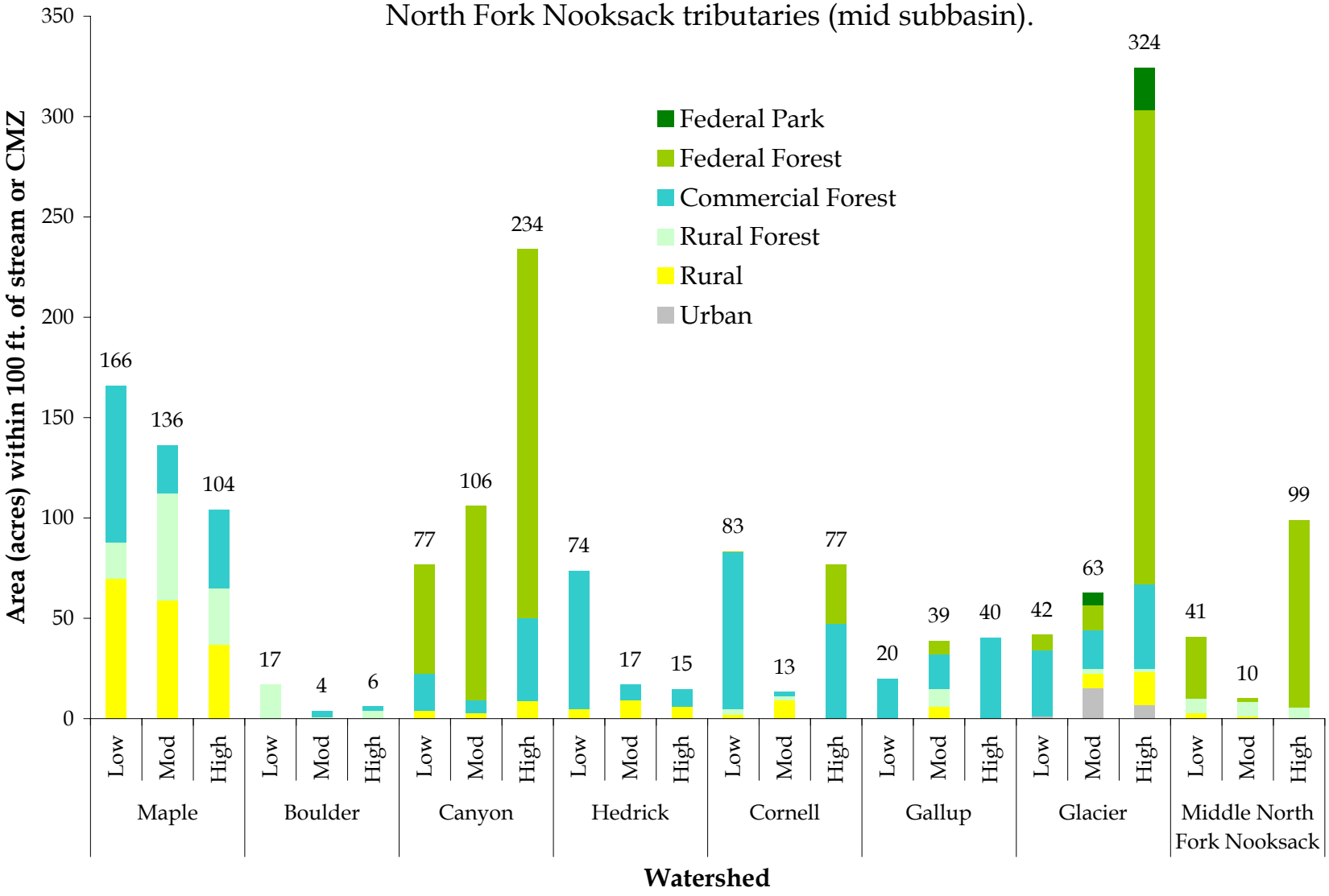


Figure 10c. Near-term LWD recruitment potential and zoning class by watershed: North Fork Nooksack tributaries (upper subbasin).

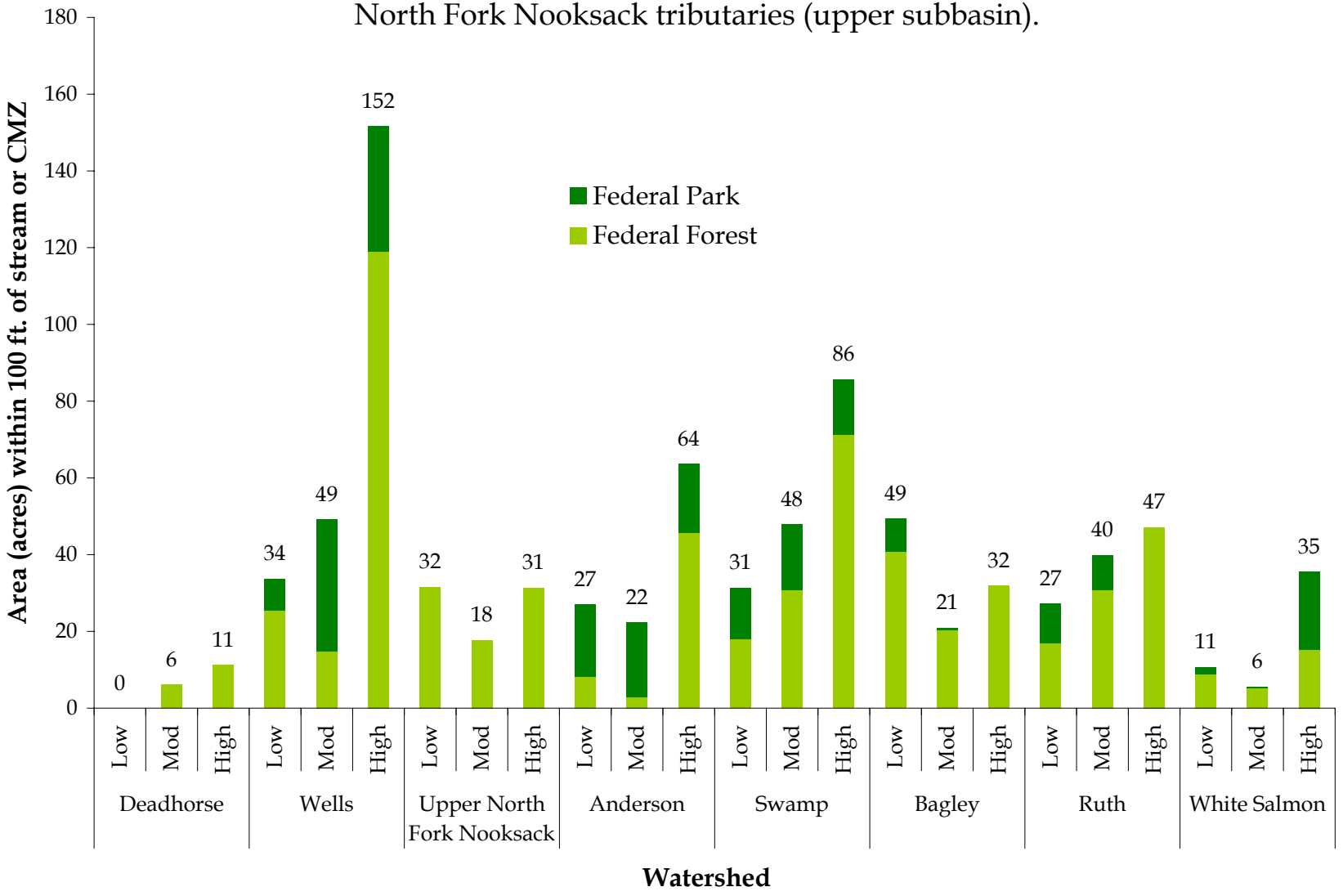


Figure 11. Near-term LWD Recruitment Potential in the Middle Fork Nooksack River Subbasin.

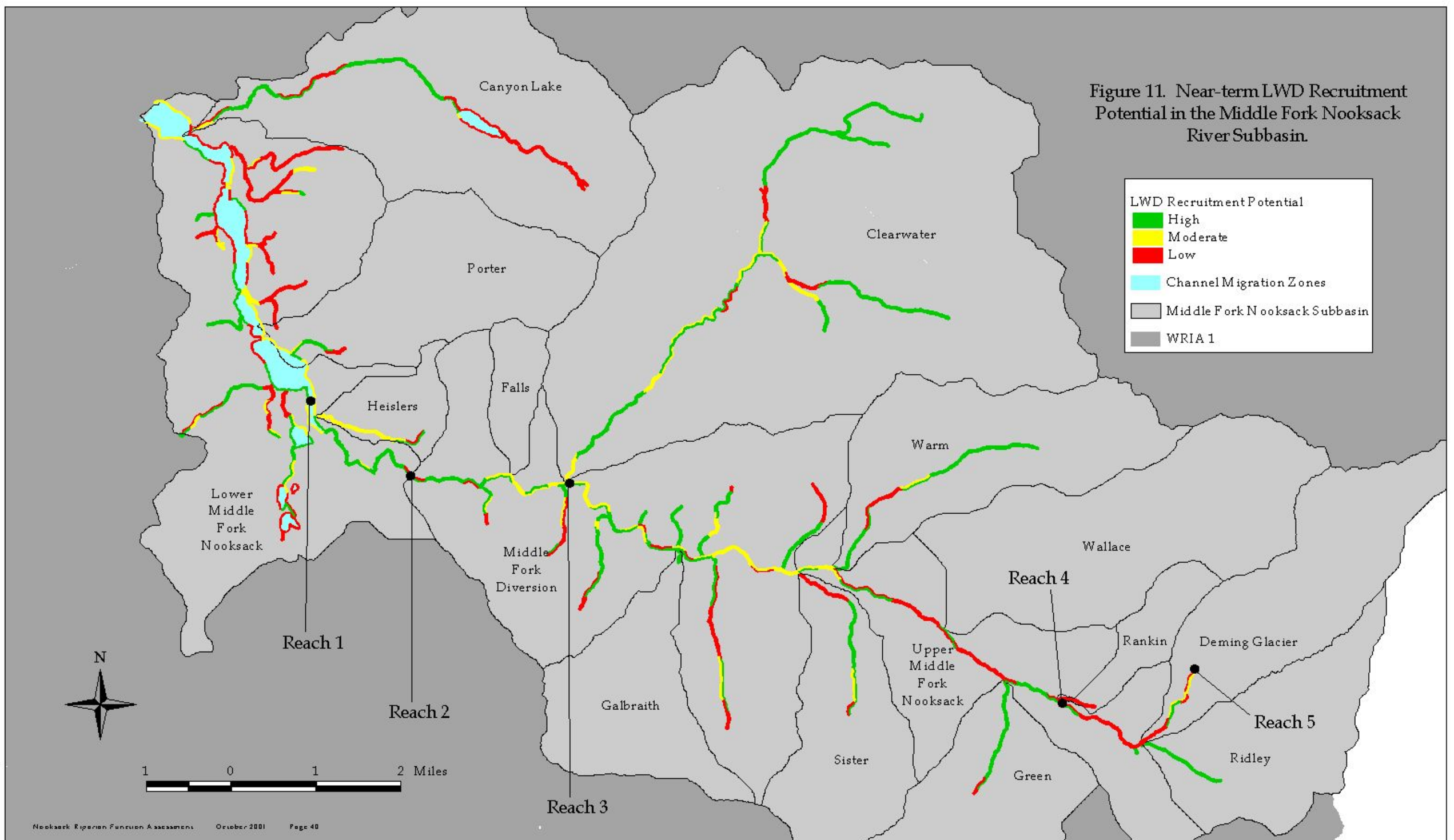


Figure 12. Near-term LWD recruitment potential and zoning class by reach: Middle Fork Nooksack.

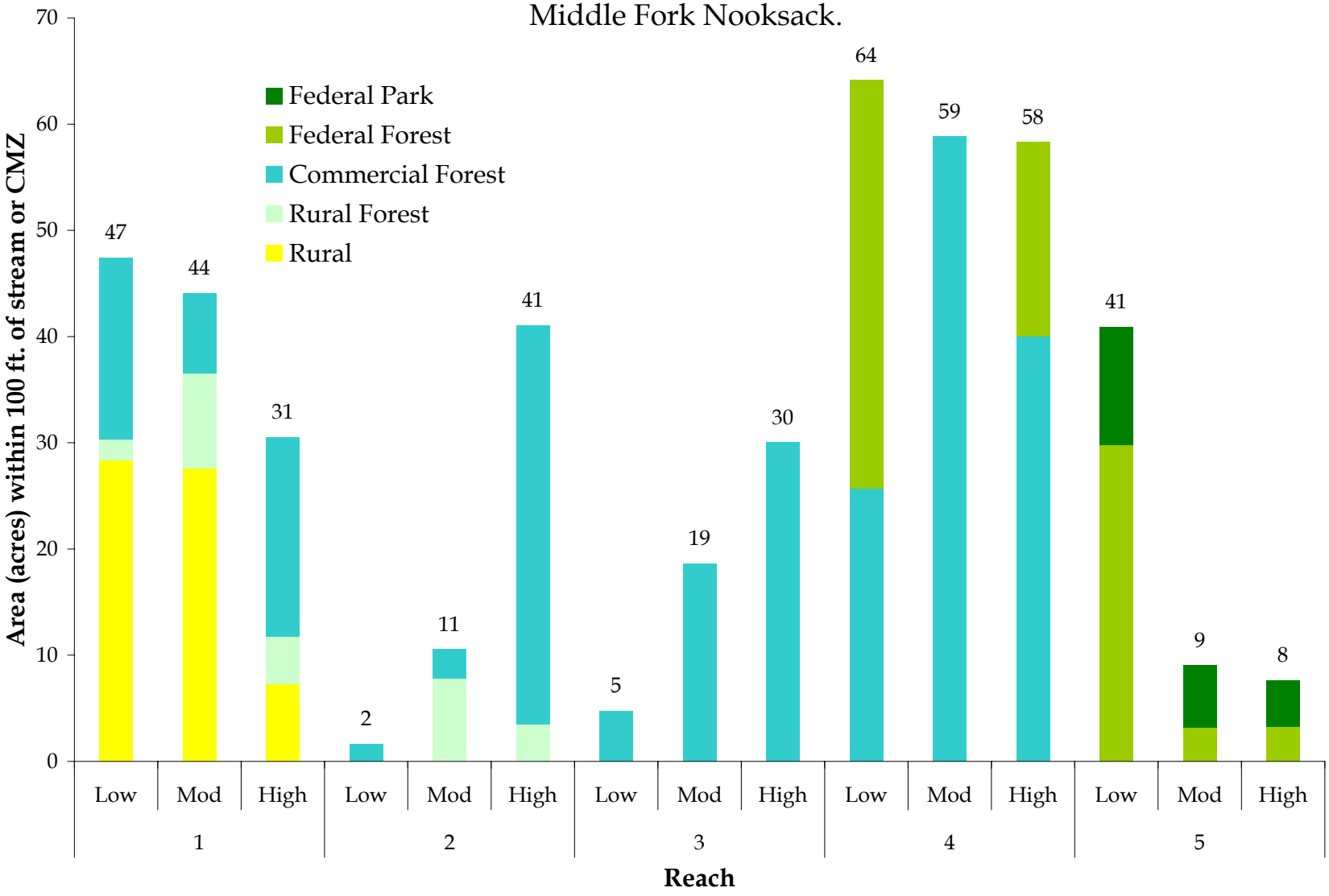


Figure 13a. Near-term LWD recruitment potential and zoning class by watershed: Middle Fork Nooksack tributaries (lower subbasin).

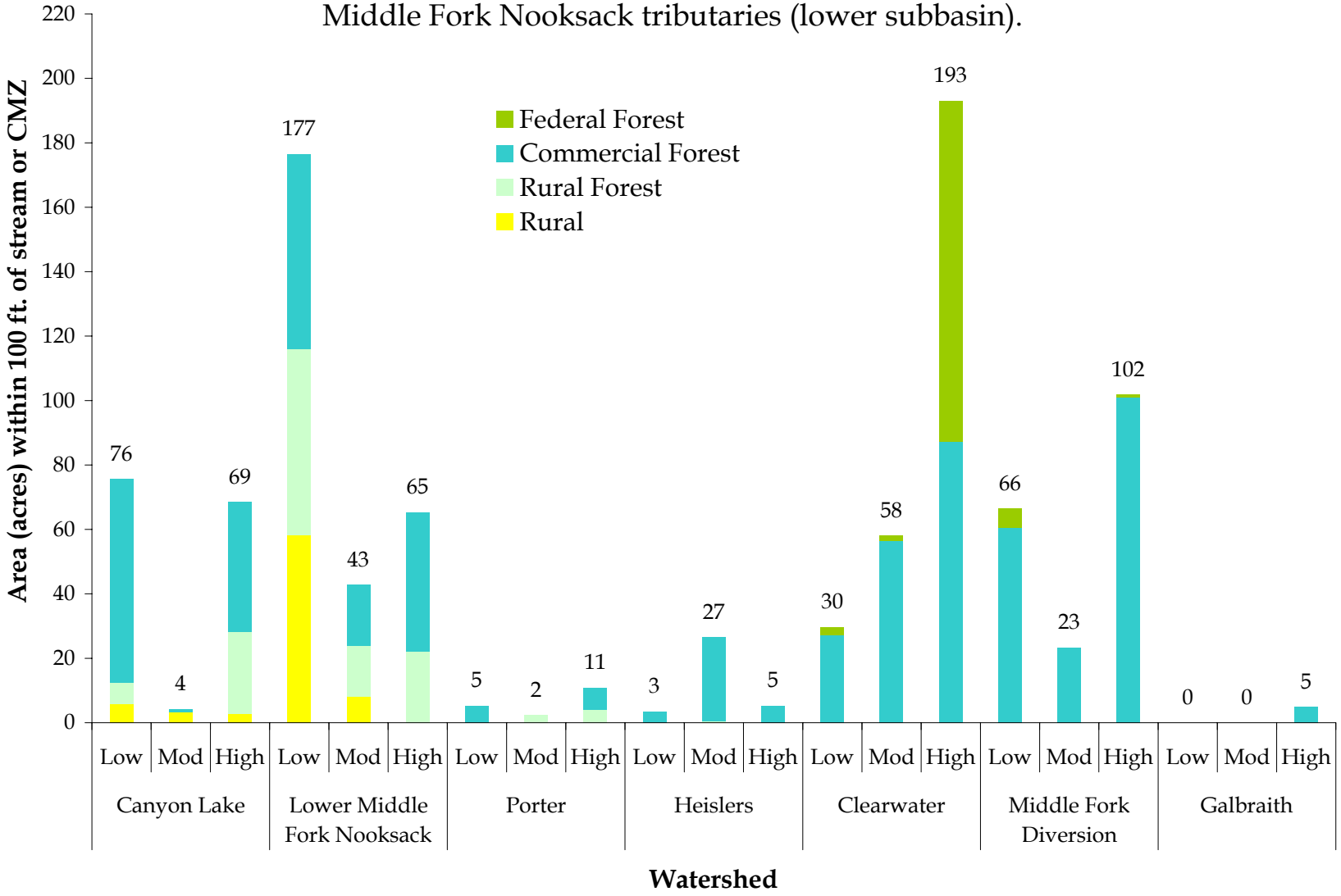


Figure 13b. Near-term LWD recruitment potential and zoning class by watershed: Middle Fork Nooksack tributaries (upper subbasin).

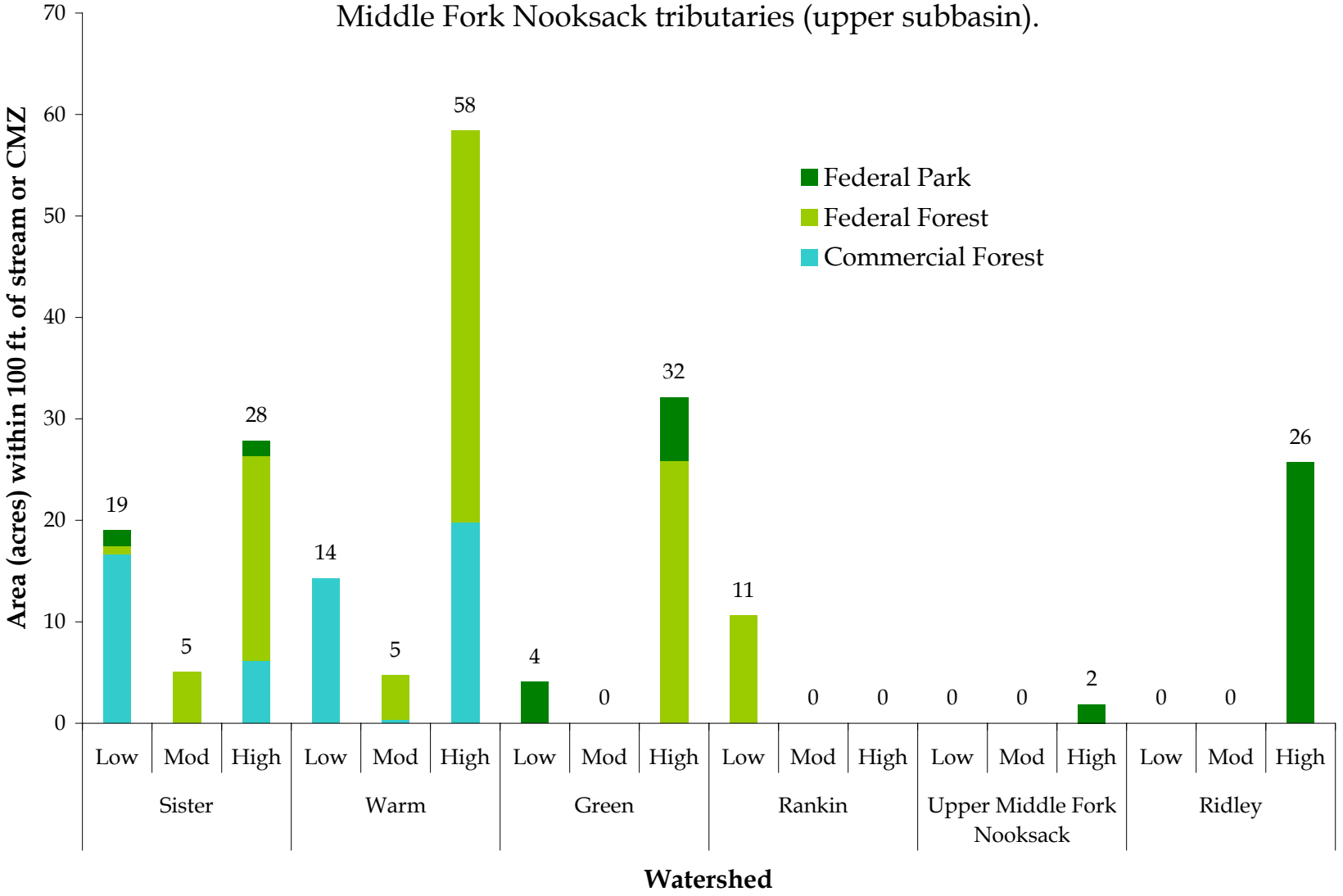


Figure 14. Near-term LWD Recruitment Potential in the South Fork Nooksack River Subbasin.

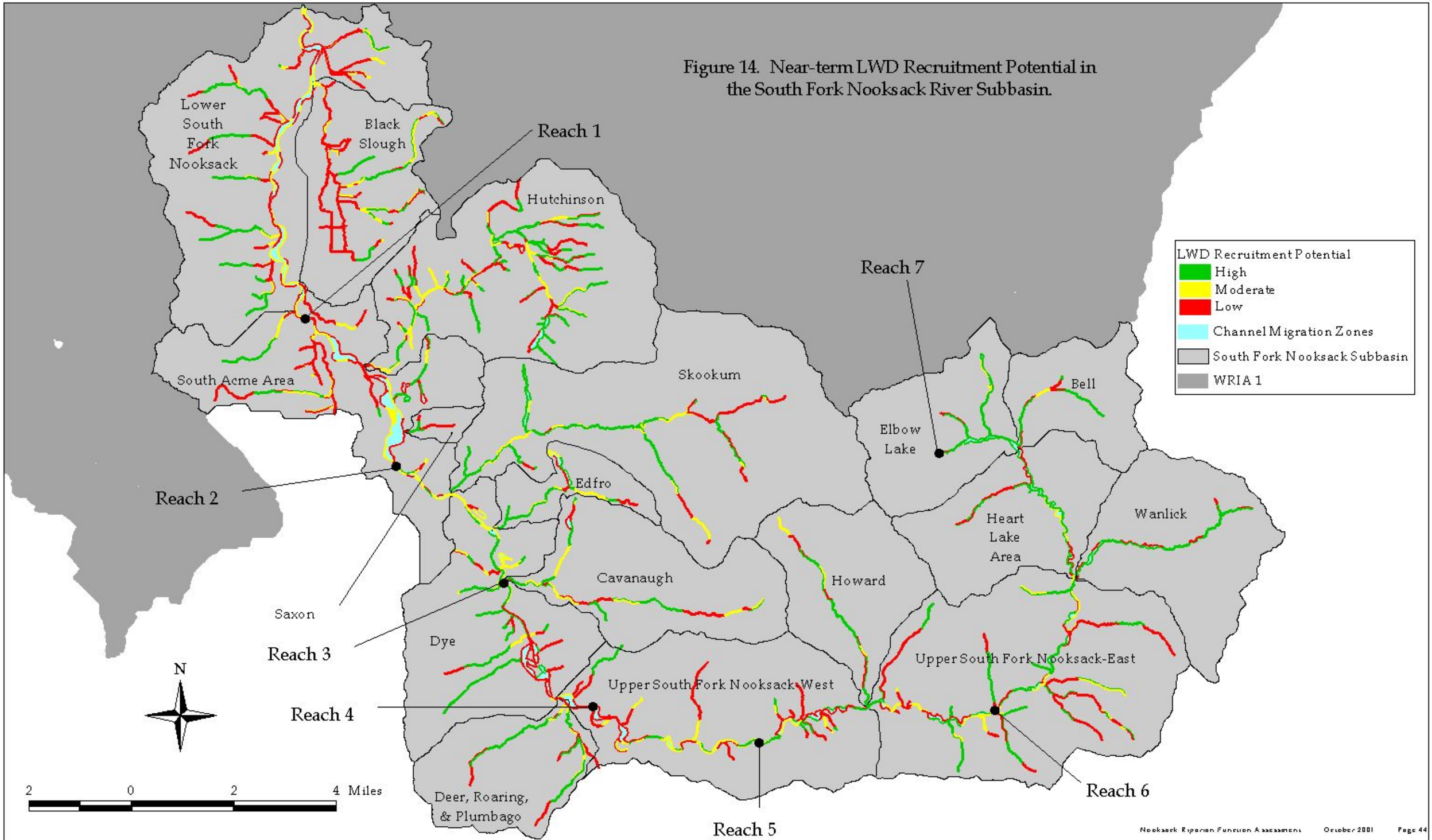


Figure 15. Near-term LWD recruitment potential and zoning class by reach: South Fork Nooksack.

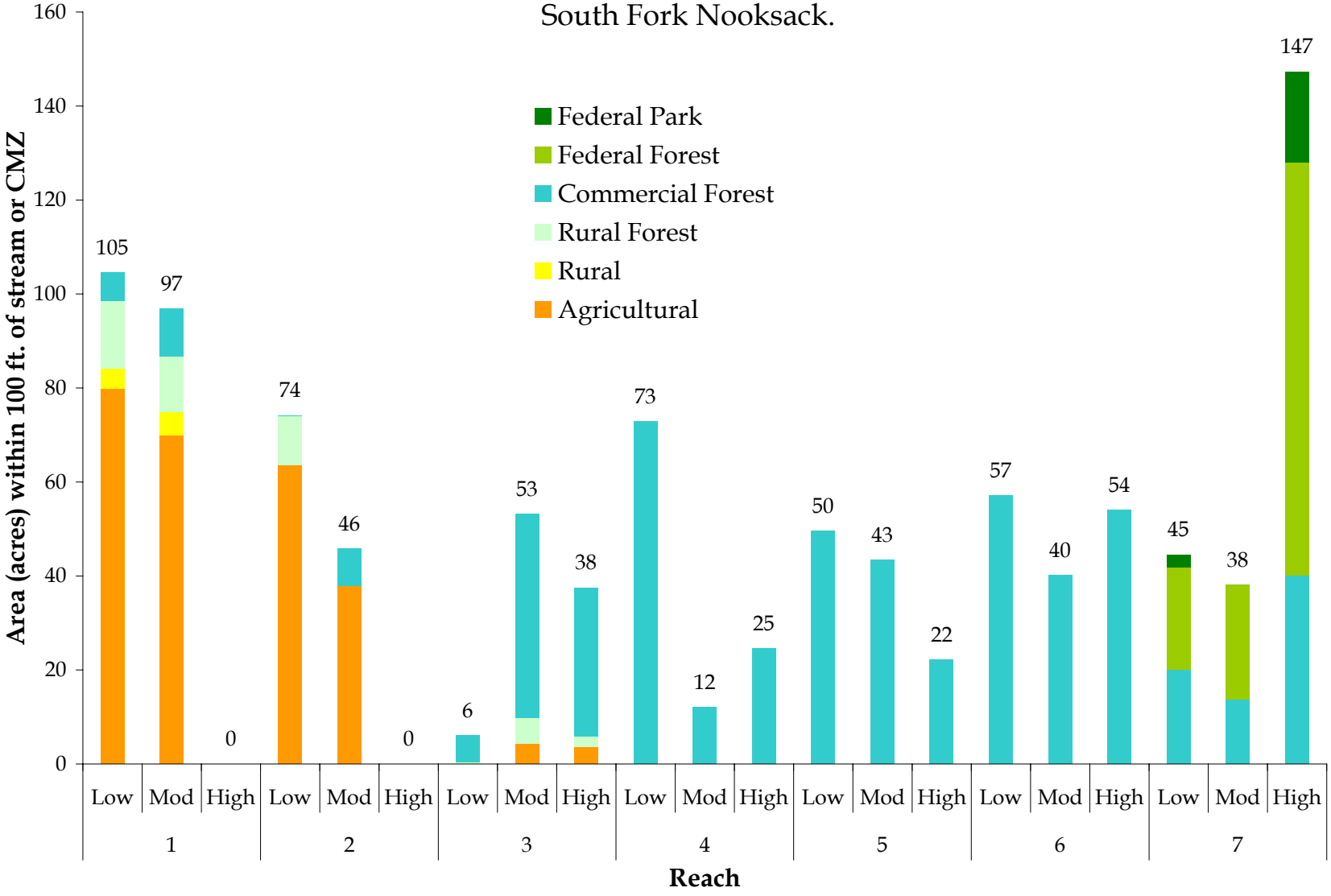


Figure 16a. Near-term LWD recruitment potential and zoning class by watershed: South Fork Nooksack tributaries (lower subbasin).

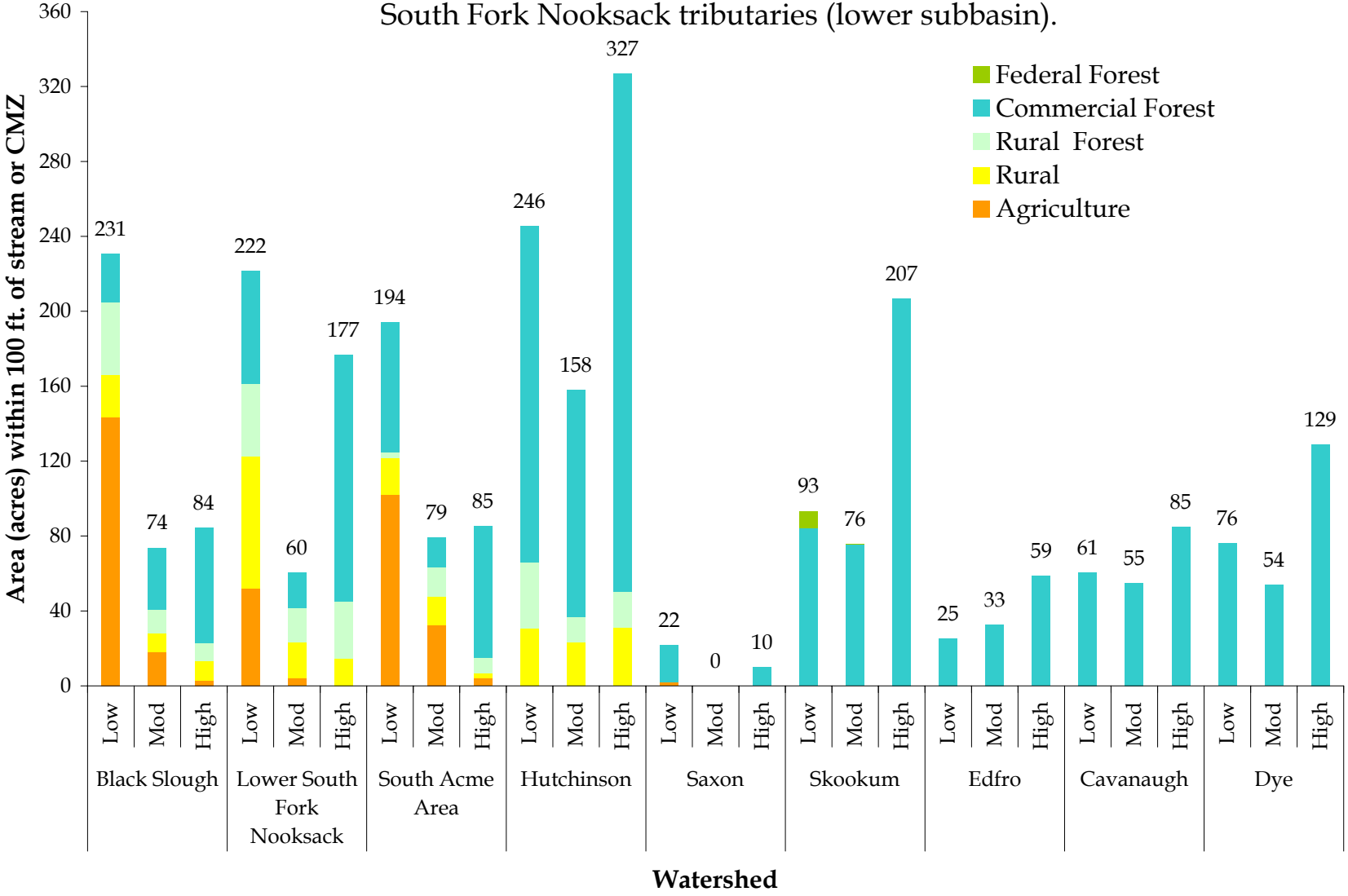


Figure 16b. Near-term LWD recruitment potential and zoning class by watershed: South Fork Nooksack tributaries (upper subbasin).

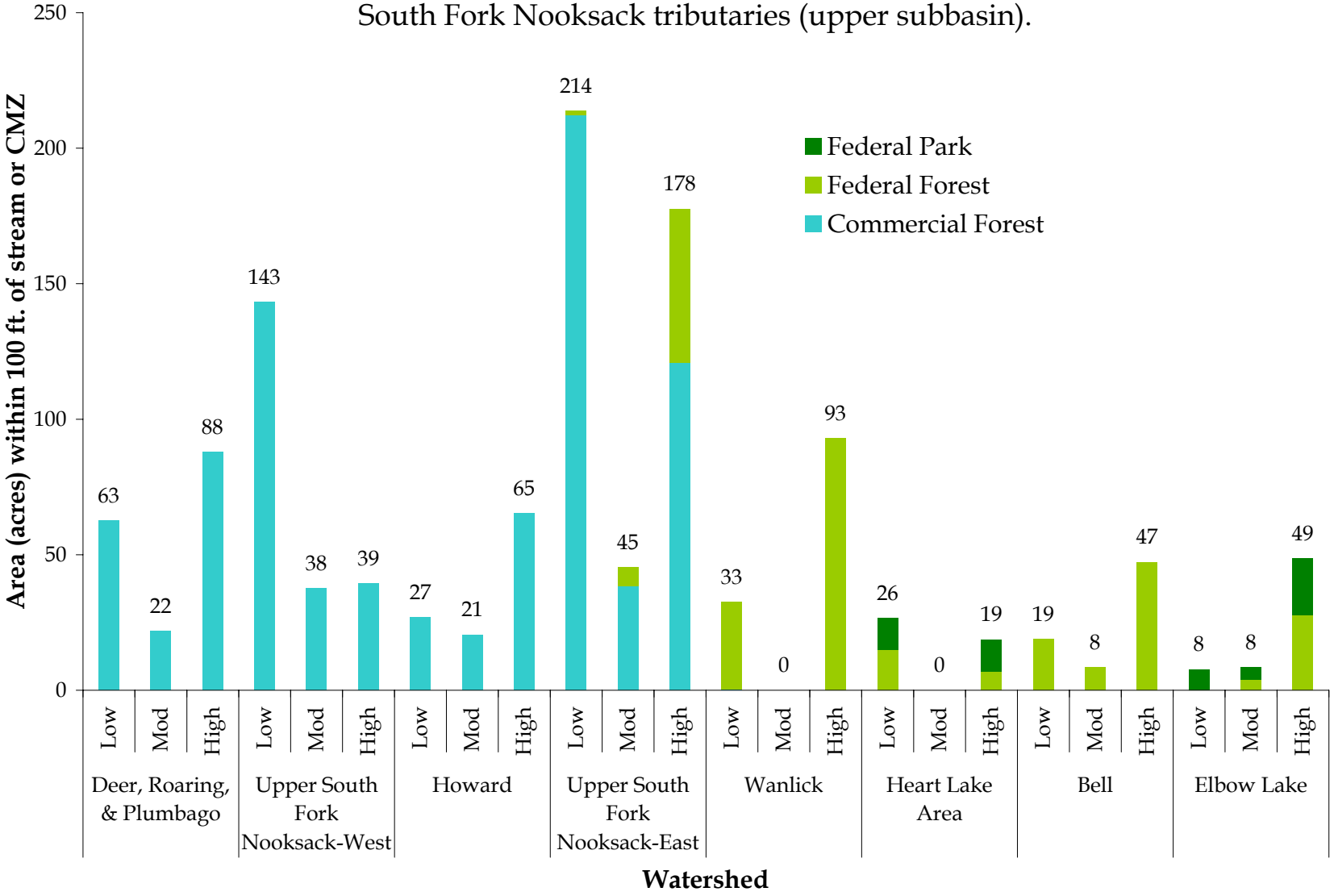


Figure 17. Stream Shading in the Nooksack River watershed.

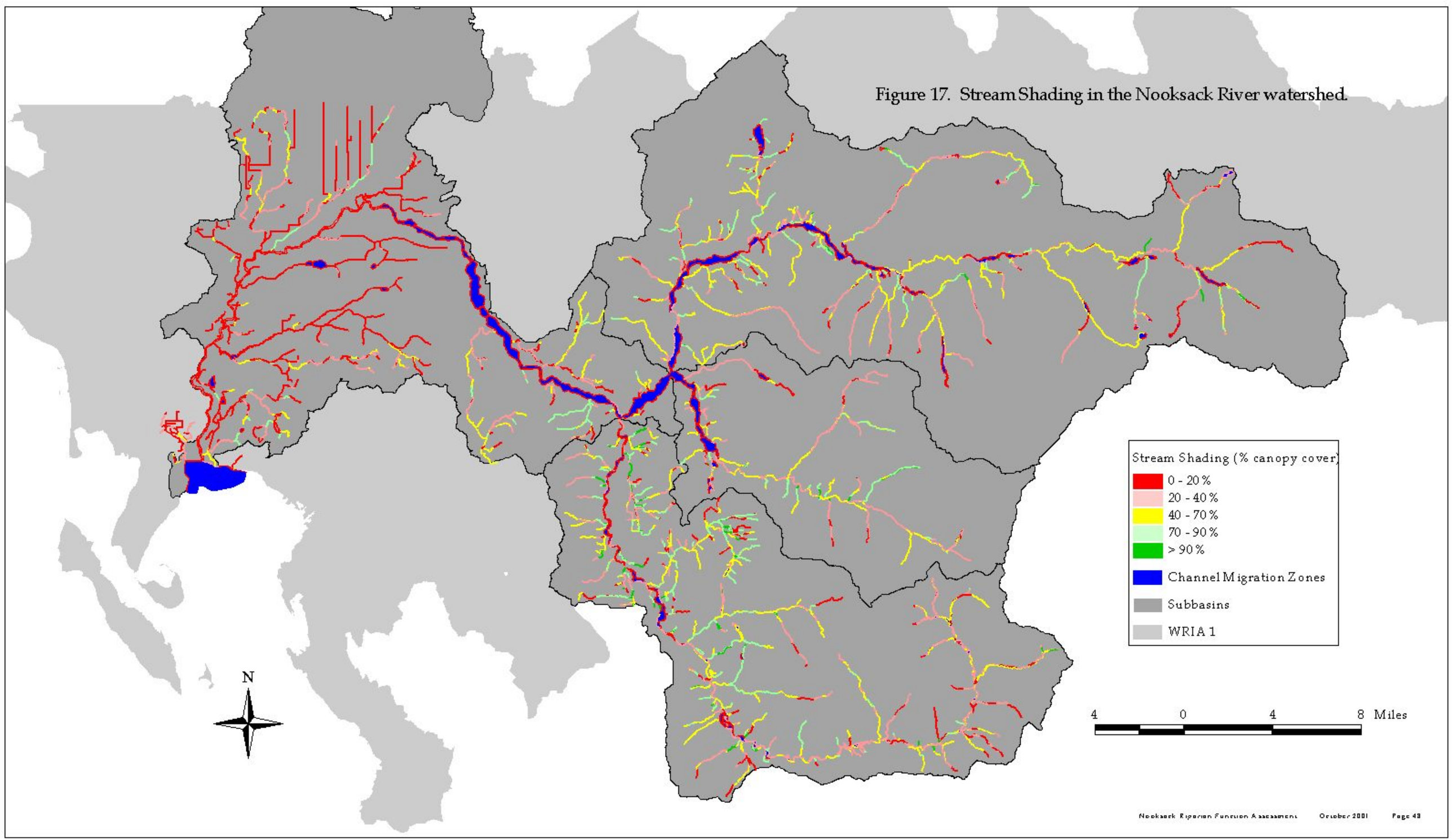


Figure 18. Stream shading hazard in the Nooksack River watershed by subbasin (Nooksack River mainstem below South Fork confluence excluded).

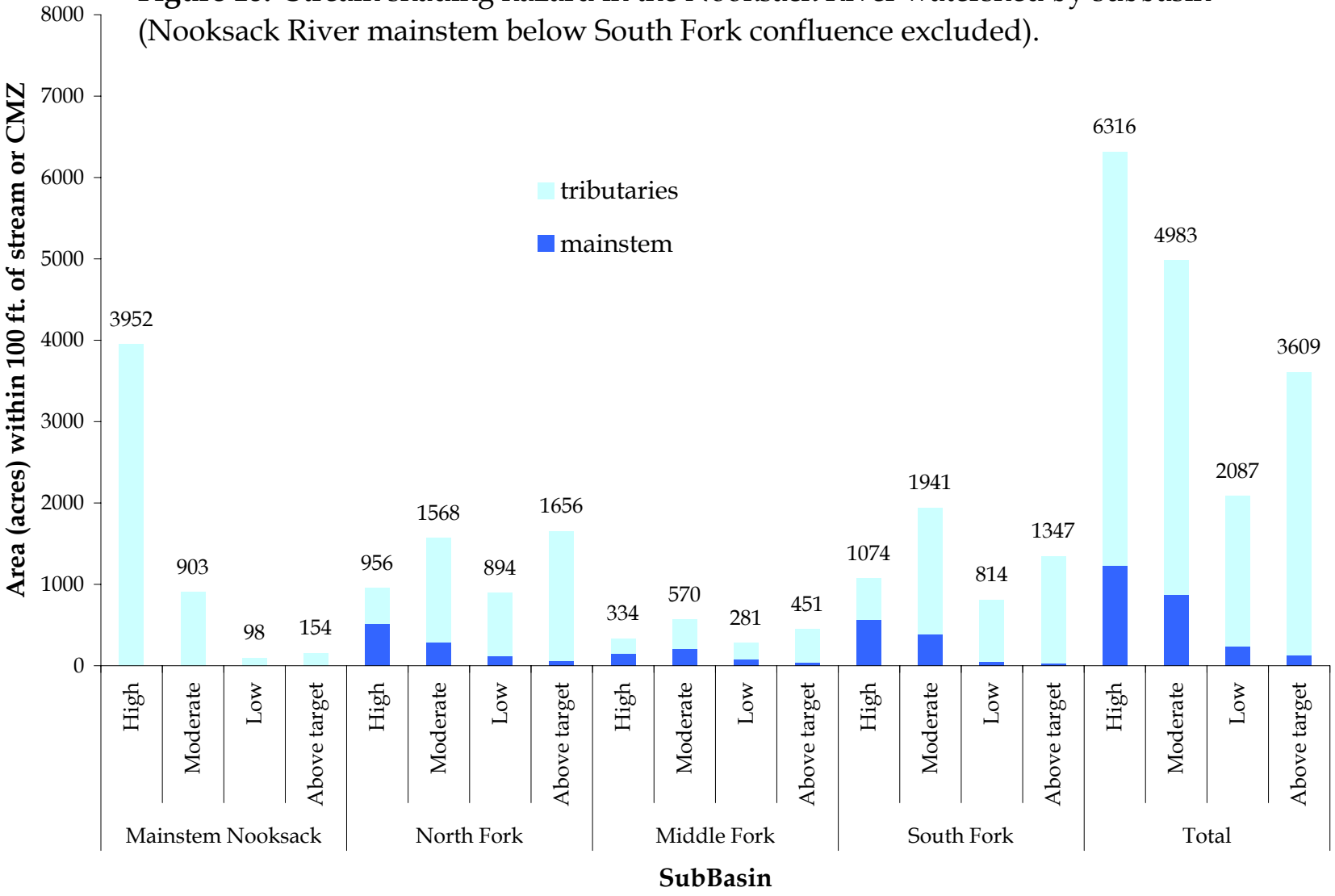


Figure 19. Distribution of stream shading hazard in the Nooksack River watershed by zoning class (Nooksack River mainstem below South Fork confluence excluded).

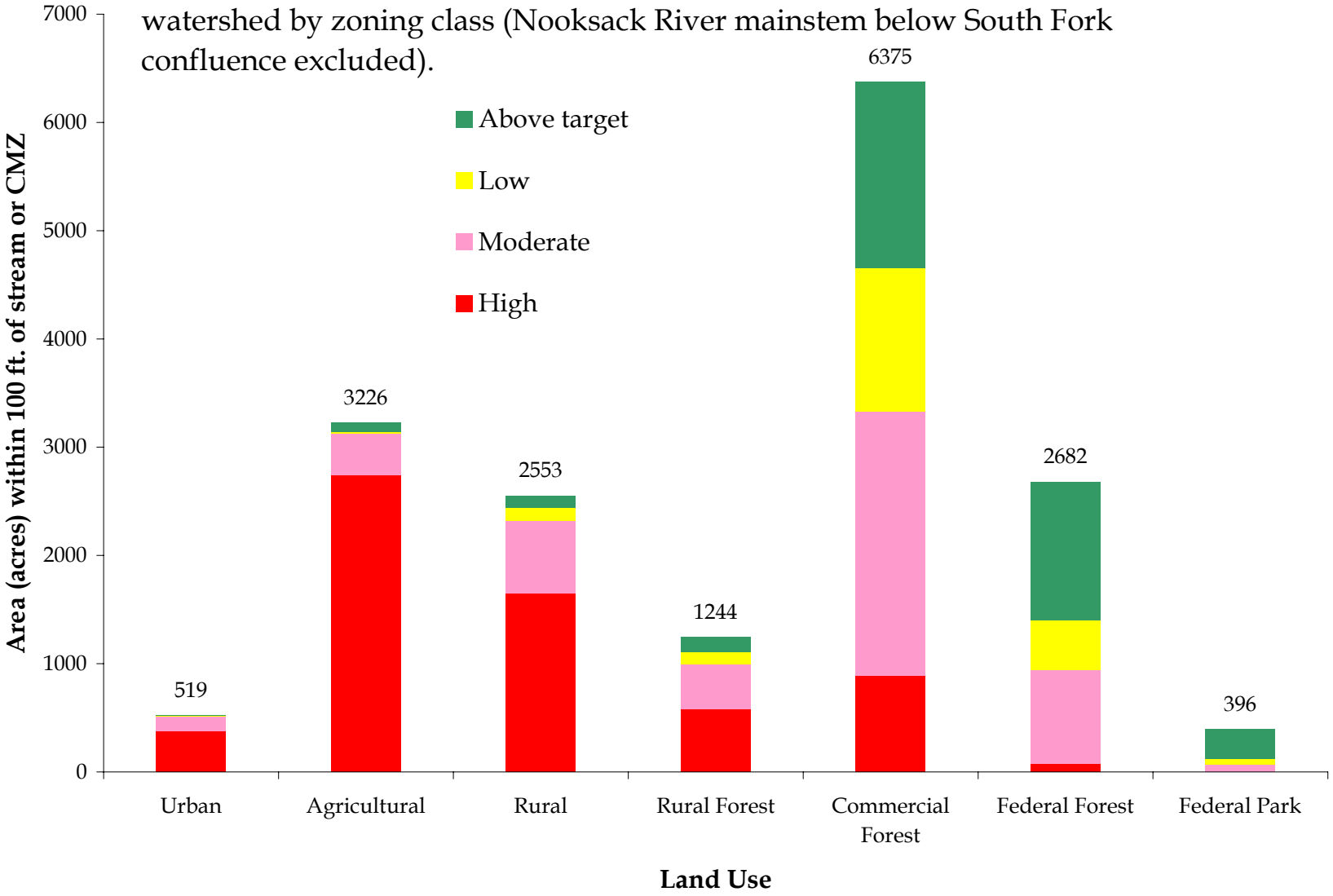


Figure 20. Stream Shading in the Mainstem Nooksack River Subbasin.

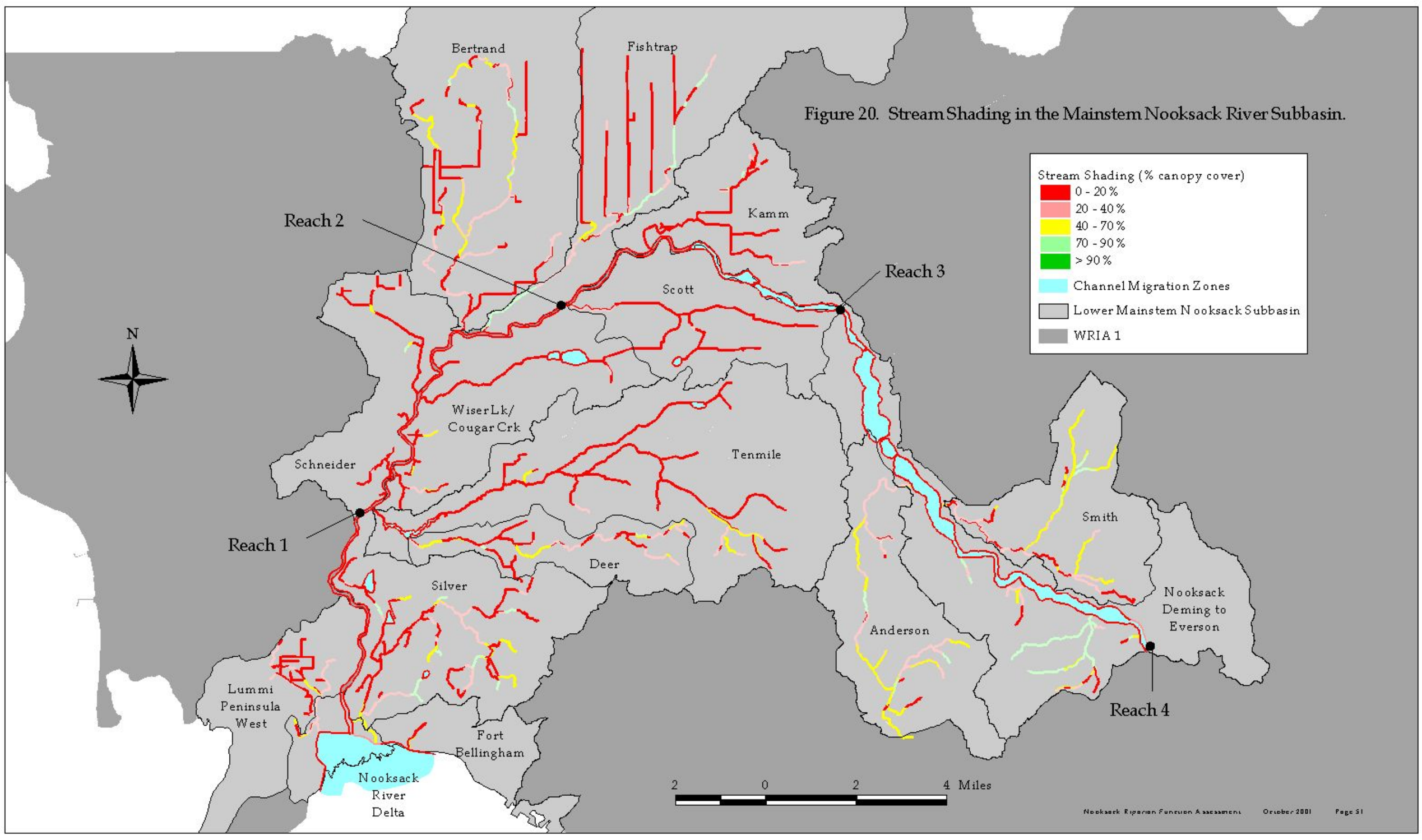


Figure 21a. Stream shading hazard by zoning class and watershed: Mainstem Nooksack tributaries (lower subbasin).

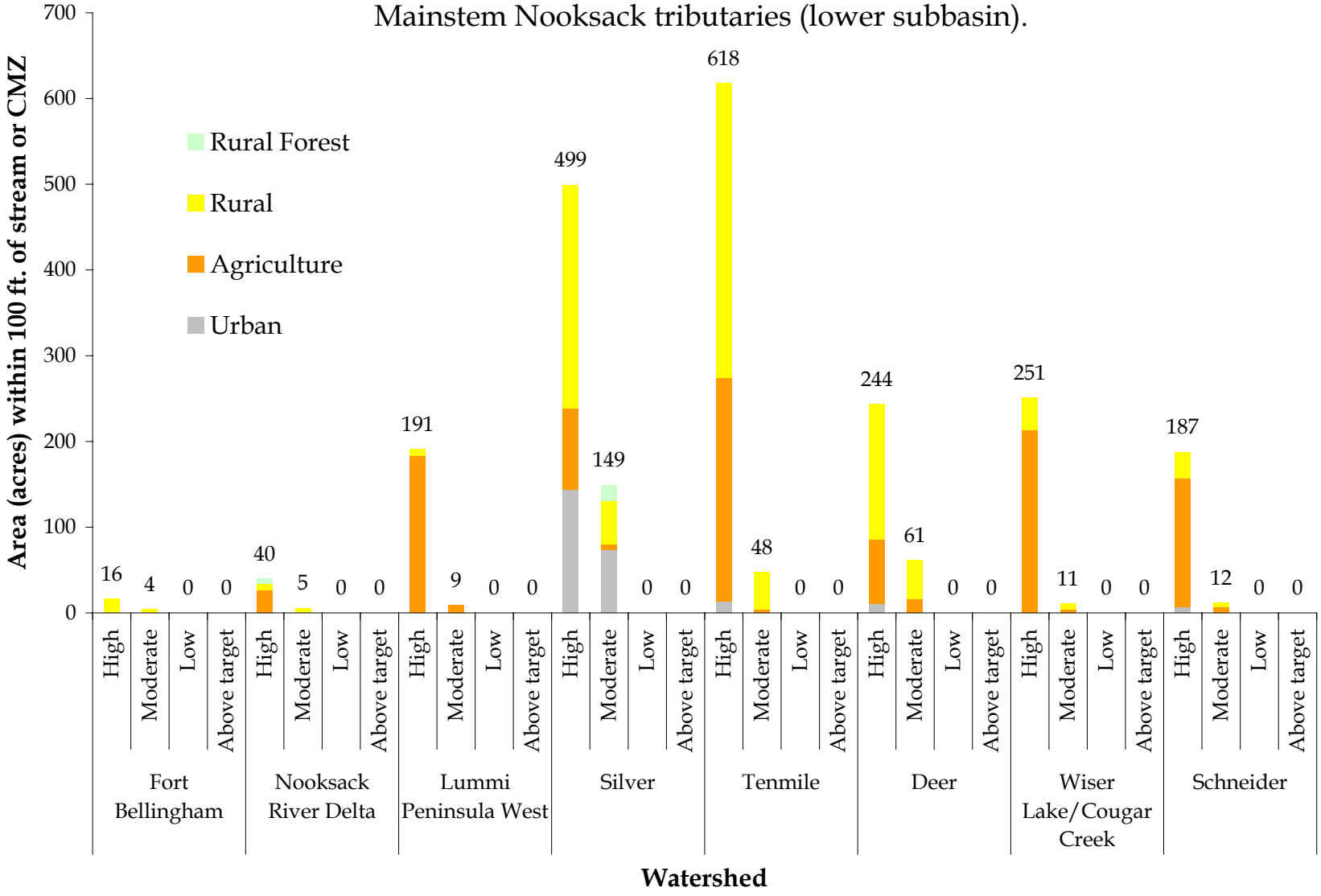


Figure 21b. Stream shading hazard by zoning class and watershed: Mainstem Nooksack tributaries (upper subbasin).

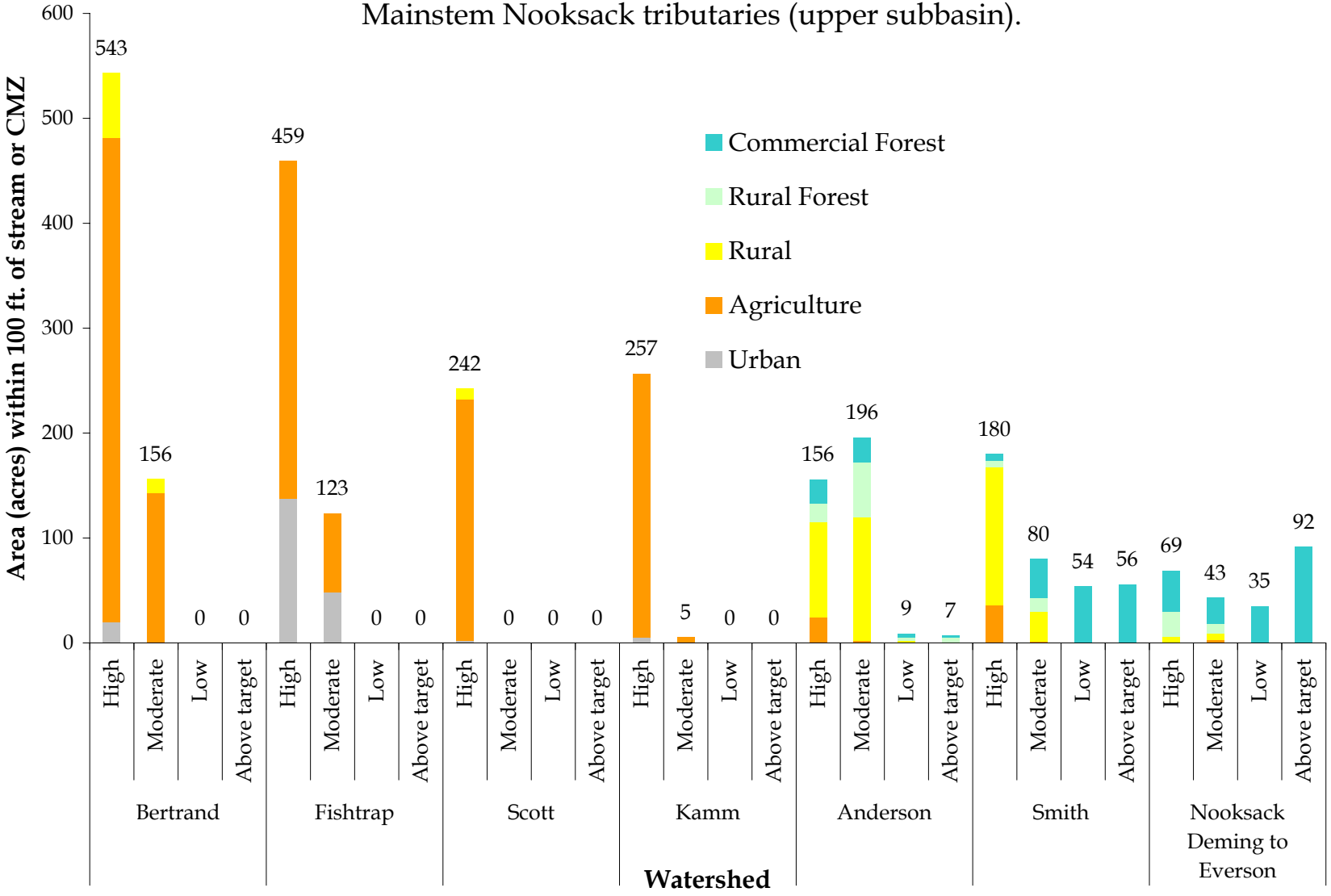


Figure 22. Stream Shading in the North Fork Nooksack River Subbasin.

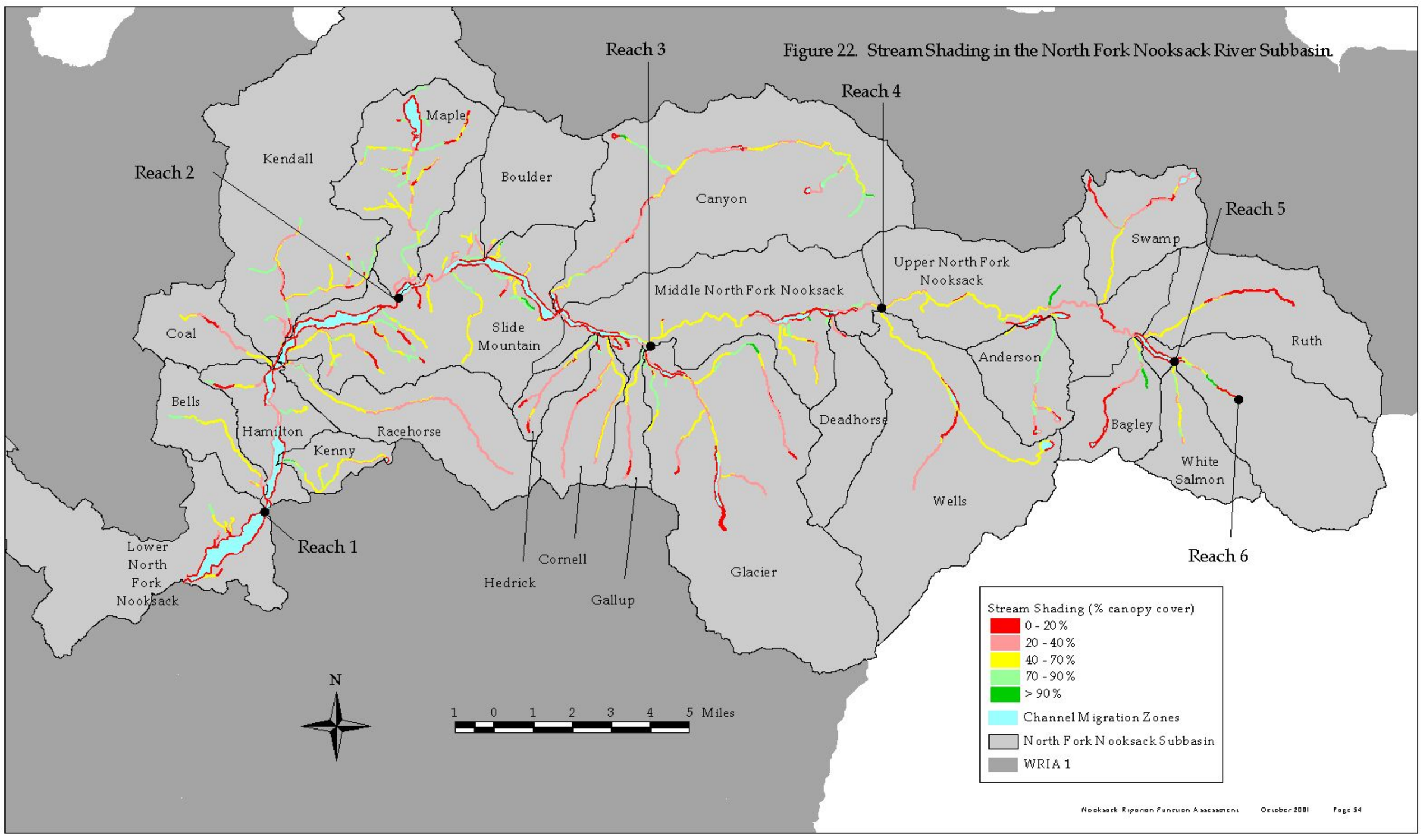


Figure 23. Stream shading hazard and zoning class by reach: North Fork Nooksack.

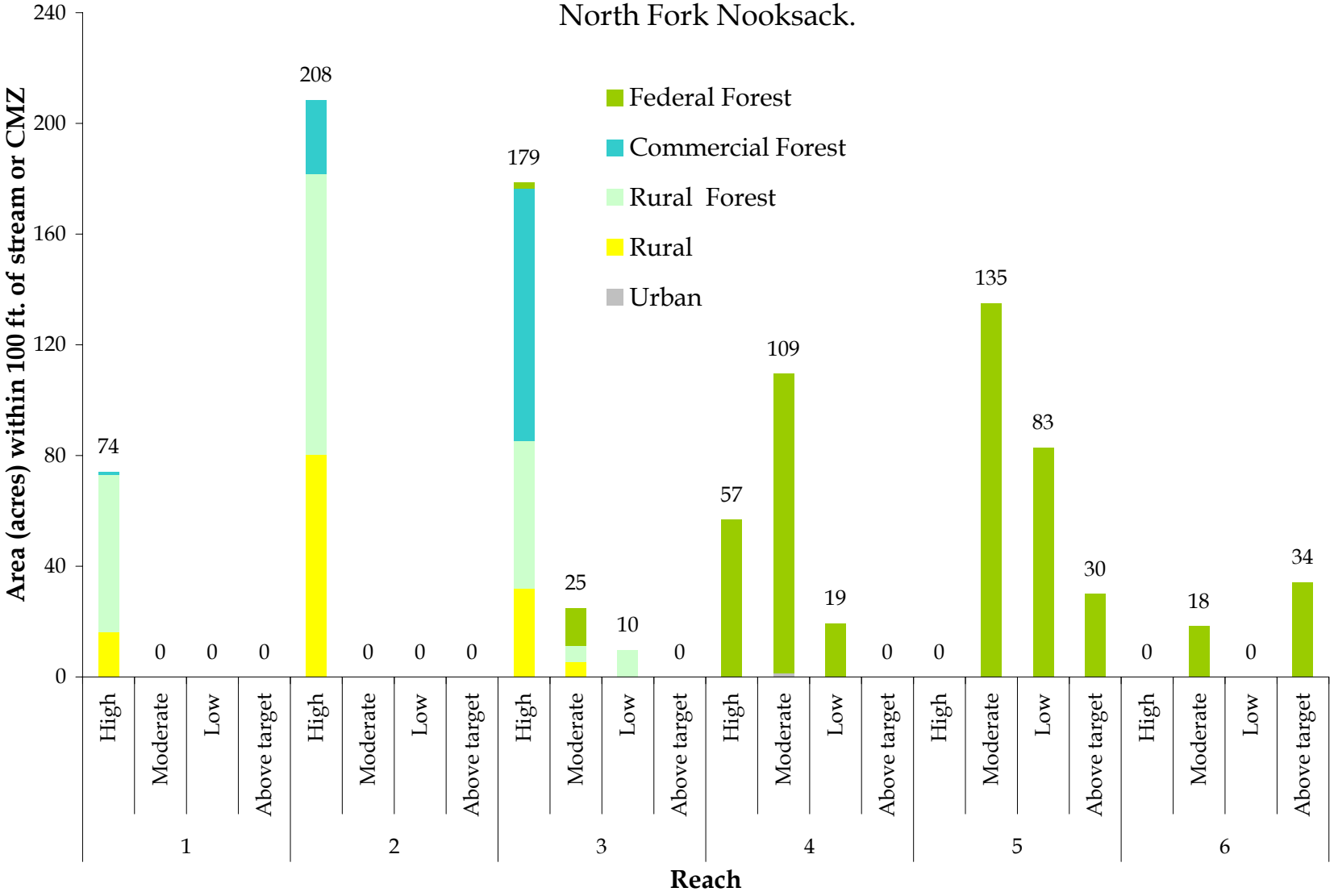


Figure 24a. Stream shading hazard by zoning class and watershed: North Fork Nooksack tributaries (lower subbasin).

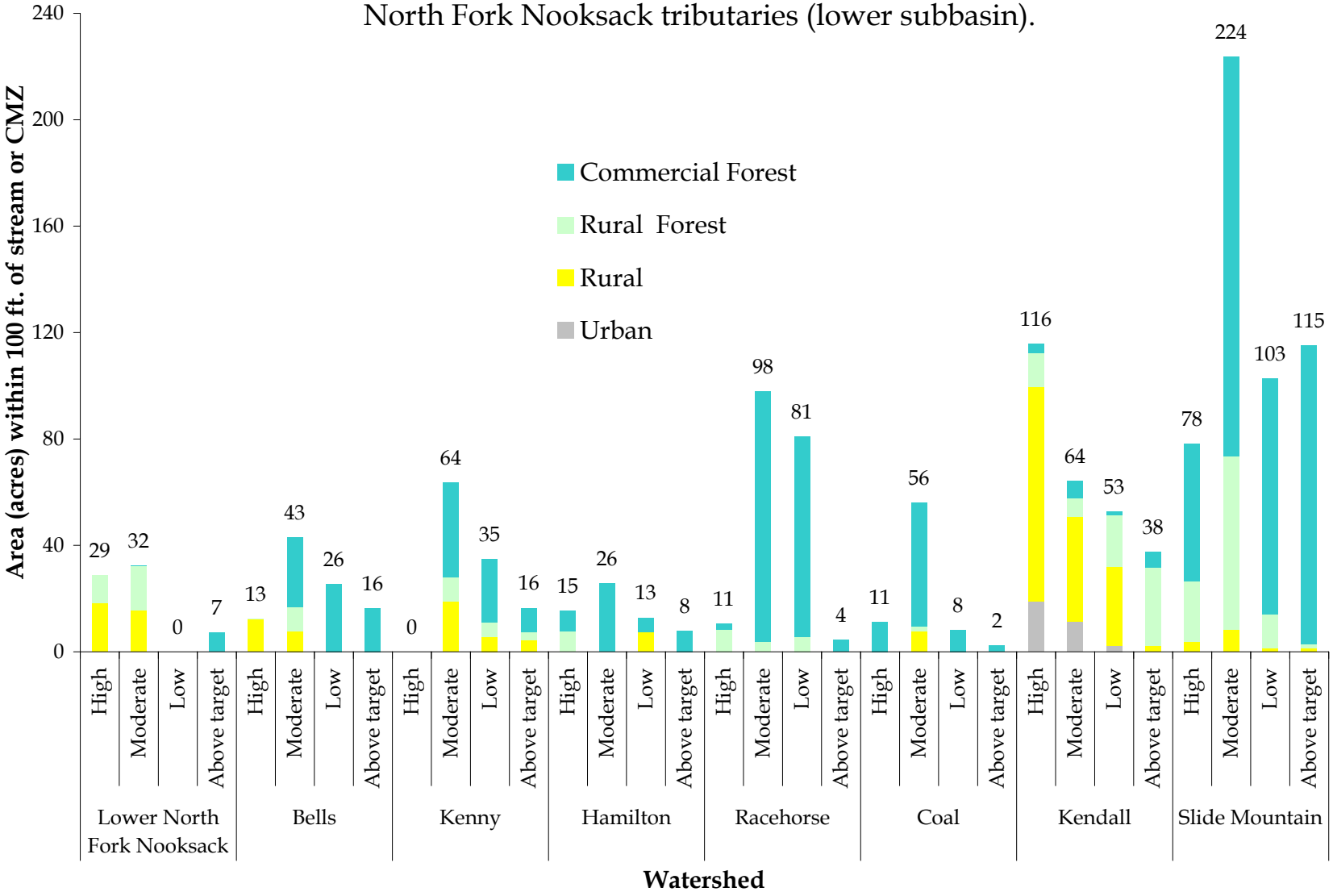


Figure 24b. Stream shading hazard by zoning class and watershed: North Fork Nooksack tributaries (middle subbasin).

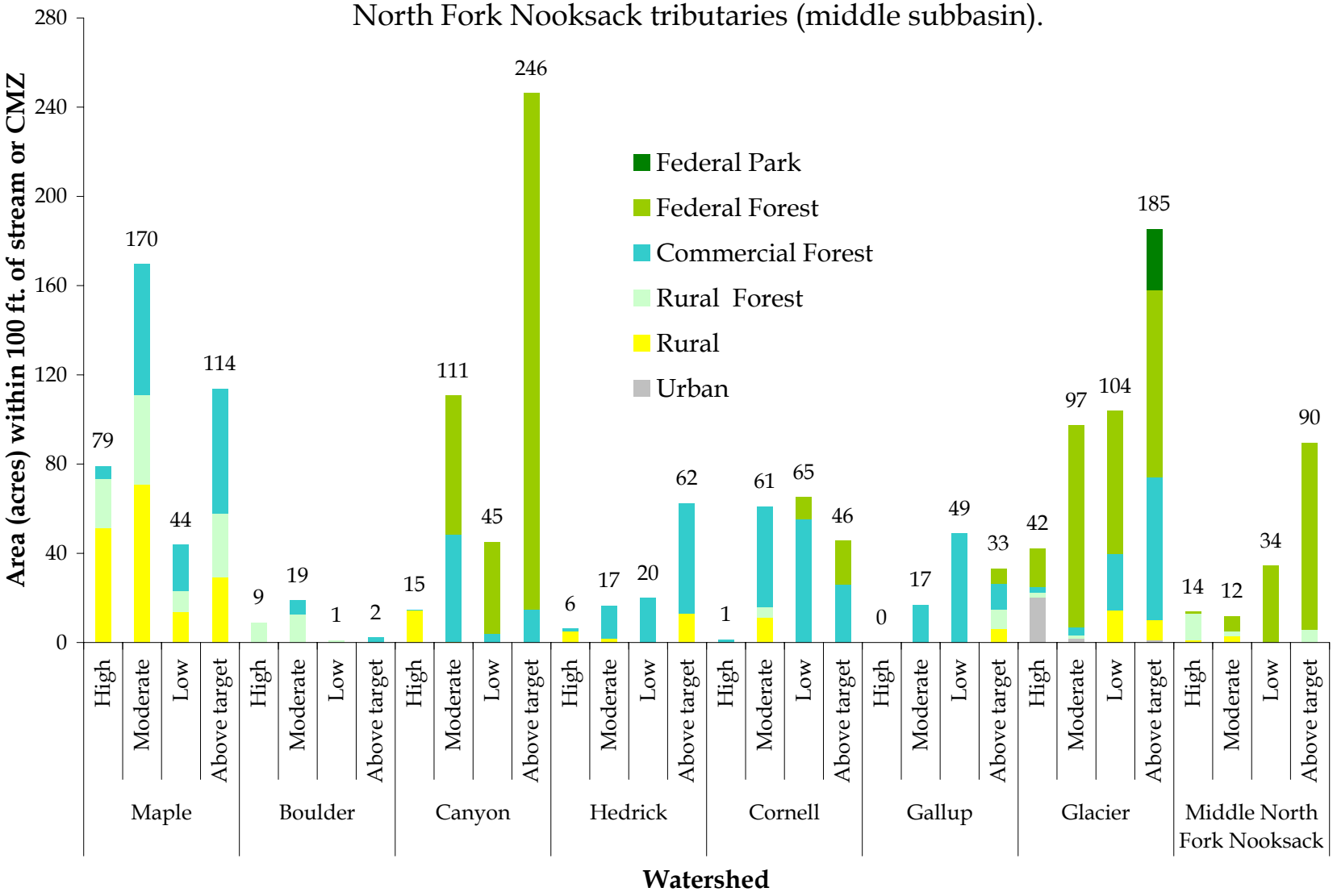


Figure 24c. Stream shading hazard by zoning class and watershed: North Fork Nooksack tributaries (upper subbasin).

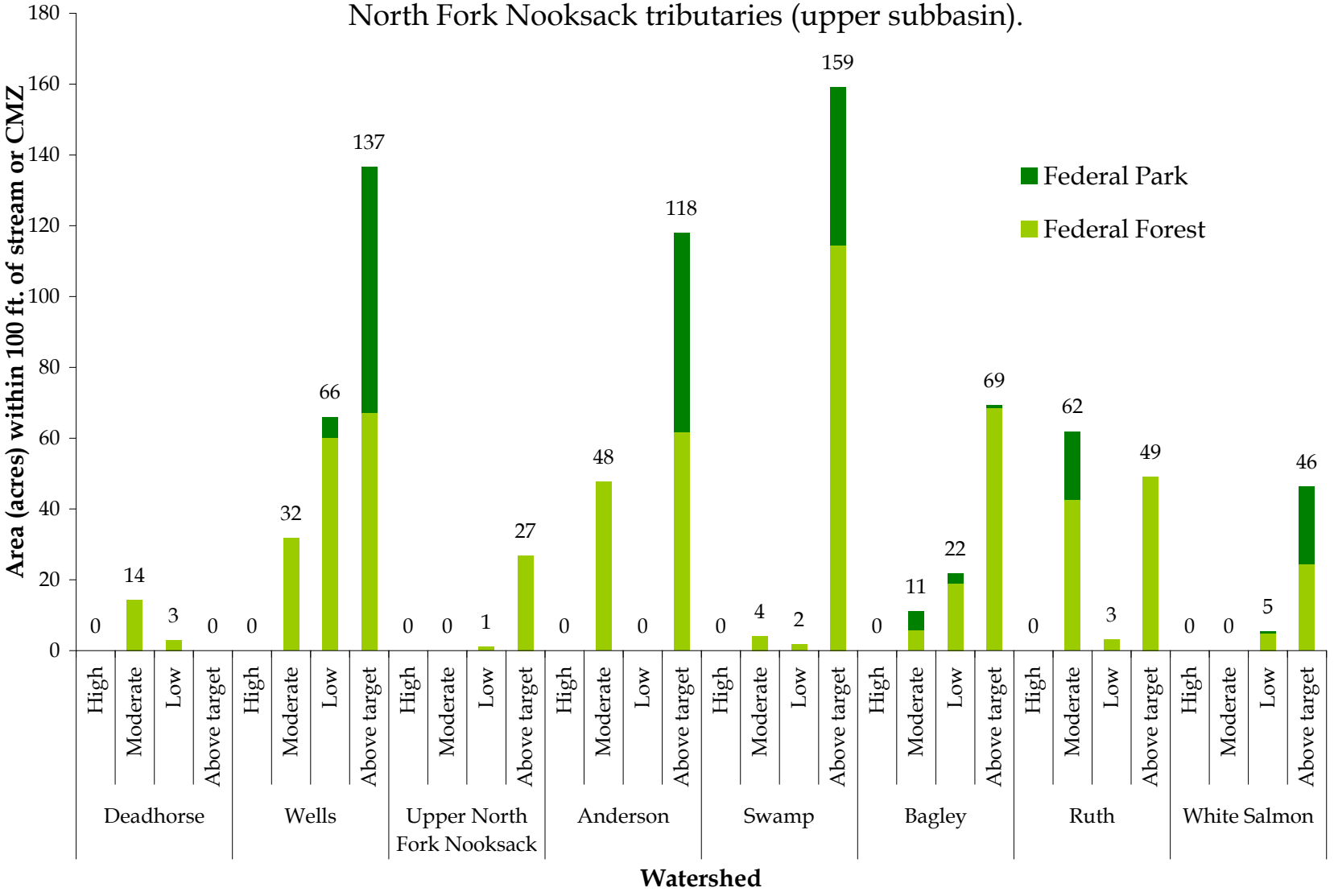


Figure 25. Stream Shading in the Middle Fork Nooksack River Subbasin.

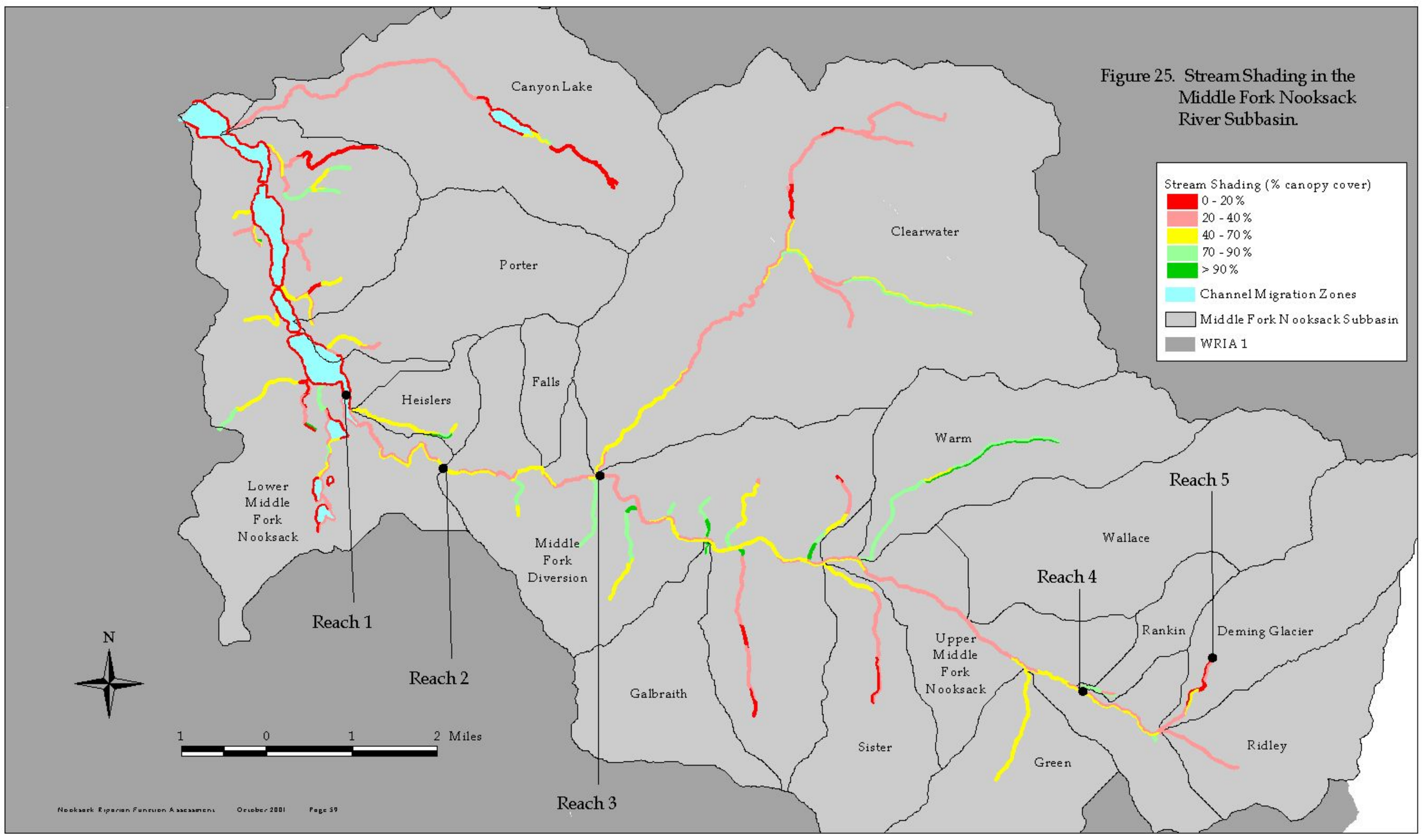


Figure 26. Stream shading hazard and zoning class by reach: Middle Fork Nooksack.

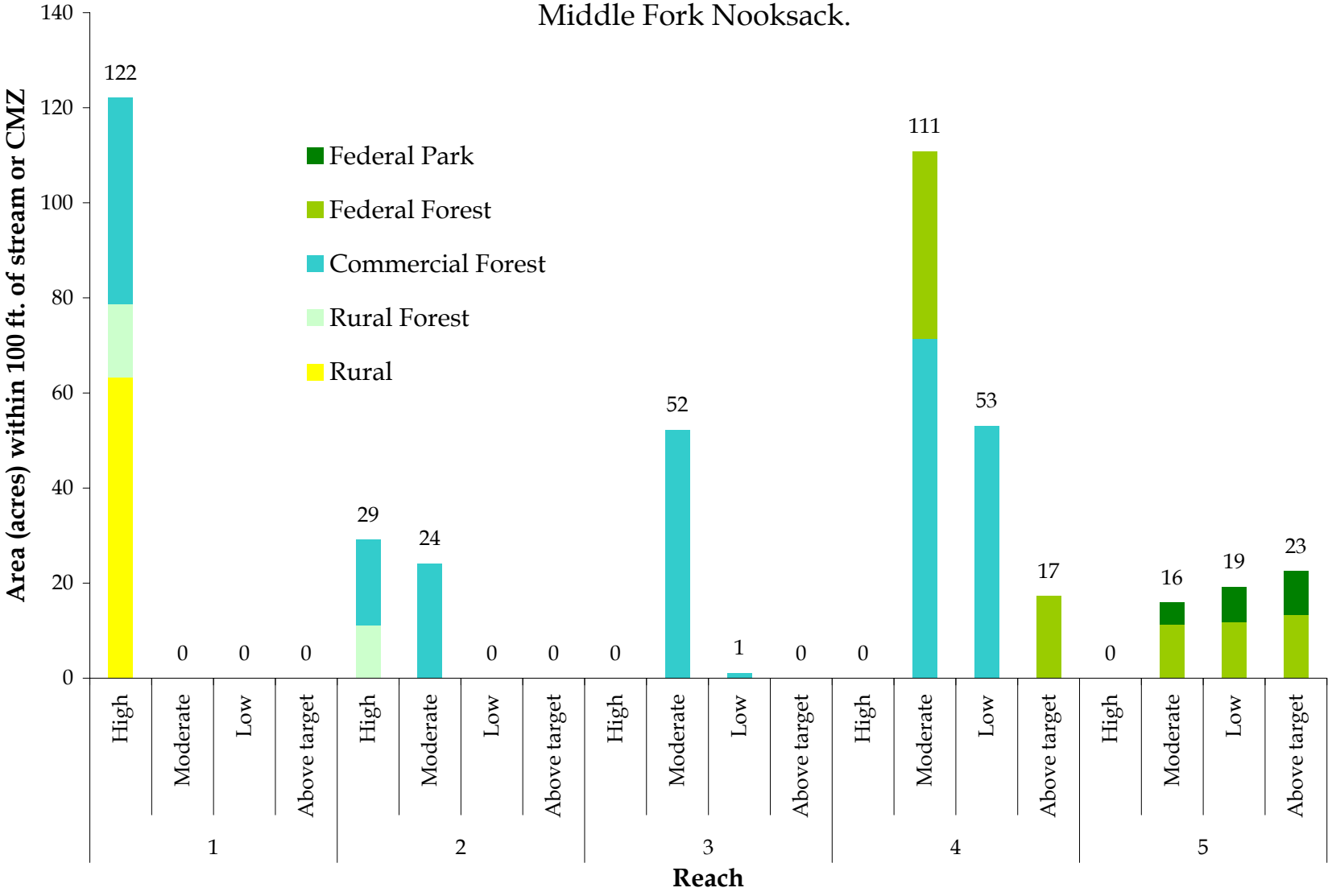


Figure 27a. Stream shading hazard by zoning class and watershed: Middle Fork Nooksack tributaries (lower subbasin).

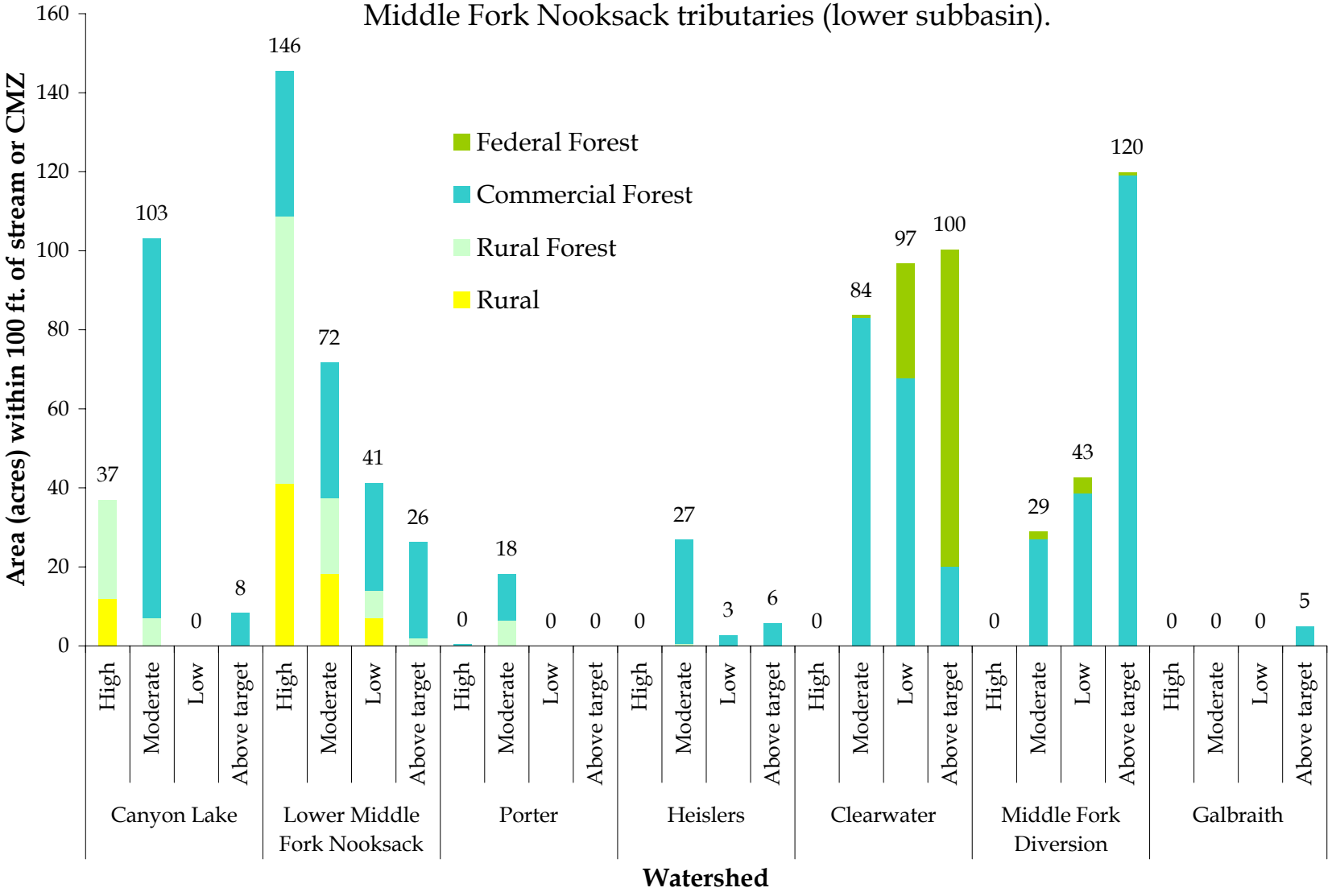


Figure 27b. Stream shading hazard by zoning class and watershed: Middle Fork Nooksack tributaries (upper subbasin).

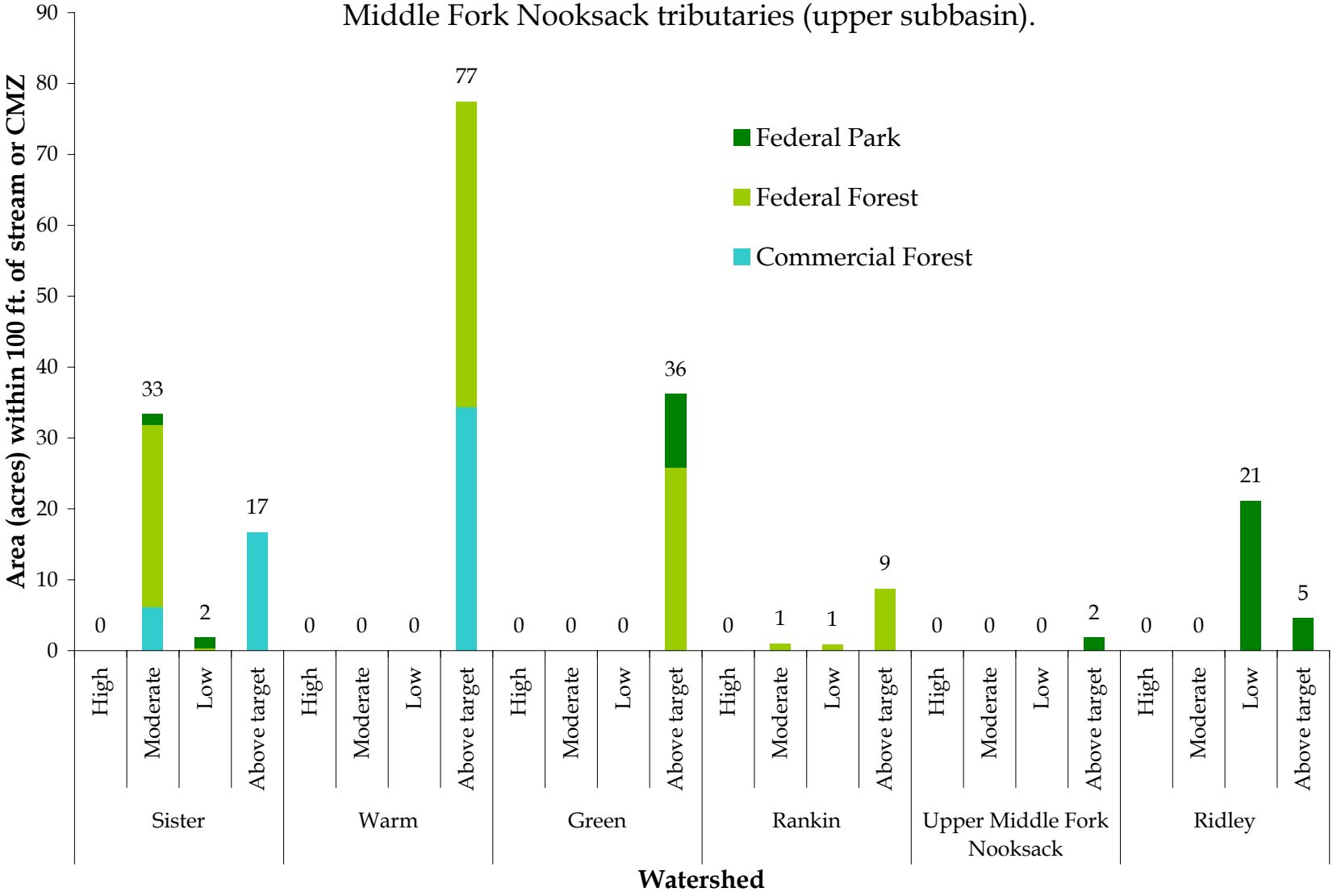


Figure 28. Stream Shading in the South Fork Nooksack River Subbasin.

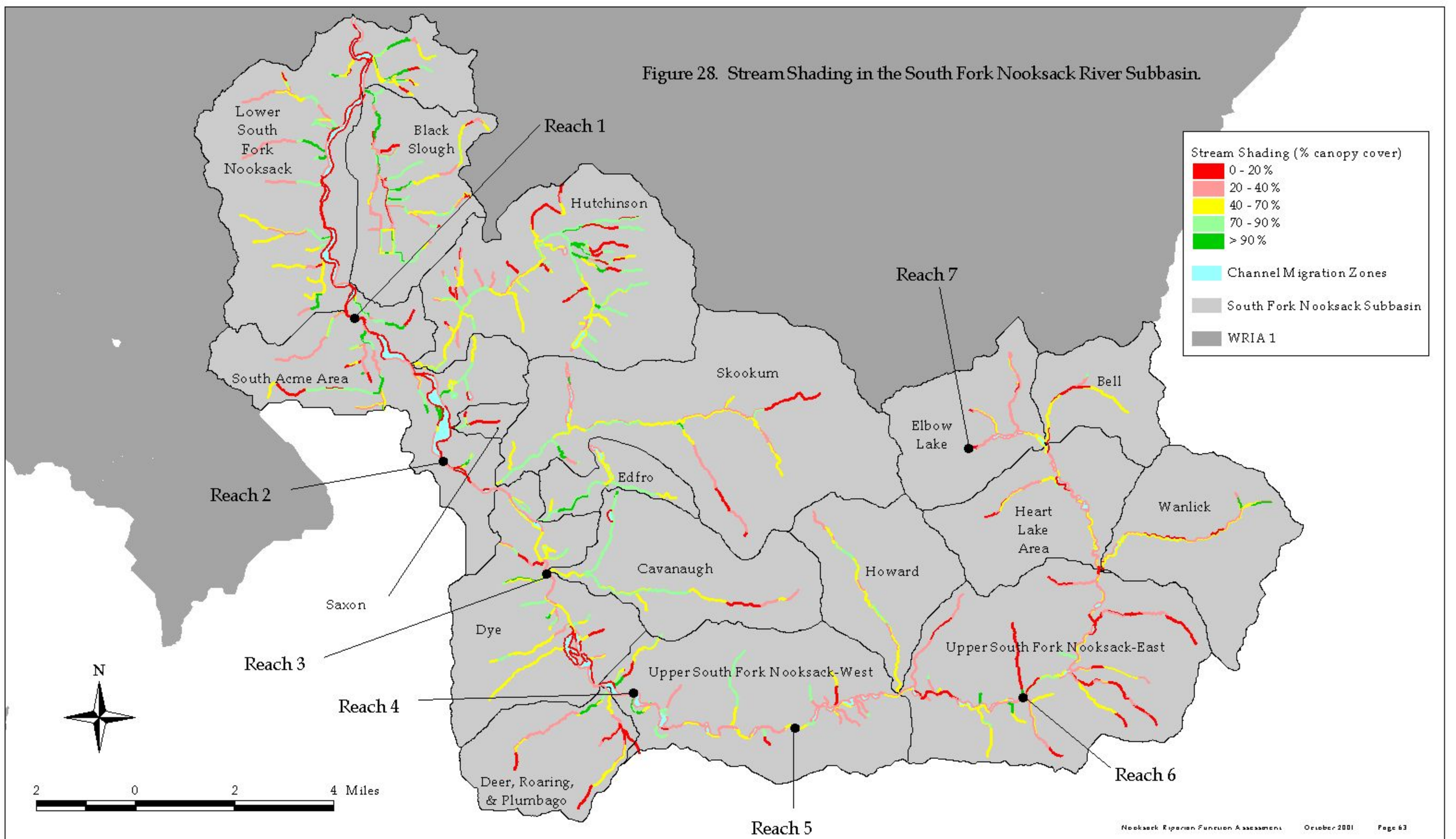


Figure 29. Stream shading hazard and zoning class by reach: South Fork Nooksack.

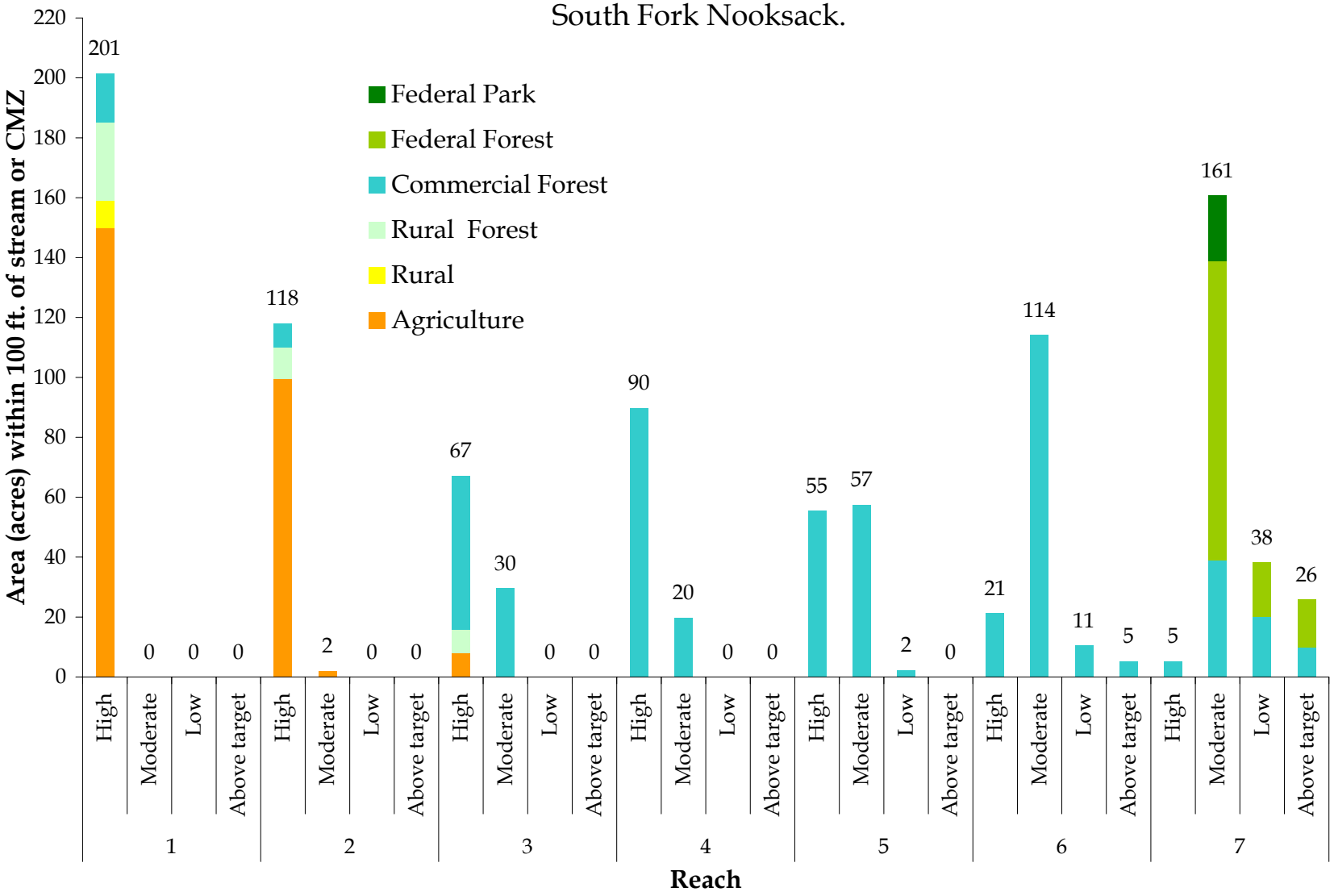


Figure 30a. Stream shading hazard by zoning class and watershed: South Fork Nooksack tributaries (lower subbasin).

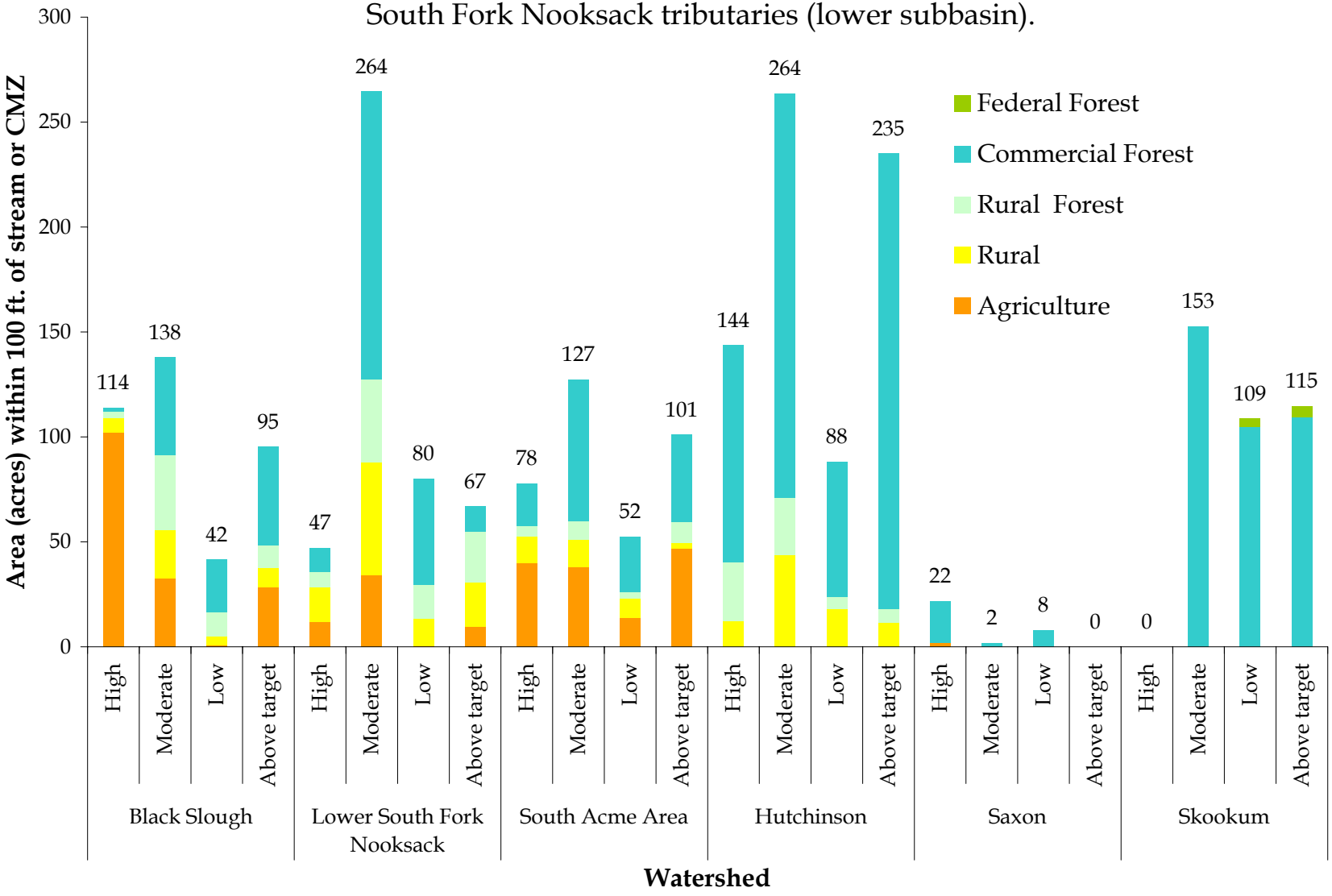


Figure 30b. Stream shading hazard by zoning class and watershed: South Fork Nooksack tributaries (mid subbasin).

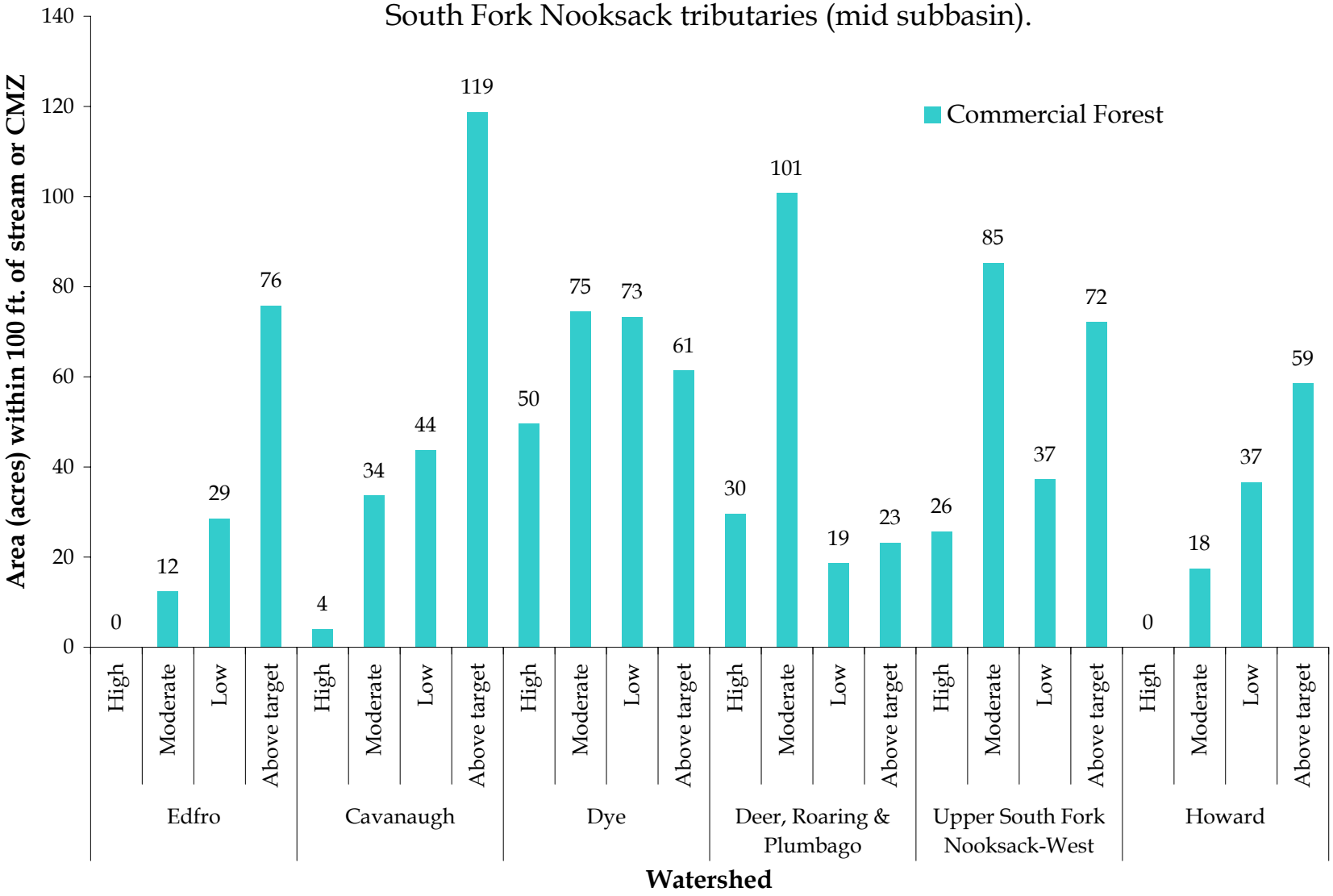


Figure 30c. Stream shading hazard by zoning class and watershedd: South Fork Nooksack tributaries (upper subbasin).

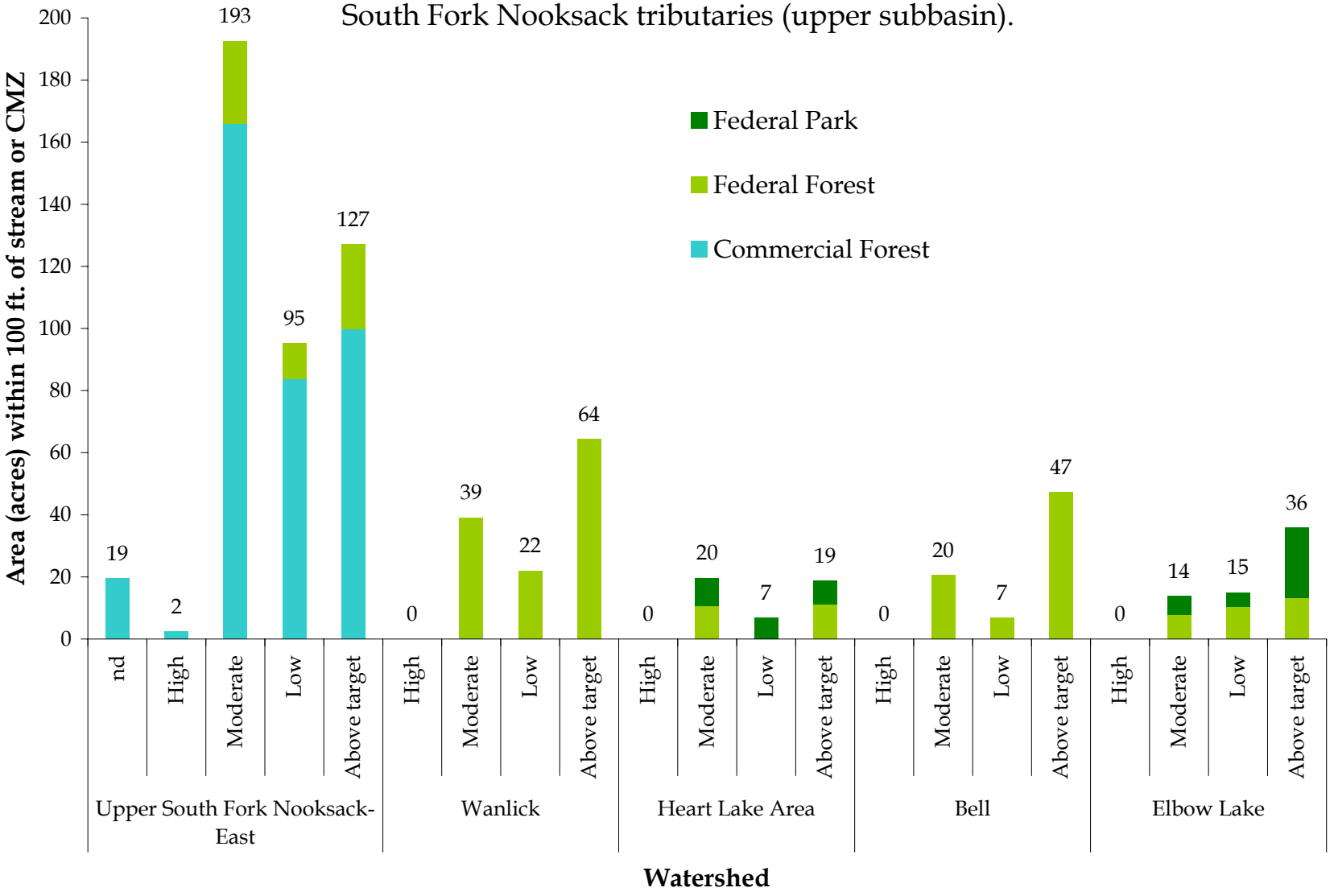


Figure 31. Channel migration zones identified in mainstem reaches of the Nooksack River watershed.

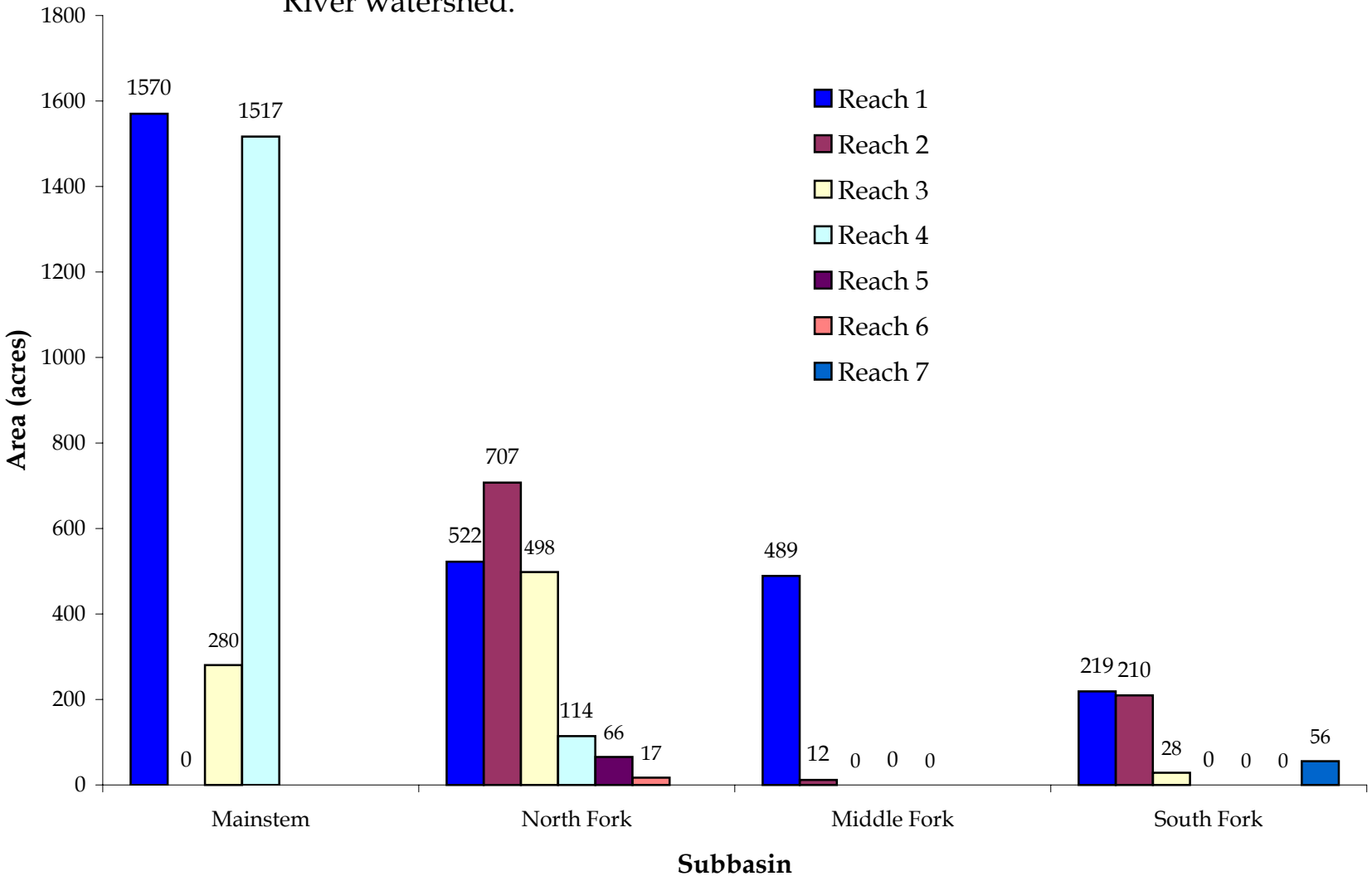
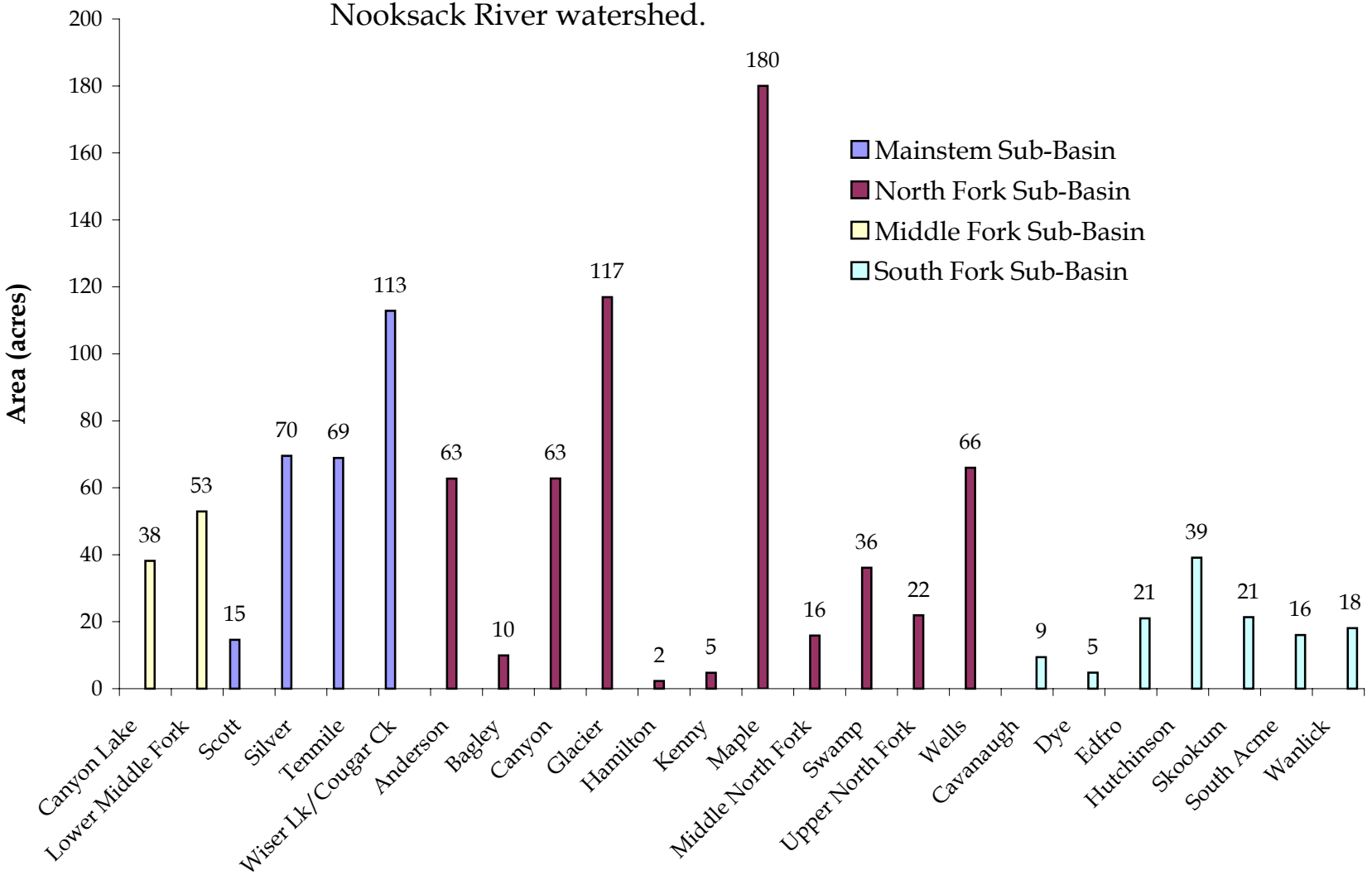


Figure 32. Channel migration zones identified in tributary watersheds of the Nooksack River watershed.



APPENDIX A

Methodology for Conducting the Year 2000 Riparian Assessment for the Nooksack Basin

Methodology for Conducting the Year 2000 Riparian Assessment for the Nooksack Basin

Jerry Middel
Duck Creek Associates, Inc
301 SW 4th
Suite 270
Corvallis, Oregon 97333
541.753.4702
middel@duckcreekassociates.com

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The following is a short description of the process used to construct both the Nooksack_RCU and Nooksack_CMZ databases.

Data Sources:

- WA Department Natural Resources Digital Orthographic Quadrangles (DOQ) to be used as base maps.
- USGS Digital Raster Graphics (DRG) to be used as base maps for areas that are not covered by the DOQs. DRGs are also used for digitizing.
- Northwest Indian Fisheries Commission FISHARCS GIS coverage to be used as guide for the extent of anadromous and resident fish streams within the Nooksack Basin.
- WA Department of Natural Resources hydrography coverage to be used to locate all Type 4 streams that are adjacent to FISHARCS. These are used as a guide for study area extent.
- SSHIAP Points used to determine the break of Type 4 streams at 20% gradient.
- WA Department of Natural Resources Flight line Points coverage to determine location of the photos within the study area
- WA Department of Natural Resources Watershed Administrative Units (WAU) coverage to determine bounds of WAUs.
- Latest aerial photographs of study area supplied by both the WA Department of Natural Resources and the United States Forest Service.

Procedures for constructing preliminary databases in ArcInfo Version 8.02 and ENVI

- Project all datasets to Washington State Plane North (FIPS Zone 4601) North American Datum 83.

- Buffer FISHARCS left and right sides at 100 feet.
- Union FISHARCS Left and Right Buffers.
- Clean new coverage with a fuzzy tolerance of 25 feet.
- Select Type 4 streams contiguous with FISHARCS from WADNR Hydro coverage.
- Clip Type 4 streams to include streams of 20 percent gradient and less using SHIAP data.
- Buffer Type 4 left and right at 100 feet. The buffers now illustrate the perimeter of the riparian condition unit (RCU) on each bank.

Procedures for selecting ground control points for pilot study portion of project

Using the Avenue script (Random Select) in ArcView Version 3.2, we selected points for the field portion of the study. This specialized script randomly distributes points within the previously buffered polygons. We picked 300 points to be randomly selected from the polygons. These points served as potential pilot study plots. A point layer was created from the randomly distributed points and was overlaid onto field maps for taking into the field during the ground truth portion of the study.

Field Pilot Study

We first built a custom handheld field data collection application for use in our Corvallis Micro technology (CMT) PCL-5 field data recorder. We then visited as many of the 300 previously selected points as was feasible. We used the maps and aerial photos to photo-locate the points. Once at the point we collected the information required in the Riparian Function Module of the Washington Forest Practices Board "Methods for Conducting Watershed Analysis". For example, at each point we would determine if conifers, hardwoods, or a mix of both were present. We measured the dominant trees' diameters at the point and determined the average size class. We also made judgments about the density of trees at our plots in terms of whether or not canopy covered 70 percent or more of the ground at each point. We also took four measurements with the densitometer at each point. By offsetting three paces from plot center we measured once to the north of the point, once to the south of the point, once to the east, and once to the west. All of the measurements described above were taken on both banks of the stream.

Due to locked gates, impassable roads, and operational constraints, reaching all of the previously selected three hundred points was not feasible. To compensate for this shortcoming, we visited additional sections of streams nearby the installed points. We attempted to select supplemental sites that exhibited a different canopy type that the nearby sample point. We delineated riparian condition units and the appropriate attributes on the aerial photos at each of these supplemental points. This provided us with sufficient confidence that we were collecting enough ground truth information for the next step: eye calibration.

Using a Topcon mirror stereoscope equipped with a 4X binocular, aerial photos with field-verified riparian condition units overlaid on acetates and inspected while referring to the information collected in the field. After several hours of eye calibration, photo interpreters would attempt to determine the attributes of a particular point *without* looking at the ground truth data. When the photo interpreter was able to correctly assign the attributes to an area we had previously field visited, we began delineating riparian condition units and assigning the appropriate attributes on other portions of the photos. If the photo interpreter could not determine with confidence the attributes of a particular riparian condition unit, the unit was put aside for a revisit. If the photo interpreter thought the call on the riparian condition unit could go one of two ways, they recorded an alternate call. That call can be found in the database as ALT_VEG.

Photo Interpretation and Building of GIS Database

Using a combination GIS, DOQs, DRGs, photo point's coverage and aerial photos, we located the landmarks. Often a road junction or stream confluence or landslide work well for finding particular points on both the photo and DOQ, DRG, etc. Once the photo interpreter was confident that the photo location was correct, they used a mirror stereoscope to delineate the riparian condition units on the acetate covering the aerial photos. Next, the interpreter assigned the required attributes to the riparian condition units directly to the acetate-covered photo, according to the Washington Forest Practices Board specifications. The interpreter determined canopy closure or percent shading by using the stereoscope without binoculars. A code of 1 through 5 was used for shading that corresponded to guidelines discussed in the WA Department of Natural Resources Riparian Function Module. A code of 1 represents 0-20% shade, a code of 2 signifies 20-40% shade, code 3 means 40-70% shade, a code of 4 translates to 70-90% shade and a code of 5 signifies >90% shade.

The WA Department of Natural Resources Riparian Function Module specifies that an individual riparian condition unit not exceed 2000' in length unless a definitive break occurs in the canopy. In our opinion, this "lumping" strategy seemed too coarse of a delineation, so we opted for a "finer" system that strove to keep riparian condition units no shorter than 1000 feet. If a definite smaller size polygon existed with clearly visible boundaries and it could be easily determined as different or unique from neighboring polygons, we created a new riparian condition unit for this type. The interpreter only split small size polygons when it was absolutely clear that they differed from their neighbors. If we were unable to make a confident call for a particular riparian condition units based on eye calibration or ground control points, we put it aside for a later visit and field verification.

Channel Migration Zones were delineated where there was obvious recent movement of the channel. Evidence of recent channel movement included areas where the channel widened and supported small to medium shrubs and hardwoods or areas where no vegetation existed. Channel migration zones ranged in area from 1.2 acres to 1,500 acres. Wetlands, small lakes and ponds were also included as channel migration zones. All attributes that were assigned to the riparian condition units were also assigned to channel migration zones with the exception

of canopy closure. Canopy closure was not determined for channel migration zones because, by definition, these areas rarely have shading present.

All delineating occurred in the GIS by "heads up" digitizing. Typically, the operator would hold the delineated photo in hand and locate the riparian condition unit on the DOQ or DRG. The preformed polygons were then split according to the breaks on the photo. Splitting polygons, assigning attributes, and "integrating" the data were all carried out using ArcInfo Version 8.02.

After completing all digitizing and integrating, data was exported from the Geodatabase format to shape file using ArcCatalog. The shape files were then viewed in ArcView and packaged on CD.

APPENDIX B

Data Tables: Near-Term LWD Recruitment Potential and Stream Shading by Zoning Class and Geographic Areas

List of Tables

Table B-1. Near-term LWD recruitment potential (LWDRP) in the Nooksack River watershed by subbasin (area in acres, rounded to the nearest acre).

Subbasin	LWDRP	mainstem	tributaries	Total
Mainstem	Low	628	3953	4582
	Mod	281	633	914
	High	0	521	521
North Fork	Low	229	1391	1620
	Mod	251	952	1204
	High	502	1749	2251
Middle Fork	Low	159	405	564
	Mod	141	167	308
	High	168	596	763
South Fork	Low	409	1702	2111
	Mod	330	731	1061
	High	286	1740	2025
Nooksack River Watershed Total	Low	1425	7451	8876
	Mod	1003	2483	3486
	High	955	4605	5560

Table B-2. Distribution of LWDRP in the Nooksack River watershed by zoning class (area in acres, rounded to the nearest acre).

	Urban	Agri-cultural	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Low	436	3329	1563	533	2415	502	100	8876
Moderate	68	486	699	480	1314	341	97	3486
High	60	109	351	288	2716	1839	198	5560
Total	564	3923	2613	1300	6445	2682	396	17923

Table B-3. LWDRP and zoning class by reach: Mainstem Nooksack (area in acres, rounded to the nearest acre).

Reach	LWDRP	Urban	Agricultural	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
1	Low	22	71	33	19	0	0	0	145
	Mod	2	13	12	20	0	0	0	47
	High	0	0	0	0	0	0	0	0
2	Low	5	176	0	0	0	0	0	181
	Mod	0	25	0	0	0	0	0	25
	High	0	0	0	0	0	0	0	0
3	Low	5	148	0	0	0	0	0	154
	Mod	6	36	0	0	0	0	0	42
	High	0	0	0	0	0	0	0	0
4	Low	1	112	15	4	16	0	0	148
	Mod	3	116	0	14	34	0	0	167
	High	0	0	0	0	0	0	0	0
Mainstem Nooksack Total	Low	34	507	48	23	16	0	0	628
	Mod	11	191	12	33	34	0	0	281
	High	0	0	0	0	0	0	0	0

Table B-4. LWDRP and zoning class by watershed: Tributaries to the Mainstem Nooksack (area, to nearest acre).

Watershed	LWDRP	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Fort Bellingham	Low	0	0	12	0	0	0	0	12
	Mod	0	0	8	0	0	0	0	8
	High	0	0	0	0	0	0	0	0
Nooksack River Delta	Low	0	20	8	6	0	0	0	33
	Mod	0	7	3	0	0	0	0	10
	High	0	1	2	0	0	0	0	2
Lummi Peninsula West	Low	0	192	8	0	0	0	0	200
	Mod	0	0	0	0	0	0	0	0
	High	0	0	0	0	0	0	0	0
Silver	Low	139	95	224	0	0	0	0	458
	Mod	33	4	53	18	0	0	0	108
	High	45	4	33	0	0	0	0	83
Tenmile	Low	14	260	269	0	0	0	0	542
	Mod	0	1	81	0	0	0	0	81
	High	0	4	37	0	0	0	0	41
Deer	Low	5	73	105	0	0	0	0	183
	Mod	6	9	63	0	0	0	0	77
	High	0	9	36	0	0	0	0	45
Wiser Lake/Couger Creek	Low	0	195	38	0	0	0	0	233
	Mod	0	18	7	0	0	0	0	24
	High	0	5	0	0	0	0	0	5
Schneider	Low	7	153	35	0	0	0	0	195
	Mod	0	4	0	0	0	0	0	4
	High	0	0	0	0	0	0	0	0

Watershed	LWDRP	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Bertrand	Low	17	464	38	0	0	0	0	519
	Mod	0	68	22	0	0	0	0	89
	High	4	72	15	0	0	0	0	91
Fishtrap	Low	183	392	0	0	0	0	0	575
	Mod	3	5	0	0	0	0	0	8
	High	0	0	0	0	0	0	0	0
Scott	Low	2	230	10	0	0	0	0	242
	Mod	0	0	0	0	0	0	0	0
	High	0	0	0	0	0	0	0	0
Kamm	Low	5	252	0	0	0	0	0	257
	Mod	0	5	0	0	0	0	0	5
	High	0	0	0	0	0	0	0	0
Anderson	Low	0	17	78	52	28	0	0	176
	Mod	0	10	99	1	4	0	0	113
	High	0	0	34	26	19	0	0	79
Smith	Low	0	37	131	8	79	0	0	255
	Mod	0	0	22	0	11	0	0	33
	High	0	0	6	11	64	0	0	81
Nooksack Deming to Everson	Low	0	0	0	12	61	0	0	73
	Mod	0	0	6	12	53	0	0	71
	High	0	3	6	9	76	0	0	94
Total Mainstem Nooksack Tributaries	Low	372	2379	956	78	168	0	0	3953
	Mod	41	128	364	31	68	0	0	633
	High	48	98	169	46	159	0	0	521

Table B-5. LWDRP and zoning class by reach: North Fork Nooksack (area in acres, rounded to the nearest acre).

Reach	LWDRP	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
1	Low	0	0	12	30	0	0	0	42
	Mod	0	0	1	27	1	0	0	30
	High	0	0	3	0	0	0	0	3
2	Low	0	0	41	34	10	0	0	85
	Mod	0	0	33	60	6	0	0	100
	High	0	0	6	7	10	0	0	24
3	Low	0	0	8	10	12	0	0	30
	Mod	0	0	14	38	33	0	0	85
	High	0	0	15	21	46	16	0	98
4	Low	0	0	0	0	0	26	0	26
	Mod	0	0	0	0	0	18	0	18
	High	1	0	0	0	0	141	0	143
5	Low	0	0	0	0	0	22	0	22
	Mod	0	0	0	0	0	19	0	19
	High	0	0	0	0	0	207	0	207
6	Low	0	0	0	0	0	25	0	25
	Mod	0	0	0	0	0	0	0	0
	High	0	0	0	0	0	28	0	28
Total North Fork Nooksack	Low	0	0	61	74	22	72	0	229
	Mod	0	0	49	125	41	37	0	251
	High	1	0	24	28	57	392	0	502

Table B-6. LWDRP and zoning class by watershed: Tributaries to the North Nooksack (area rounded to nearest acre).

Watershed	LWDRP	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Lower North Fork Nooksack	Low	0	0	20	23	0	0	0	43
	Mod	0	0	10	4	0	0	0	14
	High	0	0	5	0	7	0	0	12
Bells	Low	0	0	18	0	0	0	0	18
	Mod	0	0	2	9	42	0	0	53
	High	0	0	0	0	26	0	0	26
Kenny	Low	0	0	1	0	19	0	0	20
	Mod	0	0	23	4	22	0	0	49
	High	0	0	5	14	27	0	0	45
Hamilton	Low	0	0	0	8	33	0	0	40
	Mod	0	0	7	0	3	0	0	11
	High	0	0	0	0	11	0	0	11
Racehorse	Low	0	0	0	4	108	0	0	111
	Mod	0	0	0	7	33	0	0	40
	High	0	0	0	7	35	0	0	43
Coal	Low	0	0	0	0	23	0	0	23
	Mod	0	0	0	0	19	0	0	19
	High	0	0	7	2	26	0	0	35
Kendall	Low	29	0	124	41	3	0	0	197
	Mod	1	0	25	12	3	0	0	41
	High	3	0	3	15	11	0	0	32
Slide Mountain	Low	0	0	12	28	168	0	0	209
	Mod	0	0	1	68	59	0	0	128
	High	0	0	2	7	179	0	0	188

Watershed	LWDRP	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Maple	Low	0	0	70	18	78	0	0	166
	Mod	0	0	59	53	24	0	0	136
	High	0	0	37	28	39	0	0	104
Boulder	Low	0	0	0	17	0	0	0	17
	Mod	0	0	0	1	3	0	0	4
	High	0	0	0	4	2	0	0	6
Canyon	Low	0	0	4	0	19	54	0	77
	Mod	0	0	3	0	7	97	0	106
	High	0	0	9	0	41	184	0	234
Hedrick	Low	0	0	5	0	69	0	0	74
	Mod	0	0	9	0	8	0	0	17
	High	0	0	6	0	9	0	0	15
Cornell	Low	0	0	2	3	78	0	0	83
	Mod	0	0	9	2	2	0	0	13
	High	0	0	0	0	47	29	0	77
Gallup	Low	0	0	0	0	20	0	0	20
	Mod	0	0	6	9	17	7	0	39
	High	0	0	0	0	40	0	0	40
Glacier	Low	1	0	0	0	33	8	0	42
	Mod	15	0	7	2	19	12	6	63
	High	7	0	16	1	43	236	21	324
Middle North Fork Nooksack	Low	0	0	3	7	0	31	0	41
	Mod	0	0	1	7	0	2	0	10
	High	0	0	0	6	0	93	0	99

Watershed	LWDRP	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Deadhorse	Low	0	0	0	0	0	0	0	0
	Mod	0	0	0	0	0	6	0	6
	High	0	0	0	0	0	11	0	11
Wells	Low	0	0	0	0	0	26	8	34
	Mod	0	0	0	0	0	15	34	49
	High	0	0	0	0	0	119	33	152
Upper North Fork Nooksack	Low	0	0	0	0	0	32	0	32
	Mod	0	0	0	0	0	18	0	18
	High	0	0	0	0	0	31	0	31
Anderson	Low	0	0	0	0	0	8	19	27
	Mod	0	0	0	0	0	3	19	22
	High	0	0	0	0	0	46	18	64
Swamp	Low	0	0	0	0	0	18	13	31
	Mod	0	0	0	0	0	31	17	48
	High	0	0	0	0	0	71	14	86
Bagley	Low	0	0	0	0	0	41	9	49
	Mod	0	0	0	0	0	20	0	21
	High	0	0	0	0	0	32	0	32
Ruth	Low	0	0	0	0	0	17	10	27
	Mod	0	0	0	0	0	31	9	40
	High	0	0	0	0	0	47	0	47
White Salmon	Low	0	0	0	0	0	9	2	11
	Mod	0	0	0	0	0	5	0	6
	High	0	0	0	0	0	15	20	35
Total North Fork Nooksack Tributaries	Low	29	0	257	150	651	243	61	1391
	Mod	16	0	163	178	262	247	87	952
	High	10	0	90	84	544	915	106	1749

Table B-7. LWDRP and zoning class by reach: Middle Fork Nooksack (area in acres, rounded to nearest acre).

Reach	LWDRP	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
1	Low	0	0	28	2	17	0	0	47
	Mod	0	0	28	9	8	0	0	44
	High	0	0	7	4	19	0	0	31
2	Low	0	0	0	0	2	0	0	2
	Mod	0	0	0	8	3	0	0	11
	High	0	0	0	3	38	0	0	41
3	Low	0	0	0	0	5	0	0	5
	Mod	0	0	0	0	19	0	0	19
	High	0	0	0	0	30	0	0	30
4	Low	0	0	0	0	26	38	0	64
	Mod	0	0	0	0	59	0	0	59
	High	0	0	0	0	40	18	0	58
5	Low	0	0	0	0	0	30	11	41
	Mod	0	0	0	0	0	3	6	9
	High	0	0	0	0	0	3	4	8
Total Middle Fork Nooksack	Low	0	0	28	2	49	68	11	159
	Mod	0	0	28	17	88	3	6	141
	High	0	0	7	8	126	22	4	168

Table B-8. LWDRP and zoning class by watershed: Tributaries to the Middle Nooksack (area to nearest acre).

Watershed	LWDRP	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Canyon Lake	Low	0	0	6	6	63	0	0	76
	Mod	0	0	3	0	1	0	0	4
	High	0	0	3	25	40	0	0	69
Lower Middle Fork Nooksack	Low	0	0	58	58	61	0	0	177
	Mod	0	0	8	16	19	0	0	43
	High	0	0	0	22	43	0	0	65
Porter	Low	0	0	0	0	5	0	0	5
	Mod	0	0	0	2	0	0	0	2
	High	0	0	0	4	7	0	0	11
Heislers	Low	0	0	0	0	3	0	0	3
	Mod	0	0	0	1	26	0	0	27
	High	0	0	0	0	5	0	0	5
Clearwater	Low	0	0	0	0	27	2	0	30
	Mod	0	0	0	0	56	2	0	58
	High	0	0	0	0	87	106	0	193
Middle Fork Diversion	Low	0	0	0	0	60	6	0	66
	Mod	0	0	0	0	23	0	0	23
	High	0	0	0	0	101	1	0	102
Galbraith	Low	0	0	0	0	0	0	0	0
	Mod	0	0	0	0	0	0	0	0
	High	0	0	0	0	5	0	0	5

Watershed	LWDRP	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Sister	Low	0	0	0	0	17	1	2	19
	Mod	0	0	0	0	0	5	0	5
	High	0	0	0	0	6	20	1	28
Warm	Low	0	0	0	0	14	0	0	14
	Mod	0	0	0	0	0	4	0	5
	High	0	0	0	0	20	39	0	58
Green	Low	0	0	0	0	0	0	4	4
	Mod	0	0	0	0	0	0	0	0
	High	0	0	0	0	0	26	6	32
Rankin	Low	0	0	0	0	0	11	0	11
	Mod	0	0	0	0	0	0	0	0
	High	0	0	0	0	0	0	0	0
Upper Middle Fork Nooksack	Low	0	0	0	0	0	0	0	0
	Mod	0	0	0	0	0	0	0	0
	High	0	0	0	0	0	0	2	2
Ridley	Low	0	0	0	0	0	0	0	0
	Mod	0	0	0	0	0	0	0	0
	High	0	0	0	0	0	0	26	26
Total Middle Fork Nooksack Tributaries	Low	0	0	64	64	251	20	6	405
	Mod	0	0	12	18	126	11	0	167
	High	0	0	3	52	315	191	35	596

Table B-9. LWDRP and zoning class by reach: South Fork Nooksack (area in acres, rounded to nearest acre).

Reach	LWDRP	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
1	Low	0	80	4	14	6	0	0	105
	Mod	0	70	5	12	10	0	0	97
	High	0	0	0	0	0	0	0	0
2	Low	0	64	0	11	0	0	0	74
	Mod	0	38	0	0	8	0	0	46
	High	0	0	0	0	0	0	0	0
3	Low	0	0	0	0	6	0	0	6
	Mod	0	4	0	5	43	0	0	53
	High	0	4	0	2	32	0	0	38
4	Low	0	0	0	0	73	0	0	73
	Mod	0	0	0	0	12	0	0	12
	High	0	0	0	0	25	0	0	25
5	Low	0	0	0	0	50	0	0	50
	Mod	0	0	0	0	43	0	0	43
	High	0	0	0	0	22	0	0	22
6	Low	0	0	0	0	57	0	0	57
	Mod	0	0	0	0	40	0	0	40
	High	0	0	0	0	54	0	0	54
7	Low	0	0	0	0	20	22	3	45
	Mod	0	0	0	0	14	24	0	38
	High	0	0	0	0	40	88	19	147
Total South Fork Nooksack	Low	0	143	4	25	212	22	3	409
	Mod	0	112	5	17	171	24	0	330
	High	0	4	0	2	173	88	19	286

Table B-10. LWDRP and zoning class by watershed: Tributaries to the South Fork Nooksack (area in acres, rounded to nearest acre).

Watershed	LWDRP	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Black Slough	Low	0	143	22	39	26	0	0	231
	Mod	0	18	10	13	33	0	0	74
	High	0	3	11	9	62	0	0	84
Lower South Fork Nooksack	Low	0	52	71	39	60	0	0	222
	Mod	0	4	19	18	19	0	0	60
	High	0	0	15	30	132	0	0	177
South Acme Area	Low	0	102	19	3	69	0	0	194
	Mod	0	32	15	16	16	0	0	79
	High	0	4	3	8	70	0	0	85
Hutchinson	Low	0	0	31	35	180	0	0	246
	Mod	0	0	23	14	121	0	0	158
	High	0	0	31	20	276	0	0	327
Saxon	Low	0	2	0	0	20	0	0	22
	Mod	0	0	0	0	0	0	0	0
	High	0	0	0	0	10	0	0	10
Skookum	Low	0	0	0	0	84	9	0	93
	Mod	0	0	0	0	76	0	0	76
	High	0	0	0	0	207	0	0	207
Edfro	Low	0	0	0	0	25	0	0	25
	Mod	0	0	0	0	33	0	0	33
	High	0	0	0	0	59	0	0	59

Watershed	LWDRP	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Cavanaugh	Low	0	0	0	0	61	0	0	61
	Mod	0	0	0	0	55	0	0	55
	High	0	0	0	0	85	0	0	85
Dye	Low	0	0	0	0	76	0	0	76
	Mod	0	0	0	0	54	0	0	54
	High	0	0	0	0	129	0	0	129
Deer, Roaring, & Plumbago	Low	0	0	0	0	63	0	0	63
	Mod	0	0	0	0	22	0	0	22
	High	0	0	0	0	88	0	0	88
Upper South Fork Nooksack-West	Low	0	0	0	0	143	0	0	143
	Mod	0	0	0	0	38	0	0	38
	High	0	0	0	0	39	0	0	39
Howard	Low	0	0	0	0	27	0	0	27
	Mod	0	0	0	0	21	0	0	21
	High	0	0	0	0	65	0	0	65
Upper South Fork Nooksack-East	Low	0	0	0	0	212	2	0	214
	Mod	0	0	0	0	38	7	0	45
	High	0	0	0	0	121	57	0	178
Wanlick	Low	0	0	0	0	0	32	0	33
	Mod	0	0	0	0	0	0	0	0
	High	0	0	0	0	0	93	0	93

Watershed	LWDRP	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Heart Lake Area	Low	0	0	0	0	0	15	12	26
	Mod	0	0	0	0	0	0	0	0
	High	0	0	0	0	0	7	12	19
Bell	Low	0	0	0	0	0	19	0	19
	Mod	0	0	0	0	0	8	0	8
	High	0	0	0	0	0	47	0	47
Elbow Lake	Low	0	0	0	0	0	0	8	8
	Mod	0	0	0	0	0	4	5	8
	High	0	0	0	0	0	28	21	49
Total South Fork Nooksack Tributaries	Low	0	299	144	116	1046	77	19	1702
	Mod	0	55	68	60	524	19	5	731
	High	0	7	59	68	1342	231	33	1740

Table B-11. Stream shading hazard (SSH) in the Nooksack River watershed by subbasin (area in acres, rounded to nearest acre).

SubBasin	SSH	mainstem	tributaries	Total
Mainstem Nooksack	High	N/A. See text.	3952	3952
	Moderate		903	903
	Low		98	98
	Above Target		154	154
North Fork	High	518	438	956
	Moderate	288	1280	1568
	Low	112	782	894
	Above Target	64	1592	1656
Middle Fork	High	151	183	334
	Moderate	203	367	570
	Low	73	207	281
	Above Target	40	411	451
South Fork*	High	558	515	1074
	Moderate	384	1557	1941
	Low	51	763	814
	Above Target	31	1316	1347
Total	High	1228	5088	6316
	Moderate	875	4108	4983
	Low	237	1850	2087
	Above Target	135	3473	3609

* 20 acres in *Upper South Fork Nooksack-East* were not classified.

Table B-12. Distribution of stream shading hazard (SSH) in Nooksack River watershed by zoning class (area in acres, rounded to nearest acre; Nooksack River Mainstem below South Fork confluence excluded).

SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
High	379	2740	1652	579	888	77	0	6316
Moderate	136	385	666	418	2444	865	68	4983
Low	2	15	125	111	1319	464	51	2087
Above Target	1	85	110	136	1724	1276	277	3609
Total	519	3226	2553	1244	6375	2682	396	16994

* 20 acres in *Upper South Fork Nooksack East* were not classified.

Table B-13. Stream shading hazard (SSH) and zoning class by watershed: Tributaries to the Mainstem Nooksack (area in acres, rounded to nearest acre).

Watershed	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Fort Bellingham	High	0	0	16	0	0	0	0	16
	Moderate	0	0	4	0	0	0	0	4
	Low	0	0	0	0	0	0	0	0
	Above target	0	0	0	0	0	0	0	0
Nooksack River Delta	High	0	26	8	6	0	0	0	40
	Moderate	0	1	5	0	0	0	0	5
	Low	0	0	0	0	0	0	0	0
	Above target	0	0	0	0	0	0	0	0
Lummi Peninsula West	High	0	183	8	0	0	0	0	191
	Moderate	0	9	0	0	0	0	0	9
	Low	0	0	0	0	0	0	0	0
	Above target	0	0	0	0	0	0	0	0
Silver	High	143	96	261	0	0	0	0	499
	Moderate	73	7	50	18	0	0	0	149
	Low	0	0	0	0	0	0	0	0
	Above target	0	0	0	0	0	0	0	0
Tenmile	High	14	260	343	0	0	0	0	618
	Moderate	0	4	44	0	0	0	0	48
	Low	0	0	0	0	0	0	0	0
	Above target	0	0	0	0	0	0	0	0

Watershed	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Deer	High	11	75	158	0	0	0	0	244
	Moderate	0	16	45	0	0	0	0	61
	Low	0	0	0	0	0	0	0	0
	Above target	0	0	0	0	0	0	0	0
Wiser Lake Cougar/Creek	High	0	213	38	0	0	0	0	251
	Moderate	0	4	7	0	0	0	0	11
	Low	0	0	0	0	0	0	0	0
	Above target	0	0	0	0	0	0	0	0
Schneider	High	7	150	30	0	0	0	0	187
	Moderate	0	7	5	0	0	0	0	12
	Low	0	0	0	0	0	0	0	0
	Above target	0	0	0	0	0	0	0	0
Bertrand	High	20	461	62	0	0	0	0	543
	Moderate	0	143	13	0	0	0	0	156
	Low	0	0	0	0	0	0	0	0
	Above target	0	0	0	0	0	0	0	0
Fishtrap	High	137	322	0	0	0	0	0	459
	Moderate	48	75	0	0	0	0	0	123
	Low	0	0	0	0	0	0	0	0
	Above target	0	0	0	0	0	0	0	0
Scott	High	2	230	10	0	0	0	0	242
	Moderate	0	0	0	0	0	0	0	0
	Low	0	0	0	0	0	0	0	0
	Above target	0	0	0	0	0	0	0	0

Watershed	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Kamm	High	5	251	0	0	0	0	0	257
	Moderate	0	5	0	0	0	0	0	5
	Low	0	0	0	0	0	0	0	0
	Above target	0	0	0	0	0	0	0	0
Anderson	High	0	24	91	18	22	0	0	156
	Moderate	0	3	117	53	23	0	0	196
	Low	0	0	2	4	3	0	0	9
	Above target	0	0	0	5	2	0	0	7
Smith	High	0	36	132	6	7	0	0	180
	Moderate	0	2	28	13	37	0	0	80
	Low	0	0	0	0	54	0	0	54
	Above target	0	0	0	0	56	0	0	56
Nooksack Deming to Everson	High	0	0	6	24	39	0	0	69
	Moderate	0	3	6	9	25	0	0	43
	Low	0	0	0	0	35	0	0	35
	Above target	0	0	0	0	92	0	0	92
Total Mainstem Nooksack Tributaries	High	340	2327	1163	53	68	0	0	3952
	Moderate	122	278	324	94	86	0	0	903
	Low	0	0	2	4	92	0	0	98
	Above target	0	0	0	5	149	0	0	154

Table B-14. Stream shading hazard (SSH) and zoning class by reach: North Fork Nooksack (area in acres, rounded to nearest acre).

Reach	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
1	High	0	0	16	57	1	0	0	74
	Moderate	0	0	0	0	0	0	0	0
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	0	0	0	0
2	High	0	0	80	102	27	0	0	208
	Moderate	0	0	0	0	0	0	0	0
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	0	0	0	0
3	High	0	0	32	53	91	2	0	179
	Moderate	0	0	5	6	0	14	0	25
	Low	0	0	0	10	0	0	0	10
	Above Target	0	0	0	0	0	0	0	0
4	High	0	0	0	0	0	57	0	57
	Moderate	1	0	0	0	0	108	0	109
	Low	0	0	0	0	0	19	0	19
	Above Target	0	0	0	0	0	0	0	0
5	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	135	0	135
	Low	0	0	0	0	0	83	0	83
	Above Target	0	0	0	0	0	30	0	30

Reach	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
6	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	18	0	18
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	0	34	0	34
Total North Fork Nooksack	High	0	0	128	212	119	59	0	518
	Moderate	1	0	5	6	0	275	0	288
	Low	0	0	0	10	0	102	0	112
	Above Target	0	0	0	0	0	64	0	64

Table B-15. Stream shading hazard (SSH) and zoning class by watershed: Tributaries to the North Fork Nooksack (area in acres, rounded to nearest acre).

Watershed	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Lower North Fork Nooksack	High	0	0	18	11	0	0	0	29
	Moderate	0	0	16	17	0	0	0	32
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	7	0	0	7
Bells	High	0	0	12	0	0	0	0	13
	Moderate	0	0	8	9	26	0	0	43
	Low	0	0	0	0	26	0	0	26
	Above Target	0	0	0	0	16	0	0	16
Kenny	High	0	0	0	0	0	0	0	0
	Moderate	0	0	19	9	36	0	0	64
	Low	0	0	6	5	24	0	0	35
	Above Target	0	0	4	3	9	0	0	16
Hamilton	High	0	0	0	8	8	0	0	15
	Moderate	0	0	0	0	26	0	0	26
	Low	0	0	7	0	5	0	0	13
	Above Target	0	0	0	0	8	0	0	8
Racehorse	High	0	0	0	8	2	0	0	11
	Moderate	0	0	0	4	94	0	0	98
	Low	0	0	0	6	75	0	0	81
	Above Target	0	0	0	0	4	0	0	4

Watershed	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Coal	High	0	0	0	0	11	0	0	11
	Moderate	0	0	8	2	46	0	0	56
	Low	0	0	0	0	8	0	0	8
	Above Target	0	0	0	0	2	0	0	2
Kendall	High	19	0	81	12	3	0	0	116
	Moderate	11	0	39	7	7	0	0	64
	Low	2	0	30	19	1	0	0	53
	Above Target	0	0	2	30	6	0	0	38
Slide Mountain	High	0	0	4	22	52	0	0	78
	Moderate	0	0	8	65	150	0	0	224
	Low	0	0	1	13	89	0	0	103
	Above Target	0	0	1	2	112	0	0	115
Maple	High	0	0	51	22	6	0	0	79
	Moderate	0	0	71	40	59	0	0	170
	Low	0	0	14	9	21	0	0	44
	Above Target	0	0	29	29	56	0	0	114
Boulder	High	0	0	0	9	0	0	0	9
	Moderate	0	0	0	13	6	0	0	19
	Low	0	0	0	1	0	0	0	1
	Above Target	0	0	0	0	2	0	0	2
Canyon	High	0	0	15	0	0	0	0	15
	Moderate	0	0	0	0	48	62	0	111
	Low	0	0	0	0	4	41	0	45
	Above Target	0	0	0	0	15	232	0	246

Watershed	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Hedrick	High	0	0	5	0	1	0	0	6
	Moderate	0	0	2	0	15	0	0	17
	Low	0	0	0	0	20	0	0	20
	Above Target	0	0	13	0	49	0	0	62
Cornell	High	0	0	0	0	1	0	0	1
	Moderate	0	0	11	5	45	0	0	61
	Low	0	0	0	0	55	10	0	65
	Above Target	0	0	0	0	26	20	0	46
Gallup	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	17	0	0	17
	Low	0	0	0	0	49	0	0	49
	Above Target	0	0	6	8	12	7	0	33
Glacier	High	20	0	0	2	3	17	0	42
	Moderate	2	0	0	1	4	90	0	97
	Low	0	0	14	0	25	64	0	104
	Above Target	1	0	9	0	64	84	27	185
Middle North Fork Nooksack	High	0	0	1	12	0	1	0	14
	Moderate	0	0	3	2	0	7	0	12
	Low	0	0	0	0	0	34	0	34
	Above Target	0	0	0	6	0	84	0	90
Deadhorse	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	14	0	14
	Low	0	0	0	0	0	3	0	3
	Above Target	0	0	0	0	0	0	0	0

Watershed	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Wells	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	32	0	32
	Low	0	0	0	0	0	60	6	66
	Above Target	0	0	0	0	0	67	69	137
Upper North Fork Nooksack	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	0	0	0
	Low	0	0	0	0	0	1	0	1
	Above Target	0	0	0	0	0	27	0	27
Anderson	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	48	0	48
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	0	62	56	118
Swamp	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	4	0	4
	Low	0	0	0	0	0	2	0	2
	Above Target	0	0	0	0	0	114	45	159
Bagley	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	6	5	11
	Low	0	0	0	0	0	19	3	22
	Above Target	0	0	0	0	0	69	1	69
Ruth	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	43	19	62
	Low	0	0	0	0	0	3	0	3
	Above Target	0	0	0	0	0	49	0	49

Watershed	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
White Salmon	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	0	0	0
	Low	0	0	0	0	0	5	1	5
	Above Target	0	0	0	0	0	25	22	46
Total North Fork Nooksack Tributaries	High	39	0	187	106	87	18	0	438
	Moderate	13	0	185	174	578	306	25	1280
	Low	2	0	72	53	402	242	9	782
	Above Target	1	0	66	77	389	838	220	1592

Table B-16. Stream shading hazard (SSH) and zoning class by reach: Middle Fork Nooksack (area in acres, rounded to nearest acre).

Reach	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
1	High	0	0	63	15	43	0	0	122
	Moderate	0	0	0	0	0	0	0	0
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	0	0	0	0
2	High	0	0	0	11	18	0	0	29
	Moderate	0	0	0	0	24	0	0	24
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	0	0	0	0
3	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	52	0	0	52
	Low	0	0	0	0	1	0	0	1
	Above Target	0	0	0	0	0	0	0	0
4	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	71	39	0	111
	Low	0	0	0	0	53	0	0	53
	Above Target	0	0	0	0	0	17	0	17
5	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	11	5	16
	Low	0	0	0	0	0	12	7	19
	Above Target	0	0	0	0	0	13	9	23
Total Middle Fork Nooksack	High	0	0	63	27	61	0	0	151
	Moderate	0	0	0	0	148	51	5	203
	Low	0	0	0	0	54	12	7	73
	Above Target	0	0	0	0	0	31	9	40

Table B-17. Stream shading hazard (SSH) and zoning class by watershed: Tributaries to the Middle Fork Nooksack (area in acres, rounded to nearest acre).

Watershed	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Canyon Lake	High	0	0	12	25	0	0	0	37
	Moderate	0	0	0	7	96	0	0	103
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	8	0	0	8
Lower Middle Fork Nooksack	High	0	0	41	68	37	0	0	146
	Moderate	0	0	18	19	34	0	0	72
	Low	0	0	7	7	27	0	0	41
	Above Target	0	0	0	2	24	0	0	26
Porter	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	6	12	0	0	18
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	0	0	0	0
Heislers	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	1	26	0	0	27
	Low	0	0	0	0	3	0	0	3
	Above Target	0	0	0	0	6	0	0	6
Clearwater	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	83	1	0	84
	Low	0	0	0	0	68	29	0	97
	Above Target	0	0	0	0	20	80	0	100

Watershed	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Middle Fork Diversion	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	27	2	0	29
	Low	0	0	0	0	39	4	0	43
	Above Target	0	0	0	0	119	1	0	120
Galbraith	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	0	0	0
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	5	0	0	5
Sister	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	6	26	2	33
	Low	0	0	0	0	0	0	1	2
	Above Target	0	0	0	0	17	0	0	17
Warm	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	0	0	0
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	34	43	0	77
Green	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	0	0	0
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	0	26	10	36
Rankin	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	1	0	1
	Low	0	0	0	0	0	1	0	1
	Above Target	0	0	0	0	0	9	0	9

Watershed	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Upper Middle Fork Nooksack	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	0	0	0
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	0	0	2	2
Ridley	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	0	0	0
	Low	0	0	0	0	0	0	21	21
	Above Target	0	0	0	0	0	0	5	5
Total Middle Fork Nooksack Tributaries	High	0	0	53	93	37	0	0	183
	Moderate	0	0	18	33	285	29	2	367
	Low	0	0	7	7	136	34	23	207
	Above Target	0	0	0	2	234	159	17	411

Table B-18. Stream shading hazard (SSH) and zoning class by reach: South Fork Nooksack (area in acres, rounded to nearest acre).

Reach	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
1	High	0	150	9	26	16	0	0	201
	Moderate	0	0	0	0	0	0	0	0
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	0	0	0	0
2	High	0	99	0	11	8	0	0	118
	Moderate	0	2	0	0	0	0	0	2
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	0	0	0	0
3	High	0	8	0	8	51	0	0	67
	Moderate	0	0	0	0	30	0	0	30
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	0	0	0	0
4	High	0	0	0	0	90	0	0	90
	Moderate	0	0	0	0	20	0	0	20
	Low	0	0	0	0	0	0	0	0
	Above Target	0	0	0	0	0	0	0	0
5	High	0	0	0	0	55	0	0	55
	Moderate	0	0	0	0	57	0	0	57
	Low	0	0	0	0	2	0	0	2
	Above Target	0	0	0	0	0	0	0	0

Reach	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
6	High	0	0	0	0	21	0	0	21
	Moderate	0	0	0	0	114	0	0	114
	Low	0	0	0	0	11	0	0	11
	Above Target	0	0	0	0	5	0	0	5
7	High	0	0	0	0	5	0	0	5
	Moderate	0	0	0	0	39	100	22	161
	Low	0	0	0	0	20	18	0	38
	Above Target	0	0	0	0	10	16	0	26
Total South Fork Nooksack	High	0	257	9	45	247	0	0	558
	Moderate	0	2	0	0	260	100	22	384
	Low	0	0	0	0	33	18	0	51
	Above Target	0	0	0	0	15	16	0	31

Table B-19. Stream shading hazard (SSH) and zoning class by watershed: Tributaries to the South Fork Nooksack (area in acres, rounded to the nearest acre).

Watershed	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Black Slough	High	0	102	7	3	2	0	0	114
	Moderate	0	33	23	36	47	0	0	138
	Low	0	1	4	12	25	0	0	42
	Above target	0	28	9	11	47	0	0	95
Lower South Fork Nooksack	High	0	12	16	7	11	0	0	47
	Moderate	0	34	54	39	137	0	0	264
	Low	0	0	13	16	51	0	0	80
	Above target	0	10	21	24	12	0	0	67
South Acme Area	High	0	40	13	5	20	0	0	78
	Moderate	0	38	13	9	67	0	0	127
	Low	0	14	9	3	26	0	0	52
	Above target	0	47	3	10	42	0	0	101
Hutchinson	High	0	0	12	28	104	0	0	144
	Moderate	0	0	44	27	193	0	0	264
	Low	0	0	18	6	64	0	0	88
	Above target	0	0	11	7	217	0	0	235
Saxon	High	0	2	0	0	20	0	0	22
	Moderate	0	0	0	0	2	0	0	2
	Low	0	0	0	0	8	0	0	8
	Above target	0	0	0	0	0	0	0	0

Watershed	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Skookum	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	153	0	0	153
	Low	0	0	0	0	105	4	0	109
	Above target	0	0	0	0	109	5	0	115
Edfro	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	12	0	0	12
	Low	0	0	0	0	29	0	0	29
	Above target	0	0	0	0	76	0	0	76
Cavanaugh	High	0	0	0	0	4	0	0	4
	Moderate	0	0	0	0	34	0	0	34
	Low	0	0	0	0	44	0	0	44
	Above target	0	0	0	0	119	0	0	119
Dye	High	0	0	0	0	50	0	0	50
	Moderate	0	0	0	0	75	0	0	75
	Low	0	0	0	0	73	0	0	73
	Above target	0	0	0	0	61	0	0	61
Deer, Roaring, & Plumbago	High	0	0	0	0	30	0	0	30
	Moderate	0	0	0	0	101	0	0	101
	Low	0	0	0	0	19	0	0	19
	Above target	0	0	0	0	23	0	0	23

Watershed	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Upper South Fork Nooksack – West	High	0	0	0	0	26	0	0	26
	Moderate	0	0	0	0	85	0	0	85
	Low	0	0	0	0	37	0	0	37
	Above target	0	0	0	0	72	0	0	72
Howard	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	18	0	0	18
	Low	0	0	0	0	37	0	0	37
	Above target	0	0	0	0	59	0	0	59
Upper South Fork Nooksack – East	nd	0	0	0	0	19	0	0	19
	High	0	0	0	0	2	0	0	2
	Moderate	0	0	0	0	166	27	0	193
	Low	0	0	0	0	84	11	0	95
	Above target	0	0	0	0	100	27	0	127
Wanlick	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	39	0	39
	Low	0	0	0	0	0	22	0	22
	Above target	0	0	0	0	0	64	0	64
Heart Lake Area	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	11	9	20
	Low	0	0	0	0	0	0	7	7
	Above target	0	0	0	0	0	11	8	19

Watershed	SSH	Urban	Agricult.	Rural	Rural Forest	Commercial Forest	Federal Forest	Federal Park	Total
Bell	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	20	0	20
	Low	0	0	0	0	0	7	0	7
	Above target	0	0	0	0	0	47	0	47
Elbow Lake	High	0	0	0	0	0	0	0	0
	Moderate	0	0	0	0	0	8	6	14
	Low	0	0	0	0	0	10	5	15
	Above target	0	0	0	0	0	13	23	36
Total South Fork Nooksack Tributaries	Nd	0	0	0	0	19	0	0	19
	High	0	156	48	44	268	0	0	515
	Moderate	0	105	133	111	1088	104	15	1557
	Low	0	15	44	37	601	54	11	763
	Above target	0	85	44	52	937	169	30	1316

Table B-20. Channel migration zone areas (acres) identified in mainstem reaches of the Nooksack River watershed.

Subbasin	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Reach 7
Mainstem	1570	0	280	1517			
North Fork	522	707	498	114	66	17	
Middle Fork	489	12	0	0	0		
South Fork	219	210	28	0	0	0	56

Table B-21. Channel migration zone areas (rounded to nearest acre) identified in tributary watersheds of the Nooksack River watershed.

Watershed	Mainstem Subbasin	North Fork Subbasin	Middle Fork Subbasin	South Fork Subbasin
Scott	15			
Silver	70			
Tenmile	69			
Wiser Lake/Cougar Creek	113			
Anderson		63		
Bagley		10		
Canyon		63		
Glacier		117		
Hamilton		2		
Kenny		5		
Maple		180		
Middle North Fork		16		
Swamp		36		
Upper North Fork		22		
Wells		66		
Canyon Lake			38	
Lower Middle Fork			53	
Cavanaugh				9
Dye				5
Edfro				21
Hutchinson				39
Skookum				21
South Acme				16
Wanlick				18