Accuracy of Chugach National Forest Land Cover Maps

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Landcover/existing vegetation maps are fundamental, basic data needed for natural resource management. Such maps are useful in a wide range of applications including land management planning, ecosystem assessment, inventory, wildlife habitat assessment, rare and sensitive species modeling, invasive species modeling, recreational activity management, and climate change analyses.

As identified in the "2011 Information Needs Assessment" [1], this project evaluated existing land cover/vegetation maps for accuracy and utility for land management planning applications on the Chugach National Forest. Four Forest-wide classifications, two Copper River Delta classifications, and three Kenai Peninsula classifications were evaluated.

Specifically, the Forest-wide classifications are:
1. **NLCD** – based on satellite imagery representing 2001 conditions (Selkowitz and Stehman 2011).
2. **Cover Type** – derived from timber typing based on interpretation of air photos from the 1950s to the 1970s (Chugach NF GIS).
3. **LANDFIRE EVT** – existing vegetation cover based on satellite imagery from around 2000 (http://www.landfire.gov/notifications23.php).
4. **Landcov 1996** – based on satellite imagery from 1977 to 1991 (Markon and Williams 1996).

The Copper River Delta (CRD) classifications are:
1. **CRD 2011** – based on satellite imagery from 2009 (DRAFT; to be completed in mid 2012).
2. **CRD 1994** – based on satellite imagery from 1989 (Ducks Unlimited, Inc. 1994).

The Kenai Peninsula (KP) classifications are:
1. **KP 2006** – based on satellite imagery from 2002 (O'Brien 2006).
2. **Borough Veg** – based on air photo interpretation from 1996 through 2001 (Kenai Peninsula Borough Spruce Bark Beetle Task Force 2003).
3. **KP 1999** – based on satellite imagery from 1989 (Ducks Unlimited and Spatial Solutions 1999).

Methods

Classification accuracy was estimated by comparing the mapped classes against actual vegetation composition as documented in the following "reference" datasets:

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[1] http://fsweb.chugach.r10.fs.fed.us/program/res/infoneeds/

- **FIA** – 308 center points (point 1 of 4 at each location) sampled in the 1999 Forest Inventory and Analysis (FIA) periodic inventory that are within the Chugach National Forest. Caveat - FIA data are collected on a systematic grid (4.8 km, 3 mile) and were not intended to represent map units. Many of these grid points do not fall within the core of vegetation map polygons.
- **ecoplots** – 2177 plots sampled between 1988 and 1999 within the Chugach National Forest that were used in the development of a plant community type classification (DeVelice et al. 1999) and other ecology program applications. Caveat - Geographic position errors are likely in at least some of these data since the positions were obtained not by GPS but by transferring the sampling points from aerial photos to orthophotos.
- **CRDsites** – 503 sites sampled from helicopter or on the ground in 2010 as part of the Copper River Delta vegetation mapping project.

The mapped classes and reference classes were cross-walked into the more generalized "Level II" of the Alaska vegetation classification (Viereck et al. 1992; Table 1 and Appendix A). "Level II" is being used since it is possibly the coarsest level of classification that would still be of utility in land management planning applications.

Results and Discussion

The number of land cover classes represented among the nine maps varied from 13 to 65 (CRD 2011 and LANDFIRE EVT, respectively; Appendix A). Cross-walking the mapped classes to level II of the Alaska vegetation classification condensed the range from a low of five to a high of 11 (Table 2; Appendix A)[2].

The overall accuracy of the maps varied from 97 percent in CRD 2011 to 19 percent in LANDFIRE EVT, based on the CRDsites reference data (Table 2; Appendix B). The high accuracy of CRD 2011 when evaluated against the 2010 reference data is not surprising since a set of those data had also been used for image training[3]. As an example of the errors in LANDFIRE EVT, of 500 reference points among CRDsites, 49 are classified as needleleaf forest, but LANDFIRE EVT erroneously mapped 207 points as needleleaf forest (Appendix B).

In addition to problems associated with the caveats mentioned in the "Methods" section (above), some of the "errors" between the map classes and the reference data may be due to vegetation changes between the dates the reference data was collected and the air photo and satellite image dates used in the mapping. However, it seems unlikely that the limitations of the reference data are of sufficient magnitude to affect accuracy rank.

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[2] In general, as the number of classes is reduced in the evaluation of a given map the accuracy is expected to increase. In the one case where this was tested, the accuracy of LANDFIRE EVT based on the FIA reference data was 39 percent with 10 classes (Table 2; Appendix B) and 47 percent with seven classes.

[3] Overall accuracy of CRD 2011 based on FIA and ecoplot data (Table 2; Appendix B), is 44 and 49 percent, respectively.

Of the four Forest-wide classifications evaluated, the highest overall accuracy was estimated for the National Land Cover Database (NLCD; Table 2). In fact, NLCD was the only map where overall accuracy exceeded 60 percent against all reference data sets.[4]

Although not quantitatively evaluated, the satellite image based classifications appear to capture the fine scale pattern of vegetation on the landscape better than the Forest-wide air photo interpreted maps (figures 1, 2, and 3).

Conclusions

Of the Forest-wide classifications, NLCD and LANDFIRE EVT have appeal in that they are national products that provide seamless coverage across Alaska. Such coverage would facilitate analyses of Chugach National Forest land cover in a broader ecoregional context.

NLCD represents the best available land cover classification spanning the Chugach National Forest (Figure 4). It remains to be determined if NLCD's classification of 19 land cover types (Table 3) is rich enough to meet the range of application needs on the Forest. For the Copper River Delta portion of the Forest, the CRD 2011 mapping is currently being revised and will be finalized in 2012. **The revised CRD 2011 mapping will likely be the best available for use in Copper River Delta applications.**

LANDFIRE EVT has a rich classification of 65 types; however, low accuracy likely makes the map of limited utility to managers on the Chugach National Forest[5]. Although LANDFIRE EVT accuracy was less than 50 percent against all reference data sets, the general pattern of the vegetation on the landscape appears to be captured and, potentially, the mapped classes could be reattributed to improve accuracy.

Some Potential Next Steps

1. A team representing plant ecology, wildlife biology, and vegetation management specialties convenes to evaluate the utility of NLCD towards meeting landcover analysis needs in Chugach Forest plan revision.

2. Coordinate with Michael Fleming from "Images Unlimited" in his work on creating an Alaska Existing Vegetation Type (AKEVT) map to maximize the utility of that mapping for southcentral Alaska applications. Currently 74 classes are being mapped in the AKEVT layer. Potentially, the products generated from this work may meet the existing vegetation mapping needs of the Forest.

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[4] Accuracy of NLCD in the "Coastal Rainforest" region of southcentral and southeast Alaska (including the area of the Chugach NF) was estimated at about 88 percent by Selkowitz and Stehman (2011).
[5] Boucher et al. (2009) also report low accuracy in LANDFIRE EVT in Alaska.

3. Detailed mapping of vegetation types and fine scale pattern from air photos has been done for portions of the Forest, e.g., ecological mapping units (EMU; Figure 2) and Potyondy (1974; Figure 3). With availability of the new Forest-wide digital orthophotos, the images used to produce the orthophotos, and 3D viewing and Stereo Analyst capabilities we can efficiently produce Terrestrial Ecological Unit Inventory (TEUI) map products down to the landtype phase level. Landtype and landtype phase maps are used for comprehensive forest plan revisions, watershed assessments, burned area emergency rehabilitation efforts, wildlife habitat analysis, and project level implementation and analysis. Interpretations developed from the data are valuable for depicting land capability and potentials (Winthers et al. 2005). If such mapping cannot be accomplished as part of Forest plan revision it may be desirable to initiate it as a separate effort.

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Table 1. Alaska vegetation classification (Viereck et al. 1992) to level II[6]. See Appendix A for cross-walks of the nine cover classifications to the level II classes.

Level I	Level II	Code
I. Forest	A. Needleleaf (conifer) forest	I.A
	B. Broadleaf forest	I.B
	C. Mixed forest	I.C
II. Scrub	A. Dwarf tree scrub	II.A
	B. Tall scrub	II.B
	C. Low scrub	II.C
	D. Dwarf scrub	II.D
III. Herbaceous	A. Graminoid herbaceous	III.A
	B. Forb herbaceous	III.B
	C. Bryoid herbaceous	III.C
	D. Aquatic herbaceous	III.D
IV. non-vegetated *(not included in Alaska Vegetation Classification)*		IV

[6] See http://www.fs.fed.us/pnw/publications/pnw_gtr286/

Table 2. Overall accuracy of the nine land cover maps evaluated based on comparing the mapped classes against actual vegetation composition as documented in three reference datasets. The number of land cover classes evaluated in each comparison is also shown. See Appendix B for detailed accuracy matrices comparing each of the mapped classes against the reference datasets.

Map	Overall Accuracy (%) reference dataset			# of classes reference dataset			Overall Rank
	FIA	ecoplots	CRDsites	FIA	ecoplots	CRDsites	
Forest-wide							
NLCD	62	62	65	7	8	7	1
Cover Type	60	66	44	7	7	7	2
LANDFIRE EVT	39	44	19	10	11	11	3
Landcov 1996	37	43	22	10	10	8	3
Copper River Delta							
CRD 2011	44	49	97	9	9	8	1
CRD 1994	47	43	29	5	7	6	2
Kenai Peninsula							
KP 2006	52	57	-	8	8	-	1
Borough Veg	48	53	-	8	8	-	2
KP 1999	46	50	-	7	7	-	3

Table 3. National Land Cover Database (NLCD) class descriptions (Table 1 from Selkowitz and Stehman 2011) for the 19 classes represented on the Chugach National Forest. The numbers are the "value" field in the database.

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11. **Open water** — All areas of open water, generally with less than 25 percent cover of vegetation or soil.

12. **Perennial ice/snow** — All areas characterized by a perennial cover of ice and/or snow, generally greater than 25% of total cover.

21. **Developed, open space** — Includes areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes

22. **Developed, low intensity** — Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20–49% of total cover. These areas most commonly include single-family housing units.

23. **Developed, medium intensity** — Includes areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50–79% of the total cover. These areas most commonly include single-family housing units.

24. **Developed, high intensity** — Includes highly developed areas where people reside or work in high numbers. Examples include apartment complexes, row houses, and commercial/industrial. Impervious surfaces account for 80 to 100% of the total cover.

31. **Barren land** (rock/sand/clay) — Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.

41. **Deciduous forest** — Areas dominated by trees generally greater than 5-m tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.

42. **Evergreen forest** — Areas dominated by trees generally greater than 5-m tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.

43. **Mixed forest** — Areas dominated by trees generally greater than 5-M tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.

51. **Dwarf scrub** — Alaska only areas dominated by shrubs less than 20-cm tall with shrub canopy typically greater than 20% of total vegetation. This type is often co-associated with grasses, sedges, herbs, and non-vascular vegetation.

52. **Shrub/scrub** — Areas dominated by shrubs; less than 5-m tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.

71. **Grassland/herbaceous** — Areas dominated by graminoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing.
72. **Sedge/herbaceous** — Alaska only areas dominated by sedges and forbs, generally greater than 80% of total vegetation. This type can occur with significant other grasses or other grass like plants, and includes sedge tundra, and sedge tussock tundra.
74. **Moss** — Alaska only areas dominated by mosses, generally greater than 80% of total vegetation.
81. **Pasture/hay** — Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
82. **Cultivated crops** — Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
90. **Woody wetlands** — Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
95. **Emergent herbaceous wetlands** — Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

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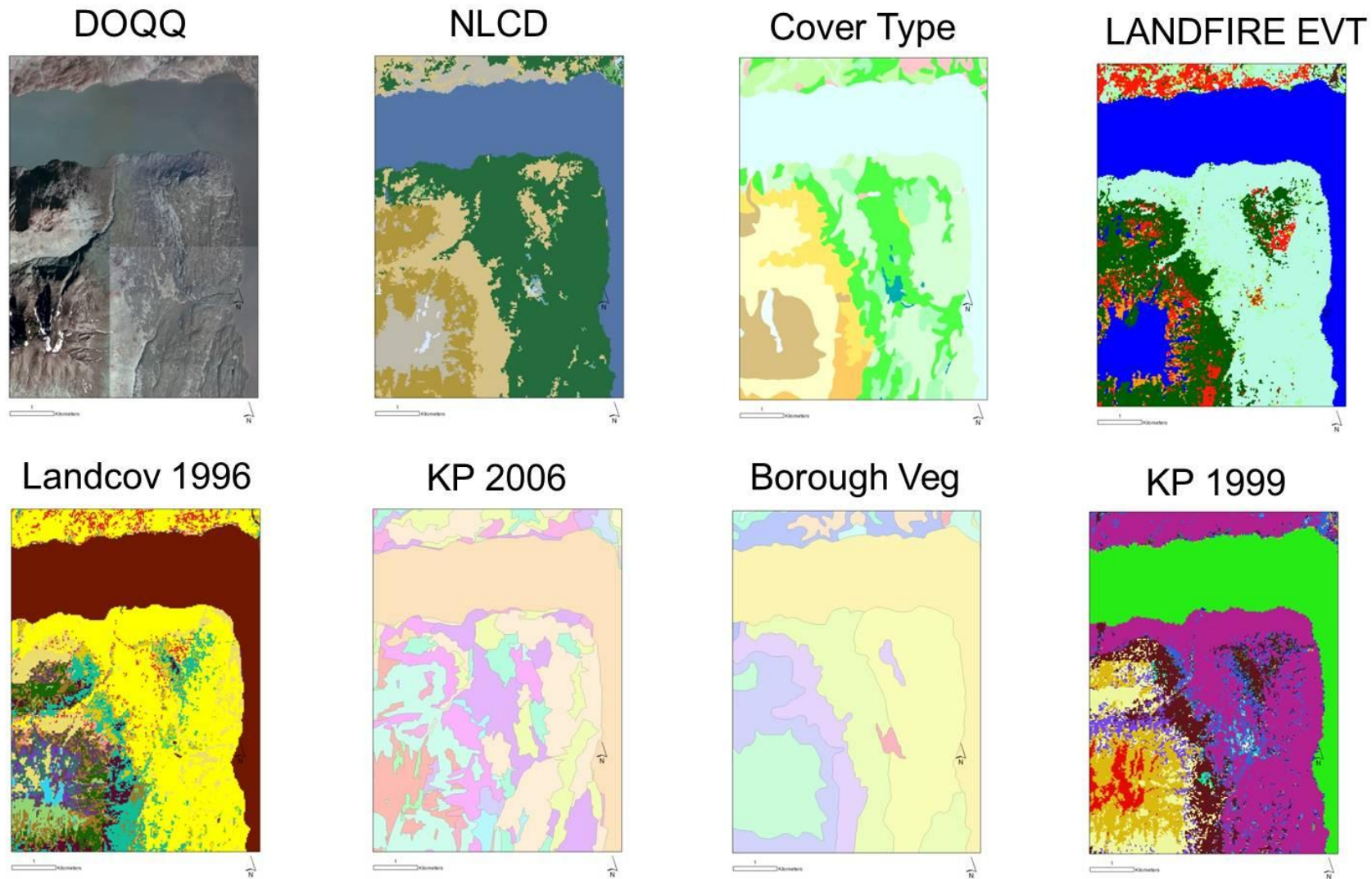
Figure 1. Comparative graphics of seven land cover maps in relation to an orthophoto (DOQQ) of a portion of the Black Mountain area on the Kenai Peninsula.
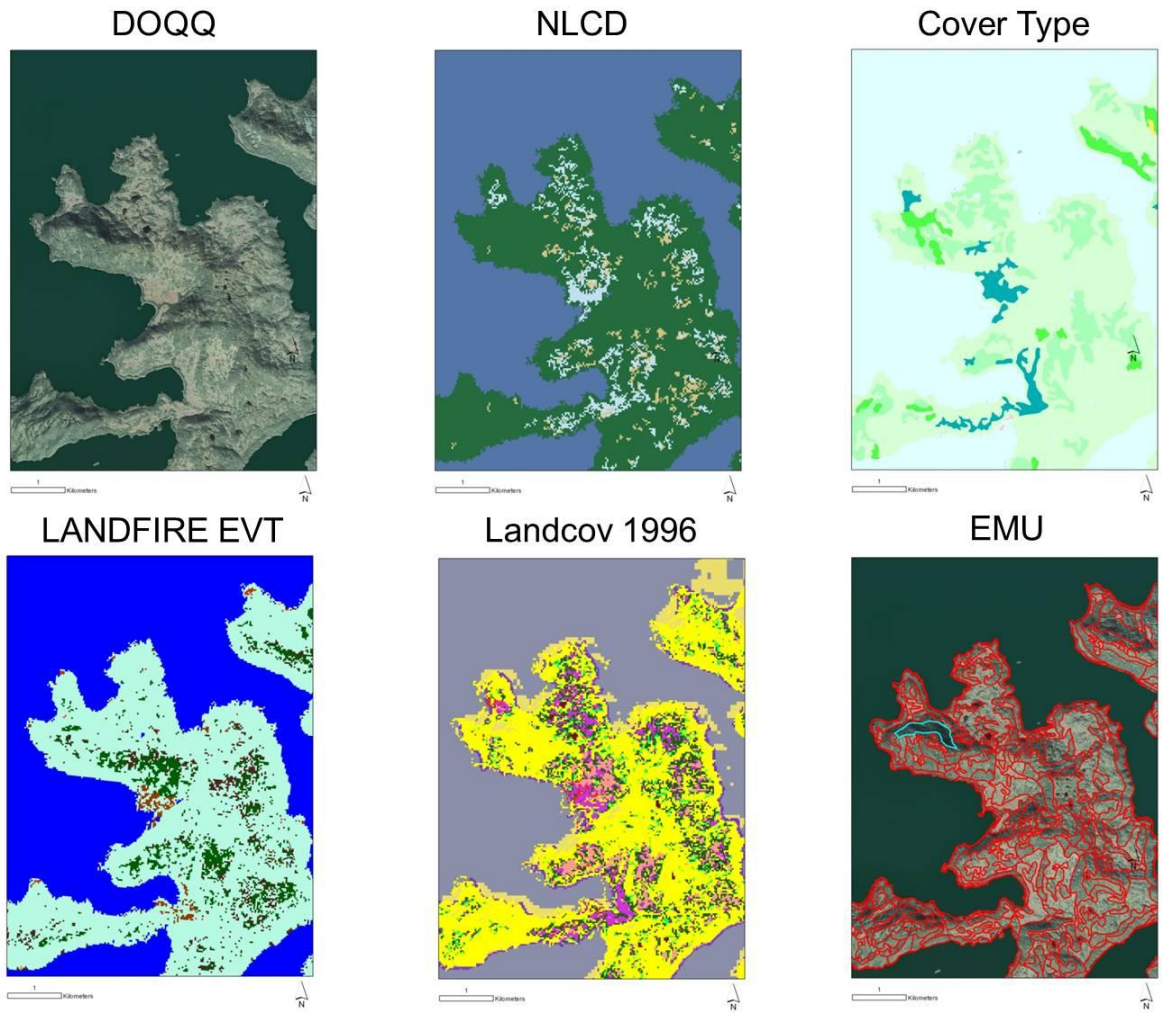
Figure 2. Comparative graphics of five land cover maps in relation to an orthophoto (DOQQ) of a portion of Naked Island in Prince William Sound. The polygon selected in the EMU map (Ecological Mapping Units; Chugach NF GIS) is of the *Tsuga mertensiana/Vaccinium ovalifolium-Echinopanax horridum* plant community type.
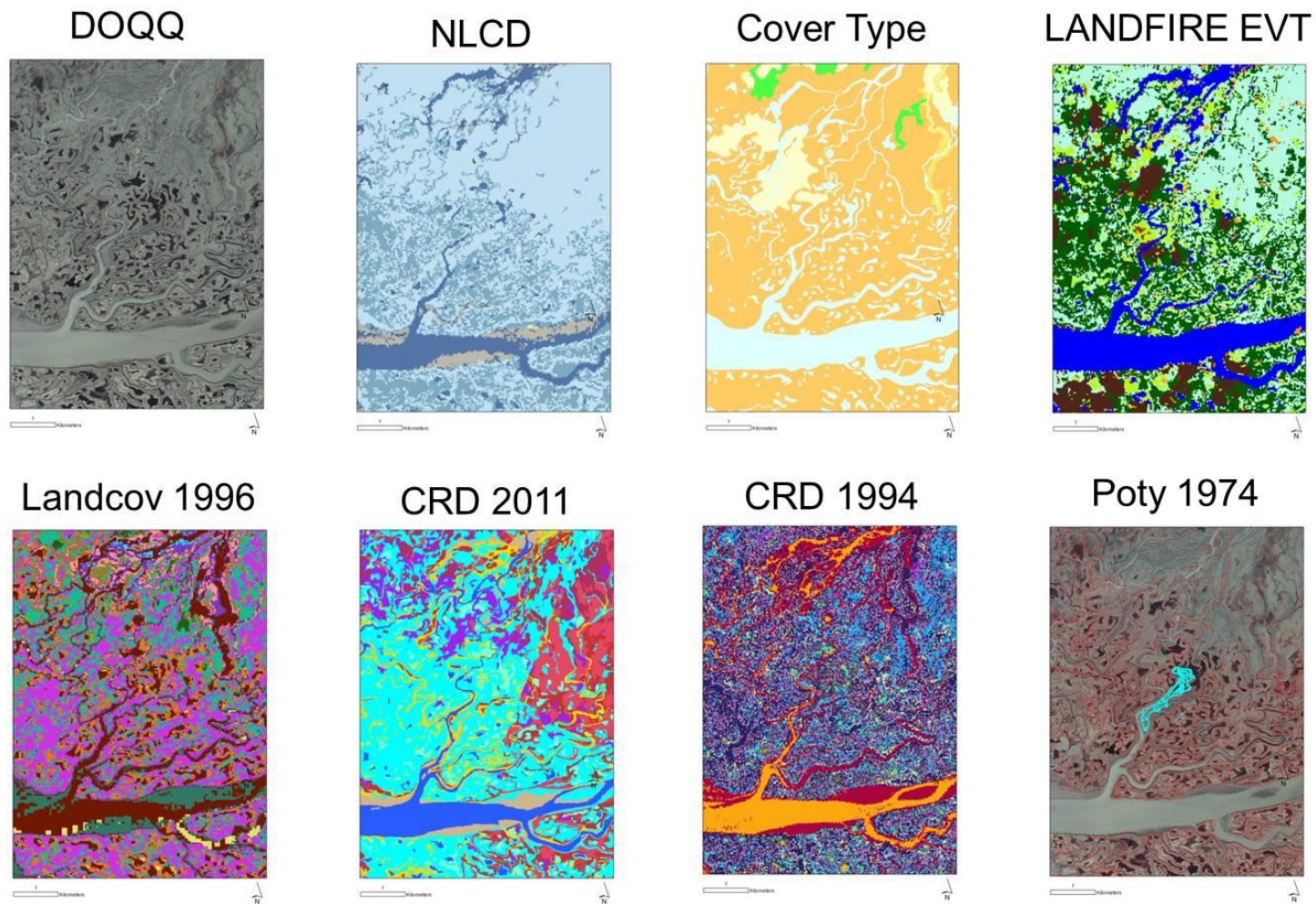
Figure 3. Comparative graphics of seven land cover maps in relation to an orthophoto (DOQQ) of a portion of the Tiedeman Slough area on the Copper River Delta. The polygon selected in the Poty 1974 map (Potyondy 1974) is of the sedge vegetation type.
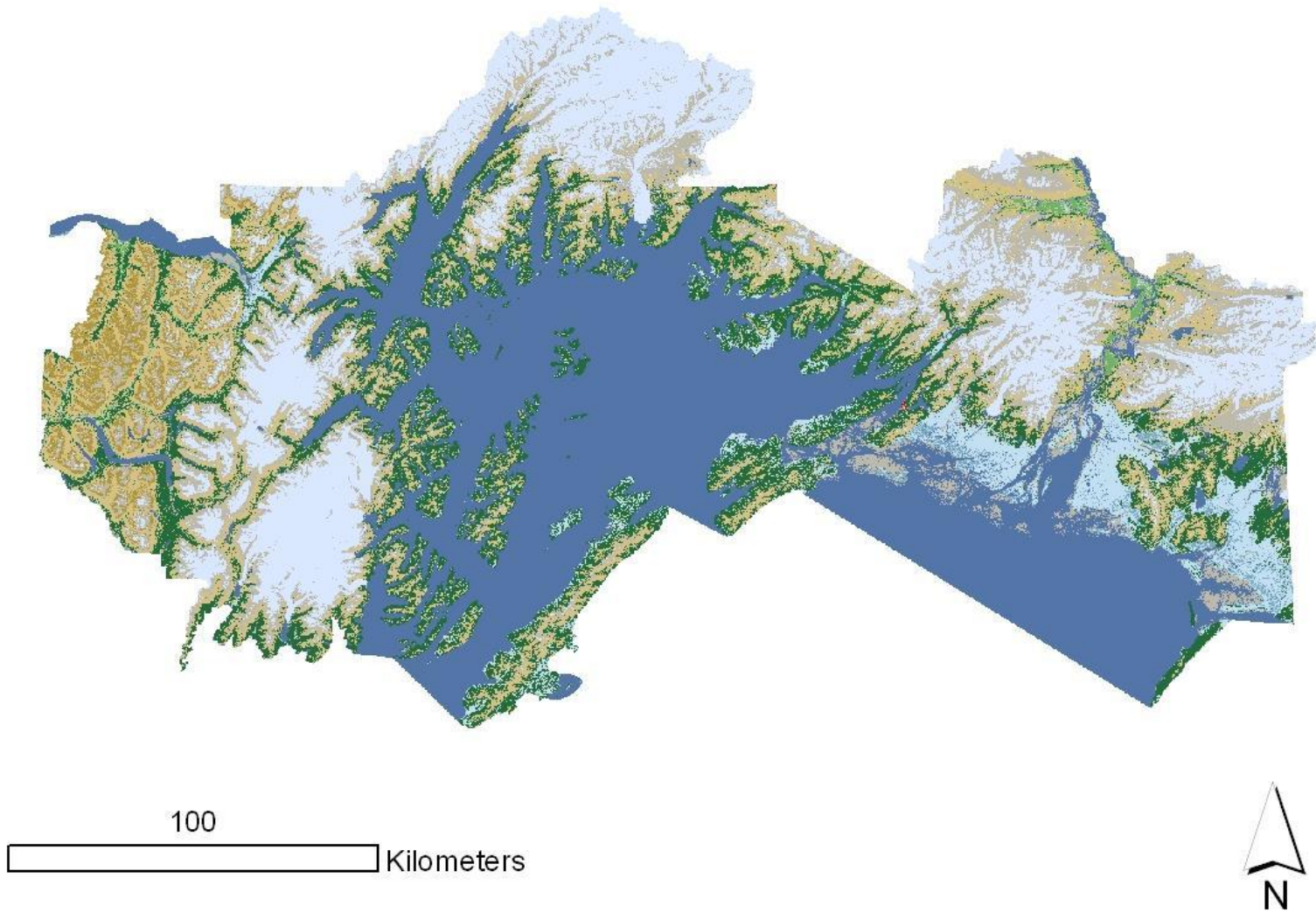
Figure 4. National Land Cover Database (NLCD) mapping across the Chugach National Forest.

Appendix A

Classes mapped in the nine land cover maps cross-walked to level II of the Alaska vegetation classification (see Table 1 for definitions of level II codes).

NLCD

LAND_COVER	LEVEL2
Evergreen Forest	I.A
Deciduous Forest	I.B
Mixed Forest	I.C
Shrub/Scrub	II.A+B+C
Woody Wetlands	II.A+B+C
Dwarf Shrub	II.D
Emergent Herbaceous Wetlands	III.A+B
Grassland/Herbaceous	III.A+B
Sedge/Herbaceous	III.A+B
Moss	III.C
Barren Land	IV
Cultivated Crops	IV
Developed, High Intensity	IV
Developed, Low Intensity	IV
Developed, Medium Intensity	IV
Developed, Open Space	IV
Open Water	IV
Pasture/Hay	IV
Perennial Ice/Snow	IV

Cover Type

COVER_TYPE	LEVEL2
BLACK SPRUCE	I.A
HEMLOCK	I.A
HEMLOCK-SPRUCE	I.A
SITKA SPRUCE	I.A
WHITE SPRUCE	I.A
NONSTOCKED	I.A or II.B
ASPEN	I.B
BIRCH	I.B
COTTONWOOD	I.B
MIXED HARDWOOD-SOFTWOOD	I.C
ALDER	II.B
OTHER BRUSH	II.B
WILLOW	II.B
GRASS AND ALPINE	II.C+D or IIIA+B
MUSKEG MEADOW	II.C+D or IIIA+B
OTHER NONFORESTED	IV
ROCK	IV
SALT WATER	IV
SNOW AND ICE	IV
WATER	IV

LANDFIRE EVT

EVT_NAME	LEVEL2
Alaska Sub-boreal Mountain Hemlock-White Spruce Forest	I.A
Alaska Sub-boreal White-Lutz Spruce Forest and Woodland	I.A
Alaskan Pacific Maritime Mountain Hemlock Forest	I.A
Alaskan Pacific Maritime Sitka Spruce Beach Ridge	I.A
Alaskan Pacific Maritime Sitka Spruce Forest	I.A
Alaskan Pacific Maritime Subalpine Mountain Hemlock Woodland	I.A
Alaskan Pacific Maritime Western Hemlock Forest	I.A
Boreal Coniferous Woody Wetland	I.A
Boreal Coniferous-Deciduous Woody Wetland	I.A
Pacific Maritime Coniferous Woody Wetland	I.A
Pacific Maritime Peatlands	I.A
Western North American Boreal Mesic Black Spruce Forest	I.A
Western North American Boreal Treeline White Spruce Woodland	I.A
Western North American Boreal White Spruce Forest	I.A
Boreal Floodplains	I.B
Boreal Riparian Stringer Forest and Shrubland	I.B
Pacific Maritime Floodplains	I.B
Western North American Boreal Dry Aspen-Steppe Bluff	I.B
Western North American Boreal Mesic Birch-Aspen Forest	I.B
Western North American Boreal Subalpine Balsam Poplar-Aspen Woodland	I.B
Alaska Sub-boreal White Spruce-Hardwood Forest	I.C
Western North American Boreal White Spruce-Hardwood Forest	I.C
Alaskan Pacific Maritime Periglacial Woodland and Shrubland	II.A
Western North American Boreal Spruce-Lichen Woodland	II.A
Alaska Sub-boreal Avalanche Slope Shrubland	II.B
Alaska Sub-boreal Mesic Subalpine Alder Shrubland	II.B
Alaskan Pacific Maritime Avalanche Slope Shrubland	II.B
Boreal Shrub Swamp	II.B
Pacific Maritime Shrub Swamp	II.B
Western North American Boreal Mesic Scrub Birch-Willow Shrubland	II.B
Alaskan Pacific Maritime Subalpine Alder-Salmonberry Shrubland	II.C
Alaskan Pacific Maritime Subalpine Copperbush Shrubland	II.C
Boreal Shrub-Tussock Tundra	II.C
Alaskan Pacific Maritime Alpine Dwarf-Shrubland	II.D
Alaskan Pacific Maritime Alpine Sparse Shrub and Fell-field	II.D
Boreal Dwarf Shrub Wetland	II.D
Boreal Peatlands	II.D
Pacific Maritime Dwarf Shrub Wetland	II.D
Western North American Boreal Alpine Dryas Dwarf-Shrubland	II.D
Western North American Boreal Alpine Dwarf-Shrub Summit	II.D

Western North American Boreal Alpine Dwarf-Shrub-Lichen Shrubland	II.D
Western North American Boreal Alpine Ericaceous Dwarf-Shrubland	II.D
Boreal Herbaceous Wetlands	III.A
Boreal Tussock Tundra	III.A
Pacific Maritime Coastal Meadows and Slough-Levee	III.A
Pacific Maritime Herbaceous Wetlands	III.A
Western North American Boreal Dry Grassland	III.A
Western North American Sub-boreal Mesic Bluejoint Meadow	III.A
Alaska Sub-boreal and Maritime Alpine Mesic Herbaceous Meadow	III.B
Alaskan Pacific Maritime Mesic Herbaceous Meadow	III.B
Western North American Boreal Alpine Mesic Herbaceous Meadow	III.B
Boreal Aquatic Beds	III.D
Agriculture-Cultivated Crops and Irrigated Agriculture	IV
Agriculture-Pasture and Hay	IV
Barren	IV
Boreal Sparsely Vegetated	IV
Developed-High Intensity	IV
Developed-Low Intensity	IV
Developed-Medium Intensity	IV
Developed-Open Space	IV
Open Water	IV
Pacific Maritime Sparsely Vegetated	IV
Snow-Ice	IV
Temperate Pacific Tidal Marshes, Aquatic Beds, and Intertidal Flats	IV

Landcov 1996

RASTERVALU	DESCRIPTION	LEVEL2
1	Closed Needleleaf Forest	I.A
2	Open Needleleaf Forest	I.A
3	Needleaf Woodland	I.A
4	Closed Broadleaf Forest	I.B
5	Open Broadleaf Forest	I.B
7	Closed Mixed Forest	I.C
8	Open Mixed Forest	I.C
11	Dwarf Tree Scrub	II.A
13	Closed Tall Scrub	II.B
14	Open Tall Scrub	II.B
15	Closed Low Scrub	II.C or D
16	Open Low Scrub	II.C or D
17	Dry/Mesic Graminoid/Forb	III.A or B
19	Wet Graminoid/Forb	III.A or B
23	Moss	III.C
24	Lichen	III.C
25	Fresh Aquatic	III.D
26	Brackish Aquatic	III.D
28	Clear Water	IV
29	Turbid Water	IV
33	Bedrock or Unconsolidated	IV
35	Sand/Mud	IV
36	Ice/Snow/Clouds	IV
39	Sparsely Vegetated	IV

CRD 2011

LABEL	LEVEL2
Sitka Spruce	I.A
Western Hemlock	I.A
Black Cottonwood	I.B
Spruce - Cottonwood	I.C
Sitka Alder	II.B
Sitka Alder - Willow	II.B
Willow	II.B
Sweetgale	II.C
Dry Graminoid	III.A (merged into III.A or B)
Mesic Wet Herbaceous	III.A or B
Aquatic Herbaceous	III.D
Clear Water	IV
Sparse/Unvegetated	IV

CRD 1994

CLASSDESCR	LEVEL2
Closed Needleleaf Forest	I.A (merged into I.A+B+C+II.B)
Cottonwood/Alder/Willow	I.A+B+C+II.B
Mixed Trees/Shrubs	I.A+B+C+II.B
Open Needleleaf Forest	I.A (merged into I.A+B+C+II.B)
Salmonberry/Fern	II.C
Sweetgale	II.C
Aquatic Emergent	III.A+B
Herb Graminoid	III.A+B
Bryoid	III.C
Aquatic Submergent	III.D
Bare Ground	IV
Clear Water	IV
Snow/Ice/Clouds	IV
Turbid Water	IV

KP 2006

LC_CODE	LC_CLASS	LEVEL2
1	Black spruce	I.A
2	White/Lutz/Sitka spruce	I.A
3	Mountain hemlock	I.A
4	Mixed conifer	I.A
5	Aspen	I.B
6	Paper birch	I.B
7	Black cottonwood (balsam poplar)	I.B
8	Mixed deciduous	I.B
9	Mixed forest	I.C
10	Alder	II.B
11	Willow	II.B
12	Alder/Willow	II.B
13	Other shrub	II.C
17	Wetland - shrub	II.C
15	Alpine	II.D
14	Herbaceous	III.A+B
16	Wetland - graminoid	III.A+B
18	Wetland - halophytic	III.A+B
19	Stream	IV
20	Lake	IV
21	Estuarine	IV
22	Snow/Ice	IV
23	Sparsely vegetated	IV
24	Barren/Rock	IV
25	Barren - wet	IV
26	Urban/Cultural	IV

Borough Veg (at FIA points)

CODE	LEVEL2
DSS3MH3C	I.A
DWS3C	I.A
DWS3MH2C	I.A
DWS3MH2O	I.A
DWS3MH3O	I.A
DWS3W	I.A
MH2C	I.A
MH3C	I.A
MH3DWS3C	I.A
MH3O	I.A
MH3WS3DWS3C	I.A
MH3WS3DWS3O	I.A
SS3C	I.A
SS3DSS3MH3C	I.A
SS3MH3O	I.A
WS3DWS3C	I.A
WS3DWS3MH2C	I.A
WS3DWS3O	I.A
AB1C	I.B
AB2C	I.B
AB3DWS3O	I.C
AB3WS3C	I.C
CW3WS3DWS3O	I.C
CW3WS3O	I.C
WS3AB3O	I.C
WS3B2O	I.C
ALD	II.B
WIL	II.B
ALP	II.D
GH	III.A+B
BN	IV

ALD = alder; ALP = alpine; A = aspen; B = birch; BN = barren/snow & ice; CW = cottonwood; D = dead; GH = grass & herb; MH = mountain hemlock ; SS = Sitka spruce; WIL = willow; WS = white spruce.

Borough Veg (at ecoplots)

CODE	LEVEL2
BS2O	I.A
DSS3MH2C	I.A
DSS3MH3C	I.A
DSS3SS3MH3C	I.A
DWS2C	I.A
DWS2MH2O	I.A
DWS3MH2C	I.A
DWS3MH2O	I.A
DWS3MH3C	I.A
DWS3MH3O	I.A
HVST	I.A
HVST/WS3O	I.A
MH2C	I.A
MH2O	I.A
MH2W	I.A
MH2WS2DWS3O	I.A
MH3C	I.A
MH3DSS3C	I.A
MH3DWS3C	I.A
MH3DWS3W	I.A
MH3WS3DWS3C	I.A
MH3WS3DWS3O	I.A
SS2C	I.A
SS3C	I.A
SS3MH3C	I.A
SS3MH3O	I.A
WS3DWS3C	I.A
WS3DWS3MH2C	I.A
WS3DWS3MH2O	I.A
WS3DWS3O	I.A
WS3O	I.A
A1O	I.B
AB1C	I.B
AB1O	I.B
AB2C	I.B
AB2O	I.B
AB2W	I.B
AB3C	I.B
B2C	I.B
B2O	I.B
CW2C	I.B
CW2O	I.B
CW3O	I.B

A2WS2O	I.C
A3CW3WS3C	I.C
A3DWS3O	I.C
AB2DWS3C	I.C
AB2WS2C	I.C
AB2WS2O	I.C
AB3BS2C	I.C
AB3BS2O	I.C
AB3DWS3C	I.C
AB3WS3C	I.C
AB3WS3O	I.C
B2C/WS1	I.C
B3DWS3C	I.C
B3WS3C	I.C
B3WS3DWS3C	I.C
CW3DWS3O	I.C
CW3WS3C	I.C
CW3WS3O	I.C
DWS3A2B2C	I.C
DWS3AB3O	I.C
WS3AB3O	I.C
WS3DWS3B3C	I.C
ALD	II.B
WIL	II.B
ALP	II.D
GH	III.A+B
BN	IV
W	IV

ALD = alder; ALP = alpine; A = aspen; B = birch; BN = barren/snow & ice; BS = black spruce; CW = cottonwood; D = dead; GH = grass & herb; HVST = harvest area; MH = mountain hemlock ; SS = Sitka spruce; WIL = willow; WS = white spruce.

KP 1999

VALUE	CLASS	LEVEL2
1	CLEAR WATER	IV
2	TURBID WATER	IV
3	SNOW/ICE	IV
4	BARREN/SPARSELY VEGETATED	IV
5	CLOSED CONIFER FOREST	I.A
6	OPEN CONIFER FOREST	I.A
7	WOODLAND CONIFER FOREST	I.A
8	CLOSED DECIDUOUS FOREST	I.B
9	OPEN DECIDUOUS FOREST	I.B
10	CLOSED MIXED FOREST	I.C
11	OPEN MIXED FOREST	I.C
12	ALDER	II.B
13	RIPARIAN ALDER/WILLOW	II.B
14	WILLOW	II.B
15	OTHER SHRUB	II.C+D
16	HERBACEOUS/GRAMINOID	III.A+B

Appendix B

Accuracy matrices for the nine land cover maps evaluated based on comparing the mapped classes against actual vegetation composition as documented in three reference datasets (see Table 1 for definitions of codes).

NLCD vs. FIA

reference level 2 classes

map level 2 classes	I.A	I.B	I.C	II.A, B, or C	II.D	III.A or B	IV	row sums
I.A	73		1	13	1	5		93
I.B	1	1	1	2				5
I.C	1		1	1				3
II.A, B, or C	19	1		80	23	26		149
II.D	1			2	21	4		28
III.A or B				1	1	15		17
IV	1			4	5	3		13
column sums	96	2	3	103	51	53	0	**308**
omissions (rows)	23	1	2	23	30	38	0	
commissions (columns)	20	4	2	69	7	2	13	
mapping accuracy (%)	63	17	20	47	36	27	0	

overall accuracy (%)   **62**

NLCD vs. ecoplots

reference level 2 classes

	I.A	I.B	I.C	II.A, B, or C	II.D	III.A or B	III.D	IV	row sums
I.A	1026	16	48	41	32	52		3	1218
I.B	17	27	21	3	1	5			74
I.C	4	2	14			2			22
II.A, B, or C	155	50	20	161	43	179	1	1	610
II.D				1	69	6		1	77
III.A or B	3	1	1	15	3	54			77
III.D									0
IV	30	2	4	19	11	31		1	98
column sums	1235	98	108	240	159	329	1	6	**2176**
omissions (rows)	209	71	94	79	90	275	1	5	
commissions (columns)	192	47	8	449	8	23	0	97	
mapping accuracy (%)	72	19	12	23	41	15	0	1	

overall accuracy (%)   **62**

map level 2 classes

NLCD vs. CRDsites

reference level 2 classes

	I.A	I.B	I.C	II.A, B, or C	III.A or B	III.D	IV	row sums
I.A	31	5	2	7	6	1	3	55
I.B		5		1				6
I.C								0
II.A, B, or C	17	10	7	192	62	2	4	294
III.A or B	1			22	69	1		93
III.D								0
IV		6		3	10	6	25	50
column sums	49	26	9	225	147	10	32	**498**
omissions (rows)	18	21	9	33	78	9	7	
commissions (columns)	24	1	0	102	24	92	25	
mapping accuracy (%)	42	19	0	59	40	0	44	

map level 2 classes

overall accuracy (%)   65

Cover Type vs. FIA

reference level 2 classes

	I.A	I.B	I.C	II.A	II.B	II.C,D or III.A,B	IV	row sums
I.A	69			1	14	8		92
I.B		1	2		2			5
I.C	3		1		2	2		8
II.A								0
II.B	5			1	39	28		73
II.C,D or III.A,B	6				4	59		69
IV	5	1			8	20		34
column sums	88	2	3	2	69	117	0	**281**

map level 2 classes

	I.A	I.B	I.C	II.A	II.B	II.C,D or III.A,B	IV
omissions (rows)	19	1	2	2	30	58	0
commissions (columns)	23	4	7	0	34	10	34
mapping accuracy (%)	62	17	10	0	38	46	0

overall accuracy (%)   60

29

Cover Type vs. ecoplots

reference level 2 classes

	I.A	I.B	I.C	II.B	II.C,D or III.A,B	III.D	IV	row sums
I.A	962	8	32	23	115		1	1141
I.B	25	61	50	21	17		1	175
I.C	22	4	21	1				48
II.B	14	15	4	63	119			215
II.C,D or III.A,B	18	1		22	173	1	2	217
III.D								0
IV	25	7		26	99		2	159
column sums	1066	96	107	156	523	1	6	**1955**
omissions (rows)	104	35	86	93	350	1	4	
commissions (columns)	179	114	27	152	44	0	157	
mapping accuracy (%)	77	29	16	20	31	0	1	

map level 2 classes

overall accuracy (%)   66

Cover Type vs. CRDsites

reference level 2 classes

	I.A	I.B	I.C	II.B	II.C,D or III.A,B	III.D	IV	row sums
I.A	29	1	2	4	10		1	47
I.B	1	2		1				4
I.C				1				1
II.B	7	3	1	83	108	1	7	210
II.C,D or III.A,B	5			7	65		1	78
III.D								0
IV	2	8	6	15	50	9	22	112
column sums	44	14	9	111	233	10	31	**452**
omissions (rows)	15	12	9	28	168	10	9	
commissions (columns)	18	2	1	127	13	0	90	
mapping accuracy (%)	47	13	0	35	26	0	18	

(left axis label: map level 2 classes)

overall accuracy (%)   44

LANDFIRE EVT vs. FIA

reference level 2 classes

	I.A	I.B	I.C	II.A	II.B	II.C	II.D	III.A	III.B	IV	row sums
I.A	76	2		1	21	13	5	9	5		132
I.B	4		2		5	1		2			14
I.C	2		1								3
II.A											0
II.B	2				17	1	5		6		31
II.C	6			1	24	6	10	12	6		65
II.D	3				7	3	19	2	6		40
III.A	1								1		2
III.B	1										1
IV	1				2	1	12	3	1		20
column sums	96	2	3	2	76	25	51	28	25	0	**308**
omissions (rows)	20	2	2	2	59	19	32	28	25	0	
commissions (columns)	56	14	2	0	14	59	21	2	1	20	
mapping accuracy (%)	50	0	20	0	19	7	26	0	0	0	

map level 2 classes

overall accuracy (%)   39

LANDFIRE EVT vs. ecoplots

reference level 2 classes

	I.A	I.B	I.C	II.A	II.B	II.C	II.D	III.A	III.B	III.D	IV	row sums
I.A	870	48	60		55	38	57	107	38		2	1275
I.B	71	17	17		14	8	8	14	8		1	158
I.C	28	6	14		7	2	4	5	2			68
II.A	58	1	1		8	6	6	17	5			102
II.B	26	2	3		17	3	24	16	3		1	95
II.C	82	10	6		17	6	8	32	10	1	2	174
II.D	46	5	3		25	8	31	25	12			155
III.A	14	2	2		3	2	7	4	1			35
III.B	2											2
III.D												0
IV	39	7	2		17	4	14	20	10			113
column sums	1236	98	108	0	163	77	159	240	89	1	6	**2177**
omissions (rows)	366	81	94	0	146	71	128	236	89	1	6	
commissions (columns)	405	141	54	102	78	168	124	31	2	0	113	
mapping accuracy (%)	53	7	9	0	7	2	11	1	0	0	0	

map level 2 classes

overall accuracy (%)   **44**

LANDFIRE EVT vs. CRDsites

reference level 2 classes

	I.A	I.B	I.C	II.A	II.B	II.C	II.D	III.A	III.B	III.D	IV	row sums
I.A	35	16	5		71	53		32	24	2	4	242
I.B	4				8	6		3	10	1	1	33
I.C												0
II.A	1				1	2			1			5
II.B					1							1
II.C	8	5	4		47	32		39	20		2	157
II.D					1			1	1			3
III.A												0
III.B												0
III.D												0
IV	1	5			4			12	5	7	25	59
column sums	49	26	9	0	133	93	0	87	61	10	32	**500**
omissions (rows)	14	26	9	0	132	61	0	87	61	10	7	
commissions (columns)	207	33	0	5	0	125	3	0	0	0	34	
mapping accuracy (%)	14	0	0	0	1	15	0	0	0	0	38	

map level 2 classes (row axis label)

overall accuracy (%)   **19**

Landcov 1996 vs. FIA

reference level 2 classes

	I.A	I.B	I.C	II.A	II.B	II.C or D	III.A or B	III.C	III.D	IV	row sums
I.A	44	1			9	4	8				66
I.B	8		2		11	3					24
I.C											0
II.A											0
II.B	12	1		1	33	14	14				75
II.C or D	14		1		6	18	8				47
III.A or B	5			1	11	13	13				43
III.C						6	2				8
III.D							1				1
IV	6				4	13	6				29
column sums	89	2	3	2	74	71	52	0	0	0	**293**
omissions (rows)	45	2	3	2	41	53	39	0	0	0	
commissions (columns)	22	24	0	0	42	29	30	8	8	29	
mapping accuracy (%)	40	0	0	0	28	18	16	0	0	0	

map level 2 classes

overall accuracy (%)   **37**

Landcov 1996 vs. ecoplots

reference level 2 classes

map level 2 classes	I.A	I.B	I.C	II.A	II.B	II.C or D	III.A or B	III.C	III.D	IV	row sums
I.A	760	29	51		39	73	105			1	1058
I.B	79	21	23		16	17	35			1	192
I.C	3				4	3	4				14
II.A	13					2	4				19
II.B	76	12	9		38	49	50			1	235
II.C or D	87	3	9		19	28	57				203
III.A or B	92	21	8		27	34	45			2	229
III.C	12	2			3	4	3				24
III.D		2			1		1				4
IV	52	7	5		13	17	19		1	1	115
column sums	1174	97	105	0	160	227	323	0	1	6	**2093**
omissions (rows)	414	76	105	0	122	199	278	0	1	5	
commissions (columns)	298	171	14	19	197	175	184	24	24	114	
mapping accuracy (%)	52	8	0	0	11	7	9	0	0	1	

overall accuracy (%)   **43**

Landcov 1996 vs. CRDsites

reference level 2 classes

map level 2 classes	I.A	I.B	I.C	II.B	II.C or D	III.A or B	III.D	IV	row sums
I.A	21	6	1	31	23	16	1	7	106
I.B									0
I.C									0
II.B	9	3	1	30	14	35	2	7	101
II.C or D	2	1	1	12	6	10		2	34
III.A or B	9	8	2	31	26	45	1	6	128
III.D	1			4	6	9	1	1	22
IV	5	7	3	24	17	32	5	7	100
column sums	47	25	8	132	92	147	10	30	**491**

	I.A	I.B	I.C	II.B	II.C or D	III.A or B	III.D	IV
omissions (rows)	26	25	8	102	86	102	9	23
commissions (columns)	85	0	0	71	28	83	21	93
mapping accuracy (%)	16	0	0	15	5	20	3	6

overall accuracy (%)   **22**

CRD 2011 vs. FIA

reference level 2 classes

map level 2 classes	I.A	I.B	I.C	II.B	II.C	II.D	III.A or B	III.D	IV	row sums
I.A	9			1						10
I.B	1									1
I.C	2									2
II.B	4			12	11	1	9			37
II.C							1			1
II.D										0
III.A or B	2			6	1		13			22
III.D	1						1			2
IV	2				1					3
column sums	21	0	0	19	13	1	24	0	0	**78**
omissions (rows)	12	0	0	7	13	1	11	0	0	
commissions (columns)	1	1	2	25	1	0	9	2	3	
mapping accuracy (%)	41	0	0	27	0	0	39	0	0	

overall accuracy (%)   44

CRD 2011 vs. ecoplots

reference level 2 classes

	I.A	I.B	I.C	II.B	II.C	II.D	III.A or B	III.D	IV	row sums
I.A	72			1			4			77
I.B	1	2	1	2			2		1	9
I.C										0
II.B	6	3		13	10	2	33	1		68
II.C					4		7			11
II.D										0
III.A or B	11	2	1	16	8	4	57			99
III.D	10			4	1		11			26
IV	1	1	1	2	2		8			15
column sums	101	8	3	38	25	6	122	1	1	305
omissions (rows)	29	6	3	25	21	6	65	1	1	
commissions (columns)	5	7	0	55	7	0	42	26	15	
mapping accuracy (%)	68	13	0	14	13	0	35	0	0	

map level 2 classes

overall accuracy (%)   **49**

CRD 2011 vs. CRDsites

reference level 2 classes

	I.A	I.B	I.C	II.B	II.C	III.A or B	III.D	IV	row sums
I.A	49								49
I.B		26				1			27
I.C			9						9
II.B		1		133	1			1	136
II.C					92	1			93
III.A or B				1		147		7	155
III.D							9		9
IV							1	24	25
column sums	49	27	9	134	93	149	10	32	**503**

	I.A	I.B	I.C	II.B	II.C	III.A or B	III.D	IV
omissions (rows)	0	1	0	1	1	2	1	8
commissions (columns)	0	1	0	3	1	8	0	1
mapping accuracy (%)	100	93	100	97	98	94	90	73

overall accuracy (%)   **97**

CRD 1994 vs. FIA

reference level 2 classes

	I.A,B,C or II.B	II.C	III.A,B	III.C	IV	row sums
I.A,B,C or II.B	21	5	6			32
II.C						0
III.A,B	6	6	10			22
III.C			2			2
IV	5	1	4			10
column sums	32	12	22	0	0	**66**

map level 2 classes

	I.A,B,C or II.B	II.C	III.A,B	III.C	IV
omissions (rows)	11	12	12	0	0
commissions (columns)	11	0	12	2	10
mapping accuracy (%)	49	0	29	0	0

overall accuracy (%)   **47**

CRD 1994 vs. ecoplots

reference level 2 classes

map level 2 classes	I.A,B,C or II.B	II.C	II.D	III.A,B	III.C	III.D	IV	row sums
I.A,B,C or II.B	80	9		41		1		131
II.C	8	3		5				16
II.D								0
III.A,B	25	7	2	43				77
III.C	6	2	1	4				13
III.D				1				1
IV	22	4	3	28			1	58
column sums	141	25	6	122	0	1	1	**296**
omissions (rows)	61	22	6	79	0	1	0	
commissions (columns)	51	13	0	34	13	1	57	
mapping accuracy (%)	42	8	0	28	0	0	2	

overall accuracy (%)   **43**

CRD 1994 vs. CRDsites

reference level 2 classes

	I.A,B,C or II.B	II.C	III.A,B	III.C	III.D	IV	row sums
I.A,B,C or II.B	84	38	43		5	6	176
II.C	11	3	9				23
III.A,B	59	14	38		2	6	119
III.C	8	4	7			3	22
III.D	1		1				2
IV	49	28	47		3	15	142
column sums	212	87	145	0	10	30	**484**

map level 2 classes

omissions (rows)	128	84	107	0	10	15
commissions (columns)	92	20	81	22	2	127
mapping accuracy (%)	28	3	17	0	0	10

overall accuracy (%)　　**29**

KP 2006 vs. FIA

reference level 2 classes

map level 2 classes	I.A	I.B	I.C	II.B	II.C	II.D	III.A or B	IV	row sums
I.A	17		2	7	1	1			28
I.B		1	1						2
I.C	1			1	1		1		4
II.B	1			18		3	1		23
II.C	1			1			1		3
II.D	1			7	2	22	8		40
III.A or B	3			1					4
IV	2			1		4	1		8
column sums	26	1	3	36	4	30	12	0	**112**

	I.A	I.B	I.C	II.B	II.C	II.D	III.A or B	IV
omissions (rows)	9	0	3	18	4	8	12	0
commissions (columns)	11	1	4	5	3	18	4	8
mapping accuracy (%)	46	50	0	44	0	46	0	0

overall accuracy (%)   **52**

KP 2006 vs. ecoplots

reference level 2 classes

	I.A	I.B	I.C	II.B	II.C	II.D	III.A or B	IV	row sums
I.A	266	9	29	10	2	6	14	2	338
I.B	10	42	6	7	1		4		70
I.C	42	17	53	5	2	2	5		126
II.B	21	8	8	61	8	13	17	1	137
II.C	5	5		4	15	2	7		38
II.D	13	1		7	1	89	32	1	144
III.A or B	33	3	3	13	2	1	29		84
IV	8	5	6	6	1	8	7	1	42
column sums	398	90	105	113	32	121	115	5	**979**
omissions (rows)	132	48	52	52	17	32	86	4	
commissions (columns)	72	28	73	76	23	55	55	41	
mapping accuracy (%)	57	36	30	32	27	51	17	2	

map level 2 classes

overall accuracy (%)   57

Borough Veg vs. FIA

reference level 2 classes

	I.A	I.B	I.C	II.B	II.C	II.D	III.A or B	IV	row sums
I.A	16		1	4	1				22
I.B				2					2
I.C	3		1	1			1		6
II.B	3	1		17		4	2		27
II.C									0
II.D	1			3	2	13	5		24
III.A or B					1				1
IV						12	3		15
column sums	23	1	2	27	4	29	11	0	**97**
omissions (rows)	7	1	1	10	4	16	11	0	
commissions (columns)	6	2	5	10	0	11	1	15	
mapping accuracy (%)	55	0	14	46	0	33	0	0	

map level 2 classes

overall accuracy (%)   48

Borough Veg vs. ecoplots

reference level 2 classes

		I.A	I.B	I.C	II.B	II.C	II.D	III.A or B	IV	row sums
	I.A	222	7	31	7	6	3	5	2	283
map level 2 classes	I.B	11	16	20	7			2	1	57
	I.C	30	21	33	3	1	1	1		90
	II.B	1	3	1	36	4	7	27		79
	II.C									0
	II.D	4			5	1	36	15		61
	III.A or B						4	8		12
	IV		2	1			61	12	2	78
	column sums	268	49	86	58	12	112	70	5	660

	I.A	I.B	I.C	II.B	II.C	II.D	III.A or B	IV
omissions (rows)	46	33	53	22	12	76	62	3
commissions (columns)	61	41	57	43	0	25	4	76
mapping accuracy (%)	67	18	23	36	0	26	11	2

overall accuracy (%)   **53**

KP 1999 vs. FIA

reference level 2 classes

		I.A	I.B	I.C	II.B	II.C or D	III.A or B	IV	row sums
map level 2 classes	I.A	18	1	1	3		1		24
	I.B				1				1
	I.C								0
	II.B	4		2	19	1	4		30
	II.C or D	1			1	4			6
	III.A or B	1			8	20	6		35
	IV					5	1		6
	column sums	24	1	3	32	30	12	0	**102**

omissions (rows)	6	1	3	13	26	6	0
commissions (columns)	6	1	0	11	2	29	6
mapping accuracy (%)	60	0	0	44	13	15	0

overall accuracy (%)   46

KP 1999 vs. ecoplots

reference level 2 classes

	I.A	I.B	I.C	II.B	II.C or D	III.A or B	IV	row sums
I.A	239	6	53	4	4	4	2	312
I.B	11	24	12	4	2			53
I.C	7	5	14	1		1		28
II.B	18	21	11	42	18	26		136
II.C or D	3	2	1	7	14	11	1	39
III.A or B	2	2	4	16	65	36		125
IV	2	2	2	2	28	10	2	48
column sums	282	62	97	76	131	88	5	**741**

map level 2 classes

	I.A	I.B	I.C	II.B	II.C or D	III.A or B	IV
omissions (rows)	43	38	83	34	117	52	3
commissions (columns)	73	29	14	94	25	89	46
mapping accuracy (%)	67	26	13	25	9	20	4

overall accuracy (%)   **50**