HABITAT ASSOCIATIONS AND LANDSCAPE ECOLOGY OF BREEDING BIRDS IN FOOTHILLS SHRUB IN THE NORTHERN COLORADO FRONT RANGE

Final Report to:

City of Boulder, Dept. of Open Space / Real Estate and Division of Mt. Parks

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ABSTRACT

Foothills shrub in the northern Colorado Front Range is a unique and understudied habitat type. I investigated habitat associations of breeding songbirds in patches of foothills shrub in relation to measures of vegetation structure, vegetation composition, landscape context, and proximity of recreational trails. Distributions of breeding birds were quantified using 50 m fixed-distance point counts at 84 study plots. Six total counts were conducted at each plot in May and June of 1996 and 1997, and species were categorized as breeding season residents (present in three or more counts) or non-residents at each plot. I quantified local vegetation structure and composition using a point-centered quarter technique and visual estimation of cover, and I determined the landscape context of plots by sampling 80 0.1 ha plots on eight 500 m radial transects, using aerial orthophotographs to classify habitat types. I used multiple logistic regression to analyze associations between breeding residence of each of the eight most common breeding bird species and 16 habitat or landscape variables. I recorded a total of 59 bird species during point counts, but only eight species were resident on more than 12 plots. Spotted towhees (*Pipilo maculatus*) were resident on 98% of plots and demonstrated no significant habitat associations. Brown-headed cowbirds (*Molothrus ater*) were associated with wild plum (*Prunus americana*). Green-tailed towhees (*Pipilo chlorurus*) were negatively associated with shrub cover, grass cover, and five of the most common shrub species. Virginia's warblers (*Vermivora virginiae*) were negatively associated with shrub cover, tree cover, chokecherry (*Prunus americana*), shrub distance, and height heterogeneity. Yellow-breasted chats (*Icteria virens*) and Broad-tailed hummingbirds (*Selasphorus platycercus*) were negatively associated with horizontal heterogeneity. Neither Lazuli buntings (*Passerina amoena*) nor Blue-gray gnatcatchers (*Polioptila caerulea*) were significantly associated with any individual variables. No species showed any significant association with landscape context variables measuring the landscape occurrence of shrub, grassland, and coniferous forest habitat, suggesting that shrub patches with appropriate local characteristics were used regardless of their natural landscape setting in this system. There were no significant associations between breeding residence and proximity of recreational trails, suggesting trail impacts have not been pervasive enough to affect species distributions.

Avian Habitat Associations

Habitat selection by individual species underlies observed patterns in communities (Cody, 1985). Many factors can affect avian community composition and avian diversity. Patterns of habitat use may be determined by current responses to habitat characteristics, historical factors, landscape characteristics, and human disturbance (Rosenzweig, 1995).

The bird species using a habitat will be only partially determined by features of the habitat itself. MacArthur and MacArthur (1961) demonstrated a linear relationship between the vertical complexity of vegetation and the diversity of bird species occurring within a habitat. Roth (1976) found that horizontal heterogeneity, or patchiness, of vegetation also was associated with avian diversity. Thus, on a regional scale, vertical and horizontal structural features of habitats are important determinants of species occurrence and of avian diversity (MacArthur & MacArthur, 1961; Roth, 1976; Willson, 1974). However, on a local scale, species composition of vegetation may be more important than structural variables in affecting avian community structure within a particular habitat type (Rotenberry, 1985; Tomoff, 1974).

Patches of otherwise similar habitats that occur in different landscape settings may be used by different bird species. Island biogeography theory (MacArthur & Wilson, 1967) has contributed to our understanding of avian communities in natural or artificial habitat islands. Small and/or highly isolated islands typically support fewer species than large islands and/or islands near a mainland area. The species that are absent from small habitat islands tend to be species with low population densities, high levels of population fluctuation, low dispersal ability, or specific habitat requirements (e.g., Bolger et al., 1991; Møller, 1987; Nilsson, 1986). In fragments of natural forests, avian richness is typically reduced (Ambuel & Temple, 1983; Howe, 1984; Lynch & Whigham, 1984; MacClintock et al., 1977; Robbins et al., 1989), and nest predation and brood parasitism may be increased (e.g., Wilcove, 1985; Yahner, 1988). The habitat context of fragments may be an important factor affecting either the habitat quality or the tendency of birds to disperse into the patch (Harris, 1984; Rosenzweig, 1995). As opposed to fragments of previously continuous habitat, the avian diversity of naturally patchy habitats may be high (Bock, 1997).

The activities of humans may alter patterns of avian habitat usage. Human disturbance has been shown to affect behavior, reproduction, and habitat

properties not currently managed as recreational parks, and recreational trails typically were not visible from study points. I recorded all study sites greater than 200 m from trails as having a distance of 200 m to trails.

Habitat Sampling

I sampled vegetation at each study plot between 1 July and 1 September 1996. Habitat characteristics were measured by establishing 16 sampling points located 10 m and 20 m from the plot center on each of eight cardinal compass directions, and using the point-centered quarter technique (Cottam & Curtis, 1956) at each vegetation sampling point. I measured the distance to the nearest woody shrub at least 50 cm tall in each of four quarters, identified the contacted shrub, and measured its height. For each plot, I calculated the average distance to the nearest shrub (shrub distance), the coefficient of variation of shrub distance (horizontal heterogeneity; Roth, 1976), the average shrub height (shrub height), and the coefficient of variation of shrub height (height heterogeneity). In addition, the percent canopy cover of shrubs (shrub cover), grass and herbaceous vegetation (grass cover), and trees (tree cover) within 50 m of the plot center were visually estimated.

Landscape sampling

I utilized aerial orthophotographs to quantify the habitat context within a distance of 500 m of each study point. Most orthophotographs were at a 1:2400 scale, but in some cases the only photos available were 1:4800 or 1:6000 scale. I used transect sampling on the aerial photographs, by placing eight transects (500 m ground distance) at each study point on each of the cardinal directions, and then sampling for habitat at 10 points on each transect, separated by 50 m. At each habitat sampling point, a 0.1 ha circle was examined on the photographs and the habitat was categorized into one of the following types: shrub, conifer, grassland, riparian, bare ground, open water, or developed. Only the habitat type covering the greatest area within each circle was recorded. For each study plot, I recorded the percent occurrence of each habitat type.

RESULTS

Habitat Characteristics

Thirty-two shrub taxa occurred on the 84 plots, including 27 species and five genera not identified to species (Table 1). Over 50% of shrubs contacted during point-quarter sampling were of only two species: skunkbrush and mountain mahogany, while five shrubs (adding chokecherry, wild plum, and hawthorn) accounted for nearly 80% of the observations. The remaining 27 shrubs occurred on an average of only 9 percent of plots.

The study plots were highly variable structurally. Average distance to the nearest shrub from vegetation sampling points ranged from 0.03 m to 22.37 m, while average shrub height ranged from 0.78 m to 4.04 m (Table 2). Cover of shrubs within 50 m of plot centers ranged from 15 to 89%, with a mean of 51.5%. Grass cover averaged 43.7%, while tree cover averaged 9.5%.

Grassland, shrub, and coniferous forest were the predominant landscape cover types surrounding the 84 study points (Table 3). Riparian forest, bare ground, open water (reservoirs), and developed land were substantially less common.

Resident birds

I recorded 59 bird species on study plots during six point counts over two years. (Table 4; see Appendix B for scientific names and Appendix C for individual plot occurrences) Thirty-four species occurred at least three times on at least one plot, and were considered breeding season residents on at least one plot. Only eight species were resident on more than 12 plots.

Multiple logistic regression revealed significant relationships between probability of breeding residence and at least one habitat variable for five of the eight most common species (Table 5). Spotted towhees were resident on 82 of 84 plots, and no significant habitat associations were revealed by multiple logistic regression. Brown-headed cowbirds were considered resident on 43 plots, and were significantly associated with frequency of wild plum. Green-tailed towhees were significantly negatively associated with seven habitat variables: shrub cover within 50 m, grass cover within 50 m, skunkbrush, mountain mahogany, chokecherry, wild plum, and hawthorn. Virginia's warblers were significantly

this species is apparently able to utilize (Andrews & Righter, 1992; Sedgwick, 1987; Shugart & James, 1973) .

Brown-headed cowbirds also were common, and revealed only one significant habitat association, with wild plum. Wild plum was most common in moist shrub patches which were frequently near forest or grassland edges. Cowbirds apparently prefer edge habitats to extensive uniform areas, as indicated by patterns of nest parasitism (Lowther, 1993; Chace, 1995). In southwestern Colorado Gambel oak habitats, cowbirds were most common in pure oak and mixed pinyon pine (*Pinus edulis*)-juniper (*Juniperus osteosperma*)-Ponderosa pine-oak associations (E. Stone, unpublished data).

Green-tailed towhees showed an interesting pattern, with negative associations with shrub and grass cover and all five of the most common shrub species, suggesting a preference for heterogeneous habitats not dominated by a single shrub species. Other studies of Green-tailed towhee habitat selection have yielded diverse results, including associations with mountain mahogany, skunkbrush, bitterbrush (*Purshia tridentata*), currant (*Ribes* sp.), and Rocky Mountain juniper (*Juniperus scopulorum*) in northern Colorado (Knopf et al., 1990); with open shrubby areas of high shrub species richness in northwest Colorado pinyon-juniper woodlands (Sedgwick, 1987); with rabbitbrush (*Chrysothamnus viscidiflorus*) and bitterbrush in the northwestern Great Basin (Wiens & Rotenberry, 1981); and with oak and oak-serviceberry (*Amelanchier* sp.) in southwestern Colorado (E. Stone, unpublished data).

Virginia's warblers were negatively associated with shrub cover, tree cover, chokecherry, average shrub distance, and height heterogeneity. This species seemed to prefer areas with many small, dense patches of shrubs, often with skunkbrush and scattered Rocky Mountain juniper or ponderosa pine. Virginia's warblers utilize a variety of habitats in Colorado, including Gambel oak, mountain mahogany, riparian thickets, ponderosa pine forests, and pinyon-juniper woodlands (Andrews & Righter, 1992). In northwestern Colorado pinyon-juniper woodlands, Sedgwick (1987) found Virginia's warblers in Gambel oak chaparral or draws; while in southwestern Colorado, this species was most common in oak-serviceberry, pinyon-juniper-oak, and pinyon-juniper-ponderosa-oak associations (E. Stone, unpublished data).

Lazuli buntings showed no significant habitat associations. Lazuli buntings occur in a variety of shrub habitats both in Colorado and throughout

No significant relationships were evident between measures of landscape context and occurrence of common breeding bird species. Patch size was not definable in this study because of the highly variable dispersion patterns of individual shrubs. Any attempt at defining patch size would have required an arbitrary selection of scale. A scale selected by a human investigator would not necessarily have been relevant to breeding songbirds (Levin, 1992; Maurer, 1985; Morris, 1987).

By contrast, fragments of deciduous forest in the eastern U. S. have typically had reduced avian species richness caused by the loss of "area-sensitive" species (Ambuel & Temple, 1983; Howe, 1984; Lynch & Whigham, 1984; MacClintock et al., 1977; Robbins et al., 1989). Herkert (1994) and Vickery et al. (1994) found that many grassland birds in Illinois and Maine were dependent on large patches of habitat. Bock et al. (In press) found that some grassland birds were unlikely to occur near suburban development at the edge of grassland patches. In western riparian systems, Gutzwiller and Anderson (1987a) and Saab (1996) found that landscape variables, including patch size and measures of landscape context, were important to species richness and the distribution of some individual species. In each case, surrounding landscapes sometimes included human-altered areas.

In addition to human-caused fragmentation, island biogeography theory also would predict small natural habitat islands to have reduced species richness relative to large islands, due to lower probabilities of colonization and higher probabilities of extinction (MacArthur & Wilson, 1967). However, if dispersal to habitat patches is frequent enough that populations are not independent (or individual patch population dynamics are not at equilibrium), metapopulation models may be more appropriate predictors of community composition than island biogeography theory (Gutzwiller & Anderson, 1987b; Pulliam, 1988; Pulliam & Danielson, 1991).

In riparian woodlands in Arizona, Strong and Bock (1992) found that patch size was not a good predictor of avian density or richness, perhaps because of the natural patchiness of these habitats. Naturally small patches may provide important resources to species with populations (or individuals) that do not exclusively utilize the individual patch.

nesting in grasslands or ponderosa pine. Further research on the potential impacts of recreational trails to birds and other wildlife in foothills shrub habitats should be carried out before additional trails are planned.

Brown-headed cowbirds occurred in more point counts in foothills shrub study plots than any species other than the Spotted towhee. The prevalence of this obligate brood parasite in the landscape strongly suggests that cowbirds may be having an impact on other breeding birds in foothills shrub. Most of the common breeding species in foothills shrub are known cowbird hosts (Chace & Cruz, 1996). Further research in foothills shrub patches should examine the effects of cowbird brood parasitism on the breeding biology of other songbird species.

Northern Colorado Front Range foothills shrub is a breeding bird habitat with substantial conservation value. Shrub patches support an extremely high density of breeding birds in comparison with other foothills habitats (Steven Jones, unpublished data). Several breeding species of foothills shrub patches are shrub specialists, including both the abundant Spotted towhees and locally less common Green-tailed towhees, Virginia's warblers, Lazuli buntings, Yellow-breasted chats, and Blue-gray gnatcatchers. While some of these species also occur in other habitat types, foothills shrub is clearly an important local habitat for each of the above species. Foothills shrub may also be important to locally rare species such as Gray catbirds (Andrews, 1979), Scrub jays, Chestnut-sided warblers, and Bushtits. Foothills shrub is a relatively rare habitat type in the northern Front Range foothills, especially in the vicinity of Boulder, and therefore may deserve a higher conservation priority than habitats with greater geographic extent, such as ponderosa pine forest. Foothills habitats on private land are vulnerable to development for suburban housing. Protection of foothills shrub patches that support a variety of breeding bird species should be a local conservation priority.

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Table 1. Shrub species recorded during habitat sampling of 84 plots in foothills shrub habitat in the northern Colorado Front Range foothills.

		Contacts:**		Plots:***	
Species*	Common Name	Number	Percent	Number	Percent
Rhus aromatica	Skunkbrush	1437	26.73	49	58.33
Cercocarpus montanus	Mountain mahogany	1304	24.26	38	45.24
Prunus virginiana	Chokecherry	633	11.77	58	69.05
Prunus americana	Wild plum	497	9.24	31	36.90
Crataegus sp. *(erythropoda/macracantha)*	Hawthorn	421	7.83	29	34.52
Symphoricarpos oreophilus	Snowberry	178	3.31	15	17.86
Symphoricarpos occidentalis	Snowberry	176	3.27	27	32.14
Physocarpus monogynus	Small ninebark	115	2.14	16	19.05
Ribes cereum	Wax currant	96	1.79	36	42.86
Rhus glabra	Smooth sumac	92	1.71	6	7.14
Acer glabrum	Mountain maple	90	1.67	10	11.90
Rubus deliciosus	Boulder raspberry	72	1.34	17	20.24
Rosa sp. *(arkansana/acicularis)*	Rose	64	1.19	21	25.00
Amelanchier sp.	Serviceberry	36	0.67	5	5.95
Celtis reticulata	Netleaf hackberry	34	0.63	7	8.33
Toxicodendron rydbergii	Poison ivy	32	0.60	8	9.52
Clematis ligustifolia	Virgin's bower	19	0.35	5	5.95
Chrysothamnus nauseosus	Rabbitbrush	15	0.28	6	7.14
Lonicera sp. *(morrowi/tatarica)*	Honeysuckle	10	0.19	2	2.38
Ceanothus fendleri	New Jersey tea	9	0.17	5	5.95
Viburnum lantana	Wayfaring-tree	8	0.15	1	1.19
Artemisia cana	Wild sagebrush	7	0.13	2	2.38
Rosa woodsii	Woods rose	6	0.11	4	4.76
Salix sp.	Willow	5	0.09	2	2.38
Rhamnus cathartica	Buckthorn	5	0.09	1	1.19
Rubus idaeus	Wild raspberry	4	0.07	1	1.19
Mahonia repens	Oregon grape	3	0.06	2	2.38
Colutea arborescens	Bladder senna	3	0.06	1	1.19
Ligustrum vulgare	Privet	2	0.04	1	1.19
Amorpha fruticosa	Leadplant	1	0.02	1	1.19
Ribes americanum	Black currant	1	0.02	1	1.19
Ribes inerme	Common gooseberry	1	0.02	1	1.19

* Species names follow Carter (1988)
** Maximum possible contacts = 5376 (84 plots X 64 contacts each)
*** Maximum possible plots = 84

Table 4. Detection of birds during six point counts on 84 plots in foothills shrub habitat in the northern Colorado Front Range foothills.

Common Name*	Code	Total Number of Plots where: Resident**	Detected	Total Number of Counts where Detected***
Spotted towhee	SPTO	82	84	460
Brown-headed cowbird	BHCO	43	73	214
Green-tailed towhee	GTTO	33	59	175
Virginia's warbler	VIWA	32	54	148
Lazuli bunting	LABU	29	68	178
Yellow-breasted chat	YBCH	28	53	160
Broad-tailed hummingbird	BTHU	22	49	139
Blue-gray gnatcatcher	BGGN	22	38	108
Black-billed magpie	BBMA	12	33	74
Western meadowlark	WEME	12	24	72
American robin	AMRO	10	27	55
Black-headed grosbeak	BHGR	10	23	59
Western tanager	WETA	7	16	35
Vesper sparrow	VESP	7	14	33
Dusky flycatcher	DUFL	5	31	46
Chipping sparrow	CHSP	5	19	35
House wren	HOWR	5	19	35
Macgillivray's warbler	MAWA	4	18	28
Warbling vireo	WAVI	4	10	24
Rock wren	ROWR	4	8	22
Gray catbird	GRCA	3	11	22
Lesser goldfinch	LEGO	2	18	27
American goldfinch	AMGO	2	16	22
Plumbeous vireo	PLVI	2	11	20
Lark sparrow	LASP	2	5	13
Mourning dove	MODO	1	13	18
Western wood pewee	WWPE	1	13	18
Pine siskin	PISI	1	11	18
Mountain chickadee	MTCH	1	10	17
Scrub jay	SCJA	1	6	9
Yellow warbler	YEWA	1	6	9
Indigo bunting	INBU	1	3	5
Song sparrow	SOSP	1	2	5
Chestnut-sided warbler	CSWA	1	1	4
Steller's jay	STJA	0	13	16
Black-capped chickadee	BCCH	0	13	15
Northern oriole	NOOR	0	11	14
House finch	HOFI	0	11	11
Brewer's sparrow	BRSP	0	6	6
Northern mockingbird	NOMO	0	5	6

Table 5. Results of multiple logistic regression analyses between breeding residence of eight songbird species and 16 habitat variables. Only statistically significant individual variable associations are listed.

	Whole Model		Significant Associations ($p < 0.05$)			
	X2	p	Variable	Estimate	X2	p
SPTO	18.90	0.27	none			
BHCO	53.26	< 0.0001	Wild plum	0.177	5.64	< 0.05
GTTO	47.47	< 0.0001	Shrub cover	-0.173	12.04	< 0.001
			Grass cover	-0.115	7.67	< 0.01
			Skunkbrush	-0.159	7.42	< 0.01
			Mountain mahogany	-0.109	4.49	< 0.05
			Chokecherry	-0.244	7.31	< 0.01
			Wild plum	-0.186	8.70	< 0.005
			Hawthorn	-0.199	5.65	< 0.05
VIWA	58.45	< 0.0001	Shrub cover	-0.196	11.45	< 0.001
			Tree cover	-0.178	7.07	< 0.01
			Chokecherry	-0.148	4.02	< 0.05
			Avg. distance	-0.636	5.11	< 0.05
			Height hetero.	-0.090	4.55	< 0.05
LABU	26.04	0.05	none			
YBCH	39.68	< 0.001	Horiz. hetero.	-0.026	7.85	< 0.01
BTHU	44.50	< 0.0005	Horiz. hetero.	-0.040	6.42	< 0.05
BGGN	47.85	< 0.0001	none			

Appendix A. Continued...

Plot	Latitude (dec. deg.)	Longitude (dec. deg.)	Elevation (m)
MS 1	40.02512014	105.29590765	1710
MS 2	40.02792675	105.29813346	1751
MS 3	40.03098391	105.29706134	1769
SM 1	39.94182362	105.26218798	1727
SM 2	39.94414047	105.27306637	1816
SM 3	39.94302426	105.27996989	1894
SM 4	39.93867145	105.28131100	1859
SM 5	39.95227476	105.28002212	1899
SM 6	39.9519649	105.27455746	1847
SM 7	39.94940001	105.26987894	1795
SM 8	39.95089376	105.26548456	1759
WL 1	40.06060937	105.29781331	1825
WL 2	40.05732942	105.29800462	1808
WL 3	40.05037937	105.29867928	1796
AP 1	39.7143415	105.21772313	2003
AP 2	39.71250916	105.22098808	2028
AP 3	39.71381201	105.22366590	2095
AP 4	39.71614719	105.22228605	2088
AP 5	39.71986063	105.22705386	2135
AP 6	39.72223707	105.22459440	2054
GP 1	39.84104197	105.27810740	2028
GP 2	39.8332512	105.26808463	1906
GP 3	39.8259853	105.26569430	1883
HP 1	39.69712884	105.20233518	1957
MW 1	39.69711299	105.21336220	2012
MW 2	39.69817602	105.21821511	2030
MW 3	39.68960757	105.20724048	1928
MW 4	39.68340974	105.20984966	1958
MW 5	39.68471226	105.21846873	2058
MW 6	39.68671485	105.21678115	2039
MW 7	39.68905759	105.21556948	2080
RE 1	39.89451715	105.26973430	1969
RE 2	39.8894159	105.25574487	1896
RE 3	39.88705963	105.25813258	1911
GL 1	39.75989693	105.24755768	1943
GL 2	39.76477742	105.24800869	1990
GL 3	39.76514436	105.25374604	2130
GL 4	39.76734686	105.25068477	2039
GL 5	39.76287748	105.24369619	1899
WR 1	39.81475949	105.26523422	1940
WR 2	39.81209117	105.26724882	2000
WR 3	39.80835399	105.26678746	2075

Appendix B. Continued...

Common Name	Code	Genus species
Red-winged Blackbird	RWBL	*Agelaius phoeniceus*
Pygmy Nuthatch	PYNU	*Sitta pygmaea*
Common Grackle	COGR	*Quiscalus quiscula*
Wilson's Warbler	WIWA	*Wilsonia pusilla*
Yellow-rumped warbler	YRWA	*Dendroica coronata*
Grasshopper Sparrow	GRSP	*Ammodramus savannarum*
Cedar Waxwing	CEWA	*Bombycilla cedrorum*
Townsend's Solitaire	TOSO	*Myadestes townsendi*
White-crowned Sparrow	WCSP	*Zonotrichia leucophrys*
Bushtit	BUSH	*Psaltriparus minimus*
Blue Grosbeak	BLGR	*Guiraca caerulea*
Brewer's Blackbird	BRBL	*Euphagus cyanocephalus*
Canyon Wren	CAWR	*Catherpes mexicanus*
Dark-eyed Junco	DEJU	*Junco hyemalus*
European Starling	EUST	*Sturnus vulgaris*
House Sparrow	HOSP	*Passer domesticus*
White-breasted Nuthatch	WBNU	*Sitta carolinensis*

Appendix C. Continued...

Plot	SPTO	BHCO	GTTO	VIWA	LABU	YBCH	BTHU	BGGN	BBMA	WEME	AMRO	BHGR
SM2	6	5	3	3	4	6	6	3	1	0	1	4
SM3	5	3	0	1	1	1	4	0	0	0	1	6
SM4	6	0	4	1	5	5	6	2	0	0	1	4
SM5	3	3	0	6	0	1	2	0	0	0	1	0
SM6	6	3	0	2	5	1	3	0	0	0	4	1
SM7	6	5	2	1	3	5	1	3	0	1	0	0
SM8	5	2	3	0	2	1	0	3	1	3	0	0
WL1	4	0	3	0	4	0	0	1	3	0	1	0
WL2	6	3	0	0	4	2	1	3	4	2	0	0
WL3	6	3	1	0	5	2	1	2	2	2	0	0
AP1	6	1	6	0	0	1	1	0	0	0	2	0
AP2	4	1	1	0	3	0	1	1	1	0	0	1
AP3	5	0	5	4	2	0	1	0	0	0	0	0
AP4	4	4	3	3	1	1	0	1	0	0	0	1
AP5	5	2	5	3	2	0	1	0	1	0	0	0
AP6	6	3	5	3	2	0	0	1	1	0	0	1
GP1	5	0	4	3	2	0	3	0	0	0	0	0
GP2	5	1	3	3	5	2	6	0	0	0	0	0
GP3	6	3	2	2	4	2	4	0	0	0	0	0
HP1	6	5	4	0	1	0	0	5	1	1	0	0
MW1	6	0	5	0	5	0	1	0	0	0	0	0
MW2	6	4	5	1	3	3	2	0	0	0	0	0
MW3	5	5	1	1	2	3	1	0	1	5	0	0
MW4	6	4	3	4	0	6	1	3	0	0	0	0
MW5	6	4	3	3	2	0	4	3	0	0	1	4
MW6	6	4	6	3	1	2	4	2	0	0	0	2
MW7	6	3	6	0	2	1	0	2	4	0	0	0
RE1	5	3	4	0	0	1	0	0	2	5	0	0
RE2	2	1	2	0	1	1	0	0	1	3	0	0
RE3	5	1	0	0	1	1	0	0	0	5	0	0
GL1	6	1	3	0	5	2	2	0	0	0	0	1
GL2	6	0	6	3	6	1	4	0	1	0	0	0
GL3	6	2	4	4	4	1	0	0	0	0	0	0
GL4	5	2	1	0	3	0	0	1	0	0	0	0
GL5	6	1	1	3	6	3	4	0	3	0	0	0
WR1	6	3	4	5	2	2	2	0	0	0	0	2
WR2	5	2	0	2	3	0	0	1	0	0	0	2
WR3	6	3	2	5	0	0	1	0	0	0	0	4

Appendix C. Continued...

Plot	WETA	VESP	DUFL	CHSP	HOWR	MAWA	WAVI	ROWR	GRCA	LEGO	AMGO	PLVI
SM2	0	0	2	0	2	1	0	0	0	0	0	0
SM3	1	0	1	0	0	3	3	0	0	0	0	0
SM4	0	0	0	0	0	3	0	0	0	0	0	0
SM5	4	0	4	2	0	0	3	0	0	0	0	2
SM6	2	0	0	3	0	0	0	0	0	0	0	2
SM7	0	0	1	2	1	0	0	0	0	0	0	0
SM8	0	0	0	0	0	0	0	0	1	0	2	0
WL1	0	0	0	0	0	0	0	0	0	0	0	0
WL2	0	0	1	1	0	0	0	0	0	0	0	0
WL3	0	0	1	0	0	0	0	3	0	0	0	0
AP1	0	0	1	0	0	0	0	0	0	0	0	0
AP2	0	0	0	0	0	0	0	2	0	0	0	0
AP3	0	0	1	0	0	0	0	2	0	0	1	0
AP4	3	0	1	0	0	0	0	0	0	0	0	1
AP5	3	0	0	3	0	0	0	0	0	0	0	0
AP6	0	0	0	1	3	0	0	0	0	1	0	0
GP1	0	0	0	0	1	0	0	0	0	0	0	0
GP2	0	0	1	0	0	0	0	0	0	0	0	0
GP3	0	0	1	0	0	2	0	0	0	1	0	0
HP1	0	0	0	0	0	0	0	0	0	0	0	0
MW1	0	0	0	0	0	0	0	0	0	0	0	0
MW2	0	4	1	0	0	0	0	0	0	0	0	0
MW3	0	0	0	0	2	0	0	0	0	0	0	0
MW4	1	0	0	0	0	0	0	0	0	0	0	0
MW5	0	3	1	0	0	1	0	0	0	1	0	0
MW6	0	0	1	0	1	1	0	0	0	0	0	0
MW7	0	2	0	1	0	0	0	0	0	0	0	0
RE1	0	3	0	1	1	1	0	0	0	0	1	0
RE2	0	3	0	1	0	0	0	0	3	1	3	0
RE3	0	3	0	0	0	0	0	0	0	0	0	0
GL1	0	0	1	0	0	0	0	3	0	0	0	0
GL2	0	0	1	0	1	0	0	4	0	0	1	0
GL3	0	0	0	2	0	1	0	4	0	0	0	0
GL4	0	0	0	1	0	0	0	0	0	0	0	0
GL5	0	0	3	0	0	0	0	0	0	0	0	0
WR1	0	0	1	0	1	0	0	0	0	0	0	0
WR2	0	0	0	1	1	0	1	0	0	2	0	1
WR3	0	0	0	0	0	0	0	0	0	0	0	0

Appendix C. Continued...

Plot	LASP	MODO	WWPE	PISI	MTCH	SCJA	YEWA	INBU	SOSP	CSWA	STJA	BCCH
SM2	0	0	1	0	0	0	0	0	1	0	0	0
SM3	0	0	0	0	0	0	0	0	0	0	0	1
SM4	0	0	0	0	0	0	1	3	0	0	0	0
SM5	0	0	0	1	2	0	0	0	0	0	1	0
SM6	0	0	0	2	1	0	0	1	0	0	0	1
SM7	0	0	1	0	0	0	0	0	0	0	1	0
SM8	0	0	0	0	0	0	0	0	0	0	0	0
WL1	0	1	0	0	2	0	0	0	0	0	0	0
WL2	0	0	0	0	0	0	0	0	0	0	0	0
WL3	0	0	0	0	0	1	0	0	0	0	0	0
AP1	0	1	0	0	0	0	0	0	0	0	0	0
AP2	0	0	0	0	0	0	0	0	0	0	0	1
AP3	0	2	0	0	0	0	0	0	0	0	2	0
AP4	0	0	0	0	0	0	0	0	0	0	1	0
AP5	0	0	0	2	0	0	0	0	0	0	1	0
AP6	0	0	0	1	0	0	0	0	0	0	1	0
GP1	0	0	0	0	0	0	0	0	0	0	2	0
GP2	0	0	0	0	0	0	0	0	0	0	0	0
GP3	0	0	0	0	0	0	0	0	0	0	0	0
HP1	0	0	0	0	0	0	0	0	0	0	0	0
MW1	0	0	0	0	0	0	0	0	0	0	0	0
MW2	0	0	0	0	0	0	1	0	0	0	0	0
MW3	0	0	1	0	0	4	0	0	0	0	0	1
MW4	0	0	0	0	0	1	0	0	0	0	0	0
MW5	0	0	0	0	0	1	0	0	0	0	0	2
MW6	0	0	0	0	0	0	0	0	4	0	0	0
MW7	0	0	0	0	0	0	0	0	0	0	0	0
RE1	0	0	0	0	0	0	0	0	0	0	0	0
RE2	0	0	0	0	0	0	2	0	0	0	0	0
RE3	0	0	0	0	0	0	0	0	0	0	0	0
GL1	0	0	0	0	0	0	0	0	0	0	0	0
GL2	0	0	0	0	0	0	0	0	0	0	0	0
GL3	0	0	0	0	1	0	0	0	0	0	0	0
GL4	0	0	1	0	0	0	0	0	0	0	1	0
GL5	0	0	0	0	0	1	0	0	0	0	0	0
WR1	0	0	0	0	0	0	0	0	0	0	0	0
WR2	0	0	0	0	0	0	0	0	0	0	0	0
WR3	0	2	1	1	0	0	0	0	0	0	0	0

Appendix C. Continued...

Plot	NOOR	HOFI	BRSP	NOMO	NOFL	RBNU	RWBL	PYNU	COGR	WIWA	YRWA	GRSP
SM2	0	0	0	0	0	1	0	0	0	0	0	0
SM3	0	0	0	0	0	0	0	0	0	0	0	0
SM4	0	0	0	0	0	0	0	0	0	0	0	0
SM5	0	0	0	0	0	0	0	0	0	1	0	0
SM6	0	0	0	0	0	0	0	0	0	0	0	0
SM7	0	0	0	0	0	0	0	0	0	0	0	0
SM8	0	0	0	0	0	0	1	0	0	0	0	0
WL1	0	0	0	0	0	0	0	0	0	0	0	0
WL2	0	0	1	0	0	0	0	0	0	0	0	0
WL3	1	0	0	0	0	0	0	0	0	0	0	0
AP1	0	1	0	0	0	0	0	0	0	0	0	0
AP2	0	0	0	0	0	0	0	0	0	0	0	0
AP3	0	0	0	0	0	0	0	0	0	0	0	0
AP4	0	0	0	0	0	1	0	1	0	0	1	0
AP5	0	1	0	0	1	0	0	1	0	0	0	0
AP6	0	0	0	0	0	0	1	0	1	0	0	0
GP1	0	0	0	0	0	0	0	0	0	0	0	0
GP2	0	0	0	0	0	0	0	0	0	0	0	0
GP3	0	0	0	0	0	0	0	0	0	0	0	0
HP1	0	0	0	0	0	0	0	0	0	0	0	0
MW1	0	0	0	0	0	0	0	0	0	0	0	0
MW2	0	0	0	0	0	0	0	0	0	0	0	0
MW3	1	0	1	0	0	0	0	0	0	0	0	0
MW4	0	1	0	0	0	0	0	0	0	0	0	0
MW5	0	1	0	0	0	0	0	0	0	0	1	0
MW6	0	0	0	0	0	0	0	0	0	0	0	0
MW7	0	0	0	0	0	0	0	0	0	0	0	0
RE1	0	0	0	1	0	0	0	0	0	0	0	0
RE2	1	0	1	0	0	0	1	0	0	0	0	1
RE3	0	0	1	0	0	0	0	0	0	0	0	2
GL1	0	1	0	0	0	0	0	0	0	0	0	0
GL2	0	0	0	0	0	0	0	0	0	0	0	0
GL3	0	0	0	0	0	1	0	0	0	0	0	0
GL4	0	0	0	0	0	0	0	0	0	0	0	0
GL5	0	0	0	0	0	0	0	0	0	0	0	0
WR1	0	0	0	0	0	0	0	0	0	0	0	0
WR2	0	0	0	0	0	0	0	0	0	0	0	0
WR3	1	0	0	0	0	0	0	0	0	0	0	0

Appendix C. Continued...

Plot	CEWA	TOSO	WCSP	BUSH	BLGR	BRBL	CAWR	DEJU	EUST	HOSP	WBNU
SM2	0	0	0	0	0	0	0	0	0	0	0
SM3	0	0	0	0	0	0	0	0	0	0	0
SM4	0	0	0	0	0	0	0	0	0	0	0
SM5	0	0	0	0	0	0	0	0	0	0	0
SM6	0	0	0	0	0	0	0	0	0	0	1
SM7	0	0	0	0	0	0	0	0	0	0	0
SM8	0	0	0	0	0	0	0	0	0	0	0
WL1	0	0	0	0	0	0	0	0	0	0	0
WL2	0	0	0	0	0	0	0	0	0	0	0
WL3	0	0	0	0	0	0	0	0	0	0	0
AP1	0	0	0	0	0	0	0	0	0	0	0
AP2	0	0	0	0	0	0	0	0	0	0	0
AP3	0	0	0	0	0	0	0	0	0	0	0
AP4	0	0	0	0	0	0	0	0	0	0	0
AP5	0	0	0	0	0	0	0	0	0	0	0
AP6	0	0	0	0	0	0	0	0	0	0	0
GP1	0	0	0	0	0	0	0	0	0	0	0
GP2	0	0	0	0	0	0	0	0	0	0	0
GP3	0	0	0	0	0	0	0	0	0	0	0
HP1	0	0	0	0	0	0	0	0	0	0	0
MW1	0	0	0	0	0	0	0	0	0	0	0
MW2	0	0	0	0	0	0	0	0	0	0	0
MW3	0	0	0	0	0	0	0	0	0	0	0
MW4	0	0	0	0	0	0	0	0	0	0	0
MW5	0	0	0	0	0	0	0	0	0	0	0
MW6	0	0	0	0	0	0	0	0	0	0	0
MW7	0	0	0	0	0	0	0	0	0	0	0
RE1	0	0	0	0	0	0	0	0	0	0	0
RE2	0	0	0	0	0	0	0	0	0	0	0
RE3	0	0	0	0	0	0	0	0	0	0	0
GL1	0	0	0	0	0	0	1	0	0	0	0
GL2	0	0	0	0	0	0	0	0	0	0	0
GL3	0	0	0	0	0	0	0	0	0	0	0
GL4	0	0	0	0	0	0	0	0	0	0	0
GL5	0	0	0	0	0	0	0	0	0	0	0
WR1	0	0	0	0	0	0	0	0	0	0	0
WR2	0	0	0	0	0	0	0	0	0	0	0
WR3	0	0	0	0	0	0	0	0	0	0	0